ATLANTIC GEOSCIENCE SOCIETY
LA SOCIÉTÉ GÉOSCIENTIFIQUE DE L'ATLANTIQUE
38th COLLOQUIUM & ANNUAL GENERAL MEETING

February 3 - 4, 2012
Delta Beauséjour, Moncton
New Brunswick

Special Sessions:
Paleontology in Atlantic Canada
Surficial Geology and Geochemistry
Stratigraphy and Sedimentology
Tectonics and Structure
Economic Geology
General Session:
Current Research in the Atlantic Provinces (and Beyond)
Workshop:
Practical Application of Fluid Inclusion Studies to Ore Deposit Settings
Field Trip:
PotashCorp Mine
Tour Sussex

PROGRAM AND ABSTRACTS

ATLANTIC GEOSCIENCE SOCIETY
38th ANNUAL GENERAL MEETING & COLLOQUIUM

February 3-4, 2012 Moncton, New Brunswick

Dear AGS Members,

On behalf of the organizing committee, we would like to welcome you to the Atlantic Geoscience Society's 38th Annual General Meeting and Colloquium at the Delta Beauséjour Hotel in Moncton, New Brunswick. This marks our 5th meeting in Moncton, the first being held back in 2001. Our program this year highlights the diversity of geoscientific research that goes on in our region and we are sure that you will find a topic of interest. We hope that you enjoy the colloquium and have a safe trip home.

Susan Johnson, Mike Parkhill, Jim Walker & Reg Wilson
2012 Colloquium Organizing Committee

For their assistance, many thanks to: Serge Allard, Pam Dickinson, Jacob Hanley, Nicole Hatheway, Steven Hinds, Daniel Kontak, Maurice Mazerolle, Steve McCutcheon, Cyndie Pitre, Brian Roulston, Ian Spooner

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ATLANTIC GEOSCIENCE SOCIETY
38th COLLOQUIUM & ANNUAL GENERAL MEETING

February 3-4, 2012, Delta Beauséjour Hotel, Moncton, New Brunswick

PROGRAM HIGHLIGHTS

Friday, February 3, 2012

11:30-5:00pm: **Mine Tour**: PotashCorp mine and mill, Penobsquis (near Sussex), NB. (*See notes on following page*)

12 noon-10:00pm: **Registration** in the Mezzanine

1:00-5:00pm: **Workshop - Ballroom C** - "Practical Application of Fluid Inclusion Studies to Ore Deposit Settings" (Daniel Kontak and Jacob Hanley)

3:30-5:00pm: **Poster set-up** Mezzanine C

4:00-5:00pm: **Atlantic Geology Editors Meeting** - Boardroom

5:00-6:30pm: **AGS Executive Council Meeting** - Boardroom

5:00-7:00pm: **Load Presentations**- Friday evening & Saturday morning speakers must load their presentations at this time

7:00-9:20pm: **Special Session** – *Surficial Geology & Geochemistry I* - Ballroom B

7:00-9:20pm: **General Session** - *Current Research in the Atlantic Provinces and Beyond I* – Ballroom C

9:20-11:00pm: **Poster Session**

9:20-Midnight: - **Social and Cash Bar** - Mezzanine C

Saturday, February 4, 2012

9:00am-12 noon: **Registration** Mezzanine

9:00-10:20pm: **Special Session**: *Surficial Geology & Geochemistry II* - Ballroom B

9:00-10:20pm: **Special Session**: *Stratigraphy & Sedimentology I* – Ballroom C

Saturday, February 4, 2012 *(continued)*

10:20-10:40am: **Coffee Break -** Mezzanine

10:20-10:40am: **Load Presentations** Saturday afternoon speakers must load their presentations at this time if they haven't already done so

10:40–12 noon: **Special Session**: - *Economic Geology I*- Ballroom B

10:40–12 noon: **General Session**: *Current Research in the Atlantic Provinces and Beyond II* - Ballroom C

12 noon-2:00pm: **LUNCHEON AND ANNUAL GENERAL MEETING** – Ballroom A

2:00-3:20pm: **Special Session:** *Paleontology in Atlantic Canada I*- Ballroom B

2:00-3:20pm: **Special Session:** *Structure and Tectonics I* - Ballroom C

3:20-3:40pm: **Coffee Break -** Mezzanine

3:40-4:20pm: **Special Session:** *Paleontology in Atlantic Canada II*- Ballroom B

3:40-5:00pm: **Special Session:** *Structure and Tectonics II* - Ballroom C

5:00-6:00pm: **Science Atlantic Earth Science Committee Meeting** – Boardroom

6:00-7:00pm: **Cash Bar** - Mezzanine

7:00-9:30pm: **AWARDS BANQUET** & **DINNER** - Ballroom A ***Guest Speaker***: Bob Grantham – *"Adventures in Geoscience Interpretation"*

9:30-12:00pm: **AGS Ceilidh & Jam Session**– Petitcodiac Room –All instruments and styles welcome

NOTES

All meetings, technical & poster sessions, luncheon and banquet take place on the conference level at the **Delta Beauséjour**, 750 Main Street, Moncton (Phone 1-888-890-3222; 1-506-854-4344; www.deltabeausejour.ca). The hotel requires notice for the number of meal attendees so please reserve your luncheon and banquet tickets before January 31st. To reserve tickets and for registration information contact Sue Johnson (Phone: 506- 432-2234) email: Susan.Johnson@gnb.ca. Also check the AGS website http://ags.earthsciences.dal.ca/ags.php

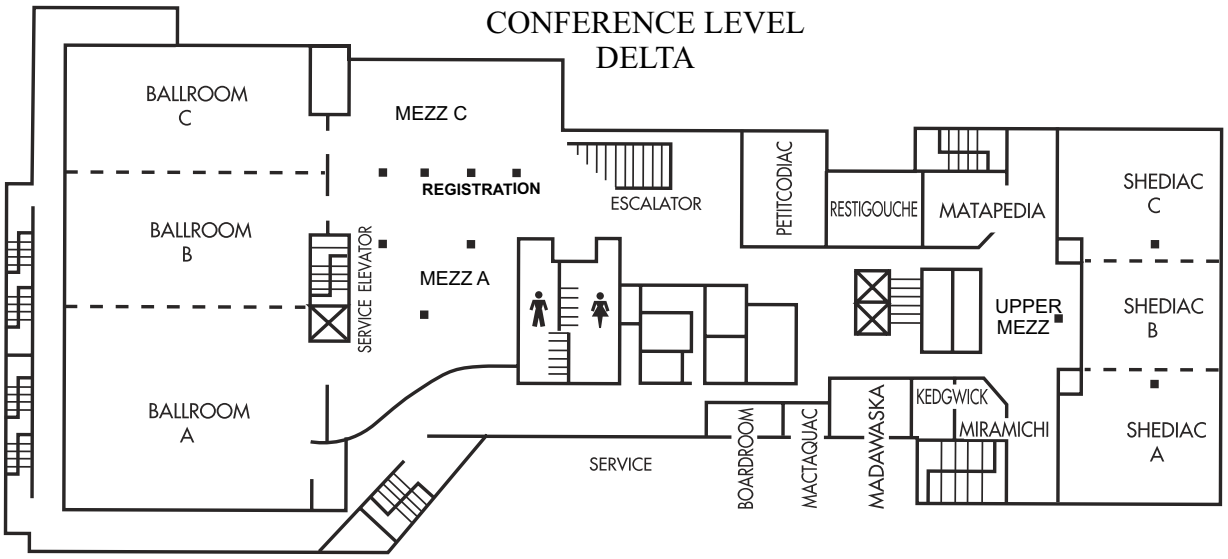
✓ **MINE TOUR:** PotashCorp's potash mine tour is from ***11:30 AM to 5:00 PM, on Friday, February 3. Participants are responsible for their own transportation to and from the mine site and should wear old clothes (field gear) and safety boots.*** The site is located about 8 km east of Sussex, on the **north** side of Route 114 (new headframes have recently been erected on the south side as part of a major expansion). From Moncton take the TCH (Highway 2) west and exit onto Highway 1 to Saint John/Sussex. Take exit 211 off Highway 1 and follow Route 114 north and west. Park in the visitor's area and report to the onsite security office by 11:30 AM Friday, February 3. ***No beards*** will be permitted underground.

✓ **LOADING PRESENTATIONS:** Please deliver your CD or high quality data stick to the technical assistant located in the Mezzanine near the registration desk well in advance of your scheduled talk. ***Friday evening and Saturday morning speakers please load your presentation between 5:00pm and 7pm on Friday, February 3.*** Laptops for all sessions use Windows Vista operating system. Please save your presentation as a Powerpoint Presentation (pps) file to avoid technical issues. Saturday afternoon speakers are also encouraged to load their presentations at this time, or at the latest during coffee break on Saturday morning.

✓ **TECHNICAL SESSIONS:** Speakers will have one LCD projector with a dedicated laptop, and a laser pointer available. Speakers will have 20 minutes, including time for questions. The sessions will be kept on schedule by the Chairs to allow for judging of the large number of student presentations eligible for the undergraduate and graduate student awards. ***There is no speaker-ready room.*** Presenters should bring a laptop if they wish to practice their talks.

✓ **POSTER SESSIONS**: Posters are required to be ***set-up in Mezzanine C between 3:30 - 5:00pm Friday*** and ***taken down by 4:00pm on Saturday.*** Posters are displayed on ***6'x 6' velcro friendly boards***. Please bring your own Velcro. Posters will be displayed throughout the conference and presenters are asked to be at their posters during the dedicated ***Poster Session on Friday night from 9:20 - 11:00 pm.***

✓ **AWARDS/ENTERTAINMENT**: The **Gesner Medal** (Distinguished Scientist) and the student awards for best poster (**Graham Williams Award**), best undergraduate paper (**Rupert MacNeill Award**) and best graduate student paper (**Sandra Barr Award**), will be presented at the banquet on Saturday evening in **Ballroom A** starting at 7:00 PM. Our **banquet speaker** is Robert Grantham, whose talk is entitled ***"Adventures in Geoscience Interpretation"***. A post-banquet tradition is the annual **AGS Ceilidh and Jam Session**. The musically-inclined are encouraged to bring their instruments and convene in the **Petitcodiac Room** after the banquet; all instruments and styles are welcome.



Workshop: Practical Application of Fluid Inclusion Studies to Ore Deposit Settings
Time: Friday, February 3, 1:00-5:00 PM, Ballroom C
Conveners: Daniel Kontak, Laurentian University, and **Jacob Hanley**, St. Mary's University

This short course is designed to introduce the novice to the wonderful world of fluid inclusions. These small vials (<10-20 μm) of ancient fluid enable one to confidently reconstruct the PTX conditions of a chemical system and, as such, their application to a wide variety of settings, from meteorites to mantle-derived xenoliths and a wide variety of ore deposits, to low-temperature diagenetic settings, has gained momentum over the past few decades. The course will integrate petrographic observations of fluid inclusion type in different settings with the necessary chemical systems (H_2O, H_2O-NaCl, H_2O-CO_2) to make conclusions about the P-T conditions of fluid entrapment, hence the capacity to stride through PT space or an ore deposit environment. The short course will also address the potential problems inherent in the method and review the classification of inclusions and the principles which guide a good study, both of which minimize errant interpretations. An outline of topics to be covered follow.

1. What are fluid inclusions?

2. Examples of fluid inclusions in different ore deposits - setting the stage!

3. Chemical systems:
    - H_2O system and concept of homogenization T and isochores.
    - H_2O-NaCl system and magmatic/porphyry/epithermal systems.
    - H_2O-CO_2 system and orogenic gold settings

4. Fluid inclusion assemblages (FIAs).

5. Classification of fluid inclusions and Roedder's rules.

6. Post entrapment modification of inclusions or knowing when to walk away.

7. Fluid inclusions salinity and solute chemistry:
    - H_2O-NaCl binary and freezing runs
    - Evaporite mounds and SEM/EDS analysis
    - LA ICP-MS analysis

8. Microthermometry with video clips.

9. Case studies of ore deposit settings.

TECHNICAL SESSIONS

***Undergraduate student speaker** ****Graduate student speaker**

FRIDAY EVENING
7:00 – 9:20 PM

Special Session: *Surficial Geology and Geochemistry I* - **BALLROOM B**
Chairs: Michael Parkhill and **Serge Allard**

7:00 – SERGE ALLARD and PAM DICKINSON – **New Brunswick surficial mapping program: review and highlights**

7:20 – MICHAEL A. PARKHILL, M. BETH MCCLENAGHAN, ALLEN A. SEAMAN, A.G. PRONK and JESSEY M. RICE – **Sisson Brook W-Mo-Cu deposit case study, central New Brunswick: indicator mineral and till geochemical signatures**

7:40 – CLIFF STANLEY, BINIAM BISRAT and JOHN MURIMBOH – **Partial digestion geochemistry of Nova Scotia soil samples: monitoring digestion conditions to understand how samples leach**

8:00 – ****N. CROWELL, T. WEBSTER, S. OLDFORD-MACLELLAN, S. BUTLER, W. LIVINGSTONE and G. ROSE – **Integrated water quality forecasting system for the Annapolis Basin, Nova Scotia

8:20 – ***SHUBHI SINGH and TOM AL – **Laser-ablation ICP-MS analysis of freshwater ferromanganese nodules

8:40 – ***MARK R. HIGGINS, MICHAEL D. YOUNG, RICHARD D. COX, DAN MACDONALD and ADRIAN FLEMMING – **Placer gold provenance in the Black Hills Creek watershed, west-central Yukon: exploration strategies from grain morphology and geochemical analysis

9:00 – JENNIFER SMITH – **The paleogeography of glacial lake Shanadithit in the Red Indian Lake Basin, Newfoundland**

General Session: *Current Research in the Atlantic Provinces and Beyond I* - **BALLROOM C**
Chairs: Sean McClenaghan and **Carlin Lentz**

7:00 – ***NATALIE PATERSON and YANA FEDORTCHOUK – **Determining the presence of aqueous fluids in Canadian kimberlites

7:20 – ***FERGUS M. TWEEDALE –Occurrence and origin of ring schlieren in the Halifax Pluton, South Mountain Batholith, Nova Scotia, Canada**

7:40 – J. BRENDAN MURPHY, STEPHANIE A. BLAIS, MICHAEL TUBRETT, DANIEL MACNEIL and MATTHEW MIDDLETON – **Tracking the crystallization of a magma chamber: rare earth element geochemistry of amphibole, Greendale Complex, Antigonish Highlands, Nova Scotia**

8:00 – REGINALD A. WILSON and SEAN H. MCCLENAGHAN – **Paragneisses, migmatites, and anatectites of the central Miramichi Highlands: a distinct Ganderian basement block?**

8:20 – J. GREGORY MCHONE and SANDRA M. BARR – **Monchiquite dykes on Machias Seal Island, New Brunswick, Canada**

8:40– CLIFF S.J. SHAW and ERIN L. WALTON – **Cooling history of shock melts in meteorites: constraints from finite element cooling models**

9:00: DANIEL J. KONTAK, RICHARD J. HORNE, APRIL BERTRAND and ROBERT CREASER – **Post 380 Ma granophile mineralization in southwestern Nova Scotia, Canada: evidence from the Clayton Hill and Gardners Meadow mineralized centres**

9:20 – POSTER SESSION – Mezzanine C – Social and Cash Bar

SATURDAY MORNING
9:00 AM– 12:00 Noon

Special Session: *Surficial Geology and Geochemistry II* - **BALLROOM B**
Chairs: Bruce Broster and **Tim Webster**

9:00: TIM WEBSTER, KEVIN MCGUIGAN, NATHAN CROWELL and MAY KONGWONGTHAIR – **Coastline change detection utilizing ground-based laser scanning**

Special Session: *Stratigraphy and Sedimentology I* - **BALLROOM C**
Chairs: Dave Keighley and **Nazrul Islam**

9:00 – ***DERRICK W. MIDWINTER and THOMAS HADLARI – **Ephemeral sedimentation in the Early Triassic Bjorne Formation of the Sverdrup Basin, Nunavut, Canada

TECHNICAL SESSIONS

***Undergraduate student speaker** ****Graduate student speaker**

SATURDAY MORNING
9:00 AM– 12:00 Noon *(continued)*

Special Session: *Surficial Geology and Geochemistry II (continued)* **– BALLROOM B**
Chairs: Bruce Broster and **Tim Webster**

9:20 – MELANIE L. IRVINE – **Monitoring coastal areas in Newfoundland and Labrador**

9:40 – G.W. KENNEDY – **Development of a GIS based approach for the assessment of seawater intrusion vulnerability in Nova Scotia**

10:00 – ****M.NASR and P.A. ARP – **Spatial pattern of mercury in stream and lake sediments in Nova Scotia, Canada

10:20 – COFFEE BREAK - Mezzanine

Special Session: *Economic Geology I* - **BALLROOM B**
Chairs: Jacob Hanley and **Chris McFarlane**

10:40 – JAMES CONLIFFE, DEREK H.C. WILTON, NIGEL J.F. BLAMEY and SANDY M. ARCHIBALD - **Paleoproterozoic Mississippi Valley Type Pb-Zn mineralization in the Ramah Group, northern Labrador**

11:00 – ***JESSICA A. GUSELLE, MICHAEL D. YOUNG and RICK J. HORNE – **Using a portable XRF spectrometer to determine geochemical and spatial correlations between alteration and gold mineralization in the Beaver Dam deposit, Nova Scotia

11:20 – ****RONALD J. MASSAWE and CLIFFORD R. STANLEY – **Lithogeochemistry of host rocks to the Bisha Cu-Zn-Au volcanic hosted massive sulphide deposit, Eritrea

11:40 – *ROBERT A. CAMPBELL, YANA FEDORTCHOUK, DAN MACDONALD and ISRAEL NONATO – **Platinum group element (PGE) mineralization associated with an Fe-Ti-V deposit, located in the Rio Jacaré Intrusion, Brazil**

Special Session: *Stratigraphy and Sedimentology I (continued)* **– BALLROOM C**
Chairs: Dave Keighley and **Nazrul Islam**

9:20 – ****NAZRUL ISLAM and DAVID KEIGHLEY – **The Mabou Group in the Penobsquis area, Sussex, New Brunswick: preliminary chemostratigraphy and correlation

9:40 – STEVEN J. HINDS – **Stratigraphic and structural relationships of the Norton to Apohaqui areas, southeastern New Brunswick, Canada: preliminary results from 2010-11 field mapping**

10:00 – JOHN W.F. WALDRON – **Withdrawal of Windsor evaporites and the stratigraphy of the Maritimes Basin**

10:20 – COFFEE BREAK - Mezzanine

General Session: *Current Research in the Atlantic Provinces and Beyond II* - **BALLROOM C**
Chairs: Grant Wach and **Darragh O'Connor**

10:40 – ****DARRAGH E. O'CONNOR and GRANT D. WACH – **Architectural elements of Mesozoic rift basin sediments: offshore Scotian margin

11:00 – JOHN CALDER – **A geoheritage strategy for Nova Scotia**

11:20 – D. BARRIE CLARKE, ALAN RUFFMAN, PETER H. REYNOLDS, GREGORY R. DUNNING, WILLIAM C. ALLAN, IAN G. MEIGHAN and DONALD R. BOWES – **Geological provenance of the Titanic gravestones in Halifax, Nova Scotia: a 100th anniversary forensic igneous petrology progress report**

11:40 – ALAN RUFFMAN and JOSE ALBERTO VIVAS VELOSO – **Archival documentation of the 1755 maremoto de Lisboa, on the shoreline of Brazil**

12 Noon – 2:00 PM - ANNUAL GENERAL MEETING AND LUNCHEON – BALLROOM A

TECHNICAL SESSIONS *continued*

SATURDAY AFTERNOON
2:00 – 5:00 PM

Special Session: *Paleontology in Atlantic Canada I* - **BALLROOM B**
Chairs: Melissa Grey and **Matt Stimson**

2:00 – ***MATT STIMSON, SPENCER G. LUCAS and GLORIA MELANSON – **The smallest known tetrapod footprints: *Batrachichnus salamandroides* from the Carboniferous of Joggins, Nova Scotia, Canada

2:20 – ****ZABRINA M. PRESCOTT, MATTHEW R. STIMSON, LYNN T. DAFOE, MARTIN R. GIBLING and R. ANDREW MACRAE – **A microbial mat and associated trace fossil assemblage at Coal Mine Point, Nova Scotia: paleoenvironmental significance and evidence of a previously unrecorded transgression

2:40 – MARTIN R. GIBLING and NEIL S. DAVIES – **The Paleozoic development of fluvial systems as terrestrial vegetation evolved, and implications for organic evolution**

3:00 - TIM J. FEDAK – **An overview of the McCoy Brook sauropodomorph dinosaur bone-bed and description of 3D photogrammetry methods for new research methods and documentation of paleontology quarries and site erosion**

3:20 – COFFEE BREAK – Mezzanine

Special Session: *Paleontology in Atlantic Canada II* - **BALLROOM B**
Chairs: Melissa Grey and **Matt Stimson**

3:40 – RANDALL F. MILLER, SUSAN TURNER and JOHN MAISEY – **Remarkable sharks from the Early Devonian Campbellton Formation, New Brunswick, Canada**

4:00 – LYNN T. DAFOE – **Reconstructing restricted to open marine settings using trace fossils in the Jurassic through Tertiary of Orphan Basin and the northern Grand Banks, offshore Newfoundland**

Special Session: *Structure and Tectonics I* - **BALLROOM C**
Chairs: Cliff Shaw and **Jamie Braid**

2:00 – FRASER KEPPIE – **Alleghenian deformation in Nova Scotia: revolution, disturbance or localized transpression?**

2:20 – ADRIAN F. PARK, ROBERT L. TREAT, SANDRA M. BARR, CHRIS E. WHITE, B.V. MILLER and P. H. REYNOLDS– **Structure and petrology of the Partridge Island block and the tectonic evolution of the Saint John area, New Brunswick**

2:40 - ***ELLA GOLDBERG and DJORDJE GRUJIC – **Analysis of the effect of principle stresses in the Bay of Fundy, Gulf of St. Lawrence, offshore Nova Scotia, and Grand Banks on faults in Nova Scotia and New Brunswick

3:00 – ***BETH COWAN, DJORDJE GRUJIC and ISABELLE COUTAND – **Climate proxies from the Siwalik Group in the eastern Himalaya: an oxygen and hydrogen isotope record from authigenic clays

3:20 – COFFEE BREAK– Mezzanine

Special Session: *Structure and Tectonics II* - **BALLROOM C**
Chairs: Cliff Shaw and **Jamie Braid**

3:40 - ***PETER J. REGAN – **Quantitative mapping in the Parry Sound domain for structural analysis

4:00 – ****DUSTIN R.L. DAHN, JAMES A. BRAID and J. BRENDAN MURPHY – **Tectonic significance of a mafic mélange in the Pangean suture zone, southwestern Iberia

4:20 – ****EVAN R. GLADNEY – **The Gil Marquez Pluton, southern Iberia: magmatism during continental collision and the amalgamation of Pangea

4:40 – JAMES A. BRAID, J. BRENDAN MURPHY, CECILIO QUESADA, LUKE BICKERTON and JAMES K. MORTENSEN – **Probing the composition of unexposed basement, South Portuguese Zone, southern Iberia: implications for the connections between the Appalachian and Variscan orogens**

6:00 PM – CASH BAR - Mezzanine
7:00 PM – AWARDS BANQUET & DINNER – BALLROOM A
9:30 PM – AGS CEILIDH & SOCIAL – PETITCODIAC ROOM

POSTER SESSION

Mezzanine C

***Undergraduate student poster** ****Graduate student poster**

SPECIAL SESSION – *Surficial Geology and Geochemistry*

* LOGAN T.C. BROWN, JOHN C. GOSSE and MARC W. CAFFEE – **Quantifying the 'deformable bed' using cosmogenic ^{10}Be concentrations in a paleotill**

T.J. HUPPERTZ and D.J.W. PIPER – **The impact of ice sheets on slope sedimentation: a long-term perspective**

C.L. LEGERE, B.E. BROSTER and J.E. HUGHES CLARKE – **Late Pleistocene regional unconformity in the Bay of Fundy, coastal southwest New Brunswick**

A. MARGRETH, J.C. GOSSE and A.S. DYKE – **Ice cap evolution and polythermal ice dynamics derived from multiple terrestrial cosmogenic nuclide (TCN) dating of tors on Cumberland Peninsula, Baffin Island

HILARY WHITE, IAN SPOONER, CHRIS WHITE, NELSON O'DRISCOLL, DEWEY DUNNINGTON and TIMOTHY JULL – **Paleolimnological records of post-glacial wetland evolution from the Chignecto Isthmus region, eastern Canada

SPECIAL SESSION – *Economic Geology*

*KACPER HALAMA and CLIFF STANLEY – **X-ray diffraction results from the weathering zone above the Bisha volcanic hosted massive sulphide deposit, Eritrea**

NEIL ROGERS, BOB ANDERSON, ALAIN PLOUFFE and M. BETH MCCLENAGHAN – **TGI-4 intrusion related mineralization project: identifying new vectors to hidden mineralization**

******W. ZHANG, D.R. LENTZ, K.G. THORNE and C.R.M. MCFARLANE – **Biotite analysis of felsic intrusive rocks near the Sisson Brook W-Mo-Cu deposit, west-central New Brunswick**

SPECIAL SESSION – *Paleontology in Atlantic Canada*

MELISSA GREY – **Current and recent research at the Joggins Fossil Cliffs UNESCO World Heritage Site**

GENERAL SESSION – *Current Research in the Atlantic Provinces and Beyond*

JANICE ALLEN and CHRISTOPHER BEAUMONT – **Impact of inconsistent density scaling on physical analogue models of margin scale salt tectonics

EDWARD KING – **Seascapes of the St Anns Bank and adjoining area, off Cape Breton, Nova Scotia**

*ALEXANDER J. HURLEY and PAUL S. HILL – **Assessing two methods for estimating bulk density of particles in suspension**

*****CARLIN LENTZ, CHRIS MCFARLANE and SEAN MCCLENAGHAN – **Early Devonian regional-contact metamorphism in the Juniper region, central New Brunswick**

*****AMY L. MACFADZEN, SANDRA M. BARR and CHRIS E. WHITE – **Petrology of the Indian Lake and Leadbetter Road plutons, Antigonish Highlands, Nova Scotia**

A. MACRAE, J. WESTON, P. ASCOLI, K. COOPER, R. FENSOME, D. SHAW and G. WILLIAMS – **A revised biostratigraphic and well-log sequence stratigraphic framework for the Scotian Margin, offshore eastern Canada**

*****MARIELLA NALEPA, IAN SPOONER and PETER WILLIAMS – **Investigation of the form and age of the Bloody Creek Crater, southwestern Nova Scotia**

******RAYA PUCHALSKI, SANDRA M. BARR and CHRIS E. WHITE – **Field relations and petrology of the Trafalgar plutonic suite, northeastern Meguma terrane, central Nova Scotia**

GENERAL SESSION *(continued)* – *Current Research in the Atlantic Provinces and Beyond*

******MORGAN E. SNYDER and JOHN W.F. WALDRON – **Fracture studies in the Horton Group, Windsor-Kennetcook subbasin, Nova Scotia**

CHRIS E. WHITE, SANDRA M. BARR, DONNELLY B. ARCHIBALD, KATHERIN E. VOY, TREVOR G. MACHATTIE, EDWIN A. ESCARRAGA and CHRIS R. M. MCFARLANE – **A new geological interpretation of the Antigonish Highlands, northern mainland Nova Scotia**

*****JASON WILLSON and SANDRA M. BARR – **Petrological comparison of Devonian megacrystic plutons: Cameron Brook pluton, Nova Scotia and Gaytons pluton, New Brunswick**

******L. ZSAMBOKI, S.M. BARR and S.A. DEHLER – **Geophysical modeling in the Cabot Strait – St. Georges Bay area between Cape Breton Island and western Newfoundland, Canada**

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ABSTRACTS

New Brunswick surficial mapping program: review and highlights

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Extensive surficial geology data have been collected by the New Brunswick Department of Natural Resources, Geological Surveys Branch (GSB) as a result of till geochemistry investigations, granular aggregate mapping projects, and other surficial mapping projects that span the past five decades. However, only modest advances have been made in synthesizing detailed maps that are comprehensive and easily accessible by clients. This is due partly to the fact that the existing data sets did not provide the level of detail needed to produce such maps. Older detailed maps are available for some areas, but in many cases they are outdated, difficult for clients to access, and unavailable in a digital georeferenced format.

Since 2009, new mapping endeavors in areas of poor coverage, combined with advanced technological capabilities in the fields of remote sensing and GIS, have enabled GSB staff to 'bridge the gap' and to produce detailed, up-to-date surficial geology maps for southwestern New Brunswick. These maps reflect a newly devised, consistent approach to field mapping and map production. The GSB has recently emphasized the compilation and publication of standardized digital maps for bedrock geology. Likewise, the current initiative to produce consistent surficial geology maps for southwestern New Brunswick represents the first step toward creating a standardized set of surficial geology maps for the entire province. Such maps will significantly improve the understanding of surficial geology in New Brunswick.

As part of the pilot project to publish standardized surficial maps for southwestern New Brunswick (NTS 21 G), the GSB staff has: (1) developed a new surficial geology map legend, deposit classification system, and map presentation style to be used in producing all new surficial geology maps in New Brunswick; (2) compiled and digitized all existing surficial geology data for southwestern New Brunswick (21 G); (3) conducted fieldwork in the Musquash, St. George, St. Stephen, Rollingdam, McDougall Lake, and Fredericton Junction map areas of 21 G; (4) conducted imagery interpretation of the St. George, McDougall Lake, Fredericton Junction, and McAdam map areas; and (5) published 1:50 000 scale surficial geology maps for the St. George, McDougall Lake, Fredericton Junction, and McAdam map areas.

Impact of inconsistent density scaling on physical analogue models of margin scale salt tectonics

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The influence of inaccuracies in density scaling on the structural evolution of physical analogue experiments of salt systems has been debated, and is investigated here, considering a gravity spreading example. Two-dimensional plane strain finite element numerical analysis was used to systematically evaluate the impact of changes in density scaling on buoyancy force, sediment strength, and pressure gradient. A range of densities typical of natural systems (including compacting sediment) and physical analogue experiments was included. A fundamental shift in the structure of the salt-sediment system, from diapir-minibasin pairs to expulsion rollover, was observed when sediment and salt densities were altered from values typical of physical experiments (1600 and 990 kg/m^3) to those most often found in nature (1900-2300 and 2150 kg/m^3). Physical analogue equivalent experiments with reduced sediment density showed diapir-minibasin pair geometry, persisting to sediment densities of ~1300 kg/m^3. Salt burial by pre-kinematic sediments was found to suppress diapir formation at depths greater than ~750 m (0.75 cm at the laboratory scale). The relative importance of disproportionately high buoyancy force and low sediment strength and pressure gradient in physical experiments was investigated by isolating each of these scaling errors in turn. Buoyancy was found to be most influential in the development of diapir-minibasin pairs versus expulsion rollover geometry. Finally, demonstrating that dry physical analogue experiments with sediment density reduced to ~1140 kg/m^3 (possibly through mixing with hollow glass beads) should provide a reasonable approximation of submarine salt systems in nature (including water load and hydrostatic pore fluid pressure).

Probing the composition of unexposed basement, South Portuguese Zone, southern Iberia: implications for the connections between the Appalachian and Variscan orogens

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Geochemistry and Sm-Nd and U-Pb (magmatic zircon) isotope data from a post- collisional granitoid batholith (Sierra Norte Batholith) that cross-cuts the allochthonous South Portuguese Zone (SPZ) of southern Iberia suggest that the basement is isotopically more juvenile than the exposed upper crust. The SPZ is an allochthonous terrane of the late Paleozoic Variscan orogen. The oldest exposed units in the SPZ are Late Devonian continental clastic rocks, and consequently the origins of the SPZ are unknown. Multifaceted inherited zircon cores from the Sierra Norte Batholith yield Neoproterozoic (ca. 561 Ma to 647 Ma) and Mesoproterozoic (ca. 1075 to ca. 1116) ages. Granitoid samples are characterized by εNd values ranging from +1.4 to -9.6 and model ages ca. 0.76-1.8 Ga. Conversely, the exposed Late Devonian clastic rocks of the SPZ are characterized by more negative εNd values (-7.5 to -10.4). Taken together, the U-Pb and Sm-Nd data indicate that the lower crust that melted to yield the Sierra Norte Batholith was (i) Neoproterozoic (ca. 560-650 Ma) to Mesoproterozoic (ca. 1.0-1.2 Ga) in age; and (ii) was not compositionally similar to the overlying Devono-Carboniferous continental detritus, but was instead more juvenile, having model ages between ca. 0.9-1.2 Ga. This unusual relationship is similar to the relationship between the relatively juvenile basement and ancient upper crust documented in the exposed portion of the Meguma terrane in the northern Appalachians, which paleogeographic reconstructions show was immediately outboard of southern Iberia in the Late Devonian.

Quantifying the 'deformable bed' using cosmogenic ^{10}Be concentrations in a paleotill

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The Hartlen Till is an extensive, variably thick (>20 m), highly compacted, grey silty diamicton that cores many of the drumlins exposed along the eastern shore of central Nova Scotia. Due to its apparent homogeneity, many of the observations made at specific locations are transferrable to other outcrops. Based on ice flow measurements, pebble provenance, and offshore stratigraphy, it has been previously determined that the till was deposited during the Caledonian glacial phase, but its exact age has yet to be established. Analysis of diamicton pebble fabrics (eigenvalues of 0.8718 and 0.8505 at two separate locations in the till) at Conrad's Head, support the previously interpreted classification that this is an undeformed lodgement till. As it commonly occurs at the base of the terrestrial stacks of tills, it may comprise material from the Meguma and associated terranes that had been previously exposed to cosmic rays for a prolonged period of time. The overlying tills appear more immature (clasts are more angular and more abundant) but have different sources. The till therefore provides an ideal means of demonstrating the plausibility of a deformable bed in a drumlin environment using cosmogenic isotopes.

Although the concept of deformable beds accounting for a significant portion of the movement beneath glaciers is generally accepted, the thickness and contribution of a deforming bed at a given time is less predictable, varying with the material properties of the bed, flow velocity, and subglacial hydrology conditions. The thickness of a deforming bed has only been observed under modern glaciers. Is it possible to use a combination of ^{10}Be with other sedimentological data to determine its thickness? The experiment uses a vertical sequence of eight samples of quartz sand from the Hartlen Till matrix. Based on previous measurements of ^{10}Be in till, it is assumed that the Hartlen quartz sand contains inherited ^{10}Be from exposure as regolith prior to its deposition. Although AMS results are unavailable at the time of abstract submission, it is thought that the vertical distribution of the ^{10}Be concentrations will have three basic end member distributions: (i) if the concentration is invariant with depth, then there was either no deformable bed, or the entire Hartlen Till was mixed by shear-induced deformation; (ii) if the concentration increases with depth in the till, indicating an inversion of stratigraphy where the most weathered (exposed) regolith was deposited first, then the pattern of concentrations provide constraints on the deformable bed thickness; and (iii) if the concentration decreases exponentially with depth, this would imply that the Hartlen Till was exposed for a quantifiable duration prior to the deposition of subsequent tills (i.e. an interglaciation). ^{10}Be measurements on the till matrix between clasts of a stone line on top of the Hartlen Till will also provide genetic insights into the origin of subglacial boulder lines.

A geoheritage strategy for Nova Scotia

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The Earth's geologic past has imbued Atlantic Canada with a rich heritage, dramatically exposed by the interaction of land and sea. Long recognized by some of the world's great scientific minds, including Lyell, Darwin, and Dawson, the geological heritage of Nova Scotia has been commemorated by local communities, in provincial and federal parks, by private sponsors, and by the ultimate recognition of UNESCO World Heritage. None of this, however, has been achieved from a systematic vision, and the desire for new commemoration requires a systematic approach, both to take inventory of geoheritage and to provide a clear vision of sites that should be recognized, and in some cases promoted or protected.

Geoheritage is defined most succinctly as geological features that inform humanity of its relationship with the Earth. Like UNESCO World Heritage, geoheritage can be divided into two categories: (i) *cultural/social geoheritage*, where value is tied to human interaction with the site (comprising spiritual sites, mine sites, and stoneworks); and (ii) *physical geoheritage*, where value lies in the aesthetic qualities of landscape, or in informing us of Earth history and Earth processes. *Geotourism* refers to the marketing of visitation to geoheritage sites and its economic benefits. Although there is great potential in geotourism, not all geoheritage sites are appropriate candidates, for reasons of integrity, visitor safety, or even scientific obscurity (type sections being one example).

Input from the geoscience community will help to establish the geoheritage list, using a rubric that considers: (i) level of significance; (ii) interpretive potential; and (iii) appropriateness as a geotourism site. In the absence of a systematic geoheritage vision, promotion of sites by individual advocates can lead to competition and allocation of resources to the 'squeaky wheel' rather than to the most meaningful or appropriate sites. In the worst case scenario, this could include sites that are inappropriate as geotourism venues because they pose risk to visitors, or are scientifically vulnerable. In contrast, a science-based inventory of geoheritage can lead to long-term dedication of resources and appropriate allocation of those resources, with reduced conflict and better decisions. The development of a systematic geoheritage list will assist government agencies in fulfilling their mandates, and in bringing scientists and communities together. Most importantly, this approach will foster promotion of the richness of geoheritage, with greater opportunities for building awareness at a time when there is a need more than ever to heed the lessons of Earth history to prepare for the future, on this Earth.

Platinum group element (PGE) mineralization associated with an Fe-Ti-V deposit, located in the Rio Jacaré Intrusion, Brazil

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The Rio Jacaré intrusion is located in north-eastern Brazil, inside the state of Bahia. Primarily explored for its abundant titaniferrous-vanadium rich magnetite occurrences, the intrusion also contains elevated levels of Pt and Pd inside magnetite ("Gulcari A" researched in this study) rich pods. The layered mafic intrusion is composed predominantly of gabbroic rocks, containing rhythmic cycles of magnetite-pyroxenite-gabbro-anorthosite. Fine-grained, magnetite rich rocks initiate the cycle followed by pyroxenites, generally capped by coarser gabbros or thin lenses of anorthosite. Unlike the common association of platinum group mineral (PGM) mineralization with chromite layers within layered mafic intrusions (LMI), the Rio Jacaré is a rare example of PGM mineralization within magnetite lenses. Processes regarding the enrichment of PGM mineralization remain unclear. A detailed mineralogical investigation of PGM mineralization within the main magnetite pod, Gulcari A, aiming to understand the nature of PGM crystallization is ongoing.

Fourteen samples with elevated Platinum Group Element (PGE) concentrations (1050-5026 ppm Pt, 25-1106 ppm Pd) were selected for this study. Reflected light microscopy and Energy Dispersive Spectroscopy (EDS) analyses were used for mineral identification. The chemical composition of PGM's are determined using electron microprobe (EMP) analyses. The ore consists of a magnetite-ilmenite aggregate, annealed and recrystallized during metamorphism. Sulphide phases fill the interstitial space and are followed by gangue minerals. The most common Pt-phases found in these slides are; Sperrylite ($PtAs_2$), nigglite (PtSn), PtNiFe, PtNi, PtSbSnNiCoS, and PtAsFeNi. The most common Pd-phases found are; PdPtSnCu, PdBiTe, PdBiSb, and PdSn. Pt-phases are found as inclusions within magnetite, ilmenite, and late forming gangue minerals. Often, PGM's form at the boundary between early magnetite-ilmenite grains and interstitial gangue minerals. Additionally, sperrylite grains have been found as partial inclusions within larger arsenide minerals. Pd-phases are found as inclusions within late gangue minerals, partial inclusions within arsenides, growths along grain boundaries between gangue minerals and primary magnetite-ilmenite grains, and as small subhedral grains within interstitial space. Overall, PGM mineralization forms small 2 μm, to larger 100 μm anhedral grains. The average grain size of PGM mineralization is between 2-10 μm.

Preliminary results suggest two different events for the formation of Pt-mineralization and Pd-mineralization. The study tested the proposed earlier mechanism of exsolution of PGM's from late sulphide phases and a possible remobilization of PGE's by late hydrothermal fluid.

Geological provenance of the Titanic gravestones in Halifax, Nova Scotia: a 100th anniversary forensic igneous petrology progress report

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The range of physical (e.g., colour, density, mineral assemblage, modal proportions, and texture), chemical (majors, traces, isotopic ratios of bulk rock and individual mineral phases), and temporal (radiometric age) properties of geological materials is large, but for single samples these combined properties can form a unique set that is the equivalent of DNA in biological material. Thus, ideally, any geological sample should precisely match its original outcrop; more practically, a geological sample should at least match the collective characteristics that define its formation, facies, or unit of origin.

In Halifax, Nova Scotia, 150 victims of the sinking of the Titanic in 1912 lie beneath petrologically identical headstones. That dimension stone, presumably supplied by the White Star Line, arrived in the port of Halifax about seven months after the Titanic sank, but no record in any newspaper, surviving shipping documents, or quarryman's journal indicates the source of this particular stone. In layman's terms, it is a "black granite"; in IUGS terms, it is a medium- to coarse-grained olivine gabbronorite with cumulus phases consisting of euhedral plagioclase (An_{50-70}), corroded olivine (Fo_{63}), minor orthopyroxene (En_{60}), and titano-magnetite (7.5 wt.% TiO_2) with Ti-hornblende and biotite reaction rims, and intercumulus material consisting of titanaugite ($Wo_{43}En_{42}Fs_{15}$) with reaction rims of titaniferrous hornblende, both of which appear to be uralitized. This noritic gabbro is distinctive for its orthopyroxene, reaction rims on titanaugite and titano-magnetite, alteration to uralite, high K_2O content (in the biotite and Ti-hornblende), and high water content (biotite, hornblende, and uralite). A $^{40}Ar/^{39}Ar$ determination on biotite yields a radiometric age of approximately 450 Ma. A new U-Pb determination on zircon should yield a more precise age.

There is no known source for this rock in eastern North America. Physically, chemically, and perhaps even temporally, the Halifax gravestones are consistent with the Younger Gabbros of northeastern Scotland; however, so far no extant quarry matches them, no known cemetery headstones match them, and no current stone cutter in Aberdeenshire recognizes them. Alternatively, the White Star Line, which built the Titanic in Belfast, may have obtained the dimension stone from an appinite quarry somewhere in Northern Ireland (Newry) or Eire (Mayo, Leinster, Donegal). Similar rocks also occur in Scotland (Appin, Loch Lomond), but with an age of ca. 430 Ma, are too young to be a suitable match, unless the new zircon date is younger than the argon date. The search for the source continues.

Paleoproterozoic Mississippi Valley Type Pb-Zn mineralization in the Ramah Group, northern Labrador

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Mississippi Valley-type (MVT) Pb–Zn sulphide mineralization is common in Paleozoic rocks but relatively few MVT deposits have been reported from Paleoproterozoic rocks. This study investigates the genesis of numerous Pb-Zn showings in the ca. 2.0 Ga Ramah Group, northern Labrador. Pb–Zn sulphide mineralization is hosted within breccia zones in the Reddick Bight Dolomite Member, Ramah Group. The mineralogy consists of coeval dark-brown sphalerite, galena, and pyrite with gangue quartz, dolomite, calcite, and feldspar (which pre- and post-date main stage mineralization). Solid pyrobitumen is common and is associated with early and main-stage mineralization.

Fluid inclusion analysis from coarse-grained sphalerite has identified H_2O – NaCl – $CaCl_2$ + CO_2 ± CH_4 within the mineralizing fluids along with high salinities (up to 19 eq. wt.% NaCl + $CaCl_2$) and homogenization temperatures of 104 to 169°C. The presence of significant volatiles in the mineralizing fluids has been confirmed through quantitative fluid inclusion gas analysis of sphalerite, which has recorded 4.46 wt.% CO_2, 0.95 wt.% N_2, and 0.14 wt.% CH_4. Fluid inclusion data from gangue quartz suggests high temperature (200 to 227°C), high salinity (up to 15 eq. wt.% NaCl + $CaCl_2$) fluids with significant volatile contents (quantitative fluid inclusion gas analysis: 17.89 wt.% CO_2). Carbon and oxygen isotope data indicate a progressive decrease in $\delta^{13}C$

from host dolomite (-1.3 ± 0.9‰) to pre-ore dolomite (-4.7 ± 1.5‰), and post-ore calcite (-5 ± 1.7‰). The $\delta^{18}O$ values remain relatively constant in all carbonate phases (-13.8 ± 2.3‰). Overall, the carbon and oxygen isotope data appear to define a mixing trend between the host dolomites and isotopically light $\delta^{13}C$ hydrocarbons (pyrobitumen), followed by re-equilibrium with the dolomite wall rocks. The $\delta^{34}S$ isotopic ratios range from 8.3 to 11.1‰ for early pyrite mineralization, 23.3 to 31.8‰ for late stage pyrite, 16.7 to 32.9‰ for galena, and 23.2 to 33.8‰ for sphalerite. The high fluid temperatures (130 to 200°C) and relatively high $\delta^{34}S$ values associated with Pb–Zn mineralization indicate that ore deposition was associated with thermochemical sulphate reduction, controlled by an influx of hydrocarbon-bearing fluids that reacted with aqueous sulphate species (dissolved sea water sulphate and/or dissolution of solid calcium sulphate).

The Pb–Zn mineralization in the Reddick Bight Dolomite Member shares many features with Paleozoic MVT mineralization, including geological setting, mineralogy, fluid characteristics, and crustal sources for both metals and sulphur. However, the elevated fluid temperatures (>150°C) and high CO_2 (>>1 mole %) content of the mineralizing fluids are unusual when compared with Paleozoic MVT deposits. Similar characteristics have been described from other Paleoproterozoic MVT deposits (e.g. Pering Zn–Pb deposit, South Africa; Kamaraga Pb–Zn deposit, Australia). This may reflect common characteristics of MVT mineralization during the Paleoproterozoic, possibly related to lower sulphate in Paleoproterozoic seawater.

Climate proxies from the Siwalik Group in the eastern Himalaya: an oxygen and hydrogen isotope record from authigenic clays

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There are growing lines of evidence for spatial and temporal correlations between rates of precipitation, surface erosion, and deformation along active orogens, however field evidence for couplings and feedbacks between erosional, climatic, and tectonic processes are still lacking. The coupled Himalayan orogen and Indian Summer Monsoon (ISM) is an ideal system to study these relationships. The Siwalik Group, at the toe of the Himalaya, was formed during the Miocene as the erosional products of the uplifting Himalaya that resulted from the collision of India and Eurasia ~55 Ma. The ISM was established by approximately 12 Ma, as a moist air package moving northward from the Bay of Bengal up to the orographic barrier, formed by the Himalayan foothills, where it rises and cools causing precipitation. The ISM is perturbed in the eastern Himalaya where the Shillong Plateau, an ~1600 m high orographic barrier, is located directly south of Bhutan, along the northward pathway of the monsoonal circulation, causing high amounts of precipitation along its southern slope and creating a rain shadow to the north.

The uplift of the Shillong Plateau occurred at the Miocene-Pliocene transition, 6-7 Ma after the ISM had been established and has potentially induced a drastic reduction in rainfall along the Bhutan Himalaya front. Meanwhile, low-temperature thermochronological data suggest that the cooling rates (i.e. erosion rates) slowed in Bhutan at the Miocene-Pliocene transition suggesting a temporal correlation between erosion and rainfall distribution.

Since the Siwalik sediments cover the period of interest for the uplift of the Shillong Plateau, these sediments may carry information on the changes in precipitation patterns and the concomitant changes in erosion in the hinterland. This study focused on extracting the climate proxies from the Siwalik sediments to assess the regional climatic changes potentially induced by the uplift of the Shillong Plateau.

A river section in southeastern Bhutan offers ~2200 m of continuous stratigraphic outcrop of the Siwalik Group. In this study, measurements of oxygen and hydrogen isotopes in authigenic clays were used to estimate the precipitation within the Himalayan foreland basin at the time of the Shillong Plateau's uplift. Processes of evaporation, condensation, and rain-out of water from air masses passing over mountain belts will systematically affect the isotope composition of the precipitation and therefore of hydrous minerals formed by weathering. Preliminary results indicate the clays to be authigenic since they are made up of kaolinite and smectite rather than detrital mica. The isotopic variations show cyclic events throughout the Siwalik Group, with sparse cyclic patterns in the upper Siwalik Group. These results are the first continental paleoclimatic record for the eastern Himalaya. Accurate dating of the sediments (magnetostratigraphy, detrital thermochronology) will allow comparison of isotopic data with the established marine record and provide a final interpretation.

Integrated water quality forecasting system for the Annapolis Basin, Nova Scotia

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Water quality is important to those living within coastal communities, the shellfish industry, and to regulatory agencies. This work focuses on developing an integrated forecasting system to predict areas of poor water quality within the Annapolis Basin, as a result of *E.coli* contamination, up to 72 hours in advance. Forecast information will provide the predicted spatial extent

of contamination and will be used to improve the efficiency of regulatory sampling, reduce unnecessary closures, and identify major sources of contamination.

Water quality forecasts will be determined by linking dynamic environmental variables (such as time, temperature, precipitation, and ultraviolet light) to a robust database composed of contamination sources, estuarine hydrodynamics, watershed hydrology, and *E.coli* loading scenarios. Loading concentrations and decay rates of *E.coli* are calculated for surrounding watersheds, and anthropogenic sources (municipal wastewater treatment and rural septic systems) using hydrological, hydrodynamic, and advection dispersion models which incorporate land cover attributes and flow dynamics. At each loading confluence, the estuarine hydrodynamics of the Annapolis Basin are modelled to simulate unsteady flow dynamics of water in response to dynamic tidal elevations. The estuarine hydrodynamic model provides the computational basis for an estuarine particle tracking module which simulates the transport and dispersion of suspended *E.coli* within the estuary. Sensitive zones, such as shellfish harvesting areas, are monitored during particle tracking runs. Extracted data are used to produce the final product of the model, concentration of *E.coli* contamination over time within sensitive zones.

To increase model efficiency, and allow for real time predictions, a database approach was adopted. A database of concentration extractions was developed by identifying unique tidal scenarios (n = 104) to undergo a battery of particle tracking runs (n = 319488) in order to simulate all possible contamination extents for each source point. Loading scenarios were developed to account for environmental and seasonal *E.coli* concentrations on the watershed level. Future system development will allow for rapid retrieval of contamination extents and concentrations based on current and predicted environmental conditions, seasonality, and time.

Reconstructing restricted to open marine settings using trace fossils in the Jurassic through Tertiary of Orphan Basin and the northern Grand Banks, offshore Newfoundland

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North of the well-explored Jeanne d'Arc Basin and the emerging Flemish Pass area is a frontier region that is slowly gaining recognition as a petroleum prospect, the Orphan Basin. With its highly attenuated continental crust, deep basin infill, and situation north of highly productive offshore wells, the depositional history of the Orphan Basin is of significant interest and is the focus of this study. Ichnological and sedimentological analysis of available core within Orphan Basin was integrated with materials from the northern Jeanne d'Arc, Outer Ridge, and Flemish Pass areas by extrapolating similarities between log signatures.

In the Late Jurassic, a significant shift in basin dynamics was observed from brackish, anoxic, restricted embayment deposition to open-marine conditions. The latter persisted through the latest Jurassic and Cretaceous and into the Tertiary. The restricted embayment deposits are dominated by laminated muddy bay, lagoonal, deltaic, and tidal flat sediments reflecting hundreds of metres of nearshore deposition in the ?Middle to Late Jurassic. Trace fossils are sparse and tend to be isolated along specific horizons, have low diversity, and are represented by highly stressed suites of the distal to proximal *Cruziana* ichnofacies. Although no core has been collected from the Late Jurassic in Orphan Basin, the ragged gamma ray signature associated with core materials in the Jeanne d'Arc area possibly correlates to ?Jurassic strata in the more recent Great Barasway well in central Orphan Basin. The restricted embayment environment resulted in dysoxic to anoxic conditions that limited colonization. The lack of oxygen allowed organic-rich material supplied by rivers to escape decomposition, contributing to a significant source rock potential.

In the Late Jurassic, relative sea level rose and flooding took place in conjunction with an opening of the area to normal marine conditions. In contrast to the restricted embayment, open marine deposits are characterized by homogenized sediment with diverse and abundant suites of trace fossils, reflecting offshore to shoreface strata. Trace fossil suites are often dominated by *Phycosiphon* and *Chondrites* of the archetypal *Cruziana* ichnofacies. Subsequently, Tertiary deposition is marked by significant deepening to bathyal conditions and deposition of shale with a distal *Cruziana* to? Zoophycos ichnofacies, in which trace fossils are visible within siltier or sideritized intervals.

Identification of trace fossils has been pivotal in understanding the variation and fluctuation between depositional environments in Orphan Basin and the northern Grand Banks. Future correlation in conjunction with seismic interpretation and refined biostratigraphy will provide a better understanding of the depositional history within this frontier basin.

Tectonic significance of a mafic mélange in the Pangean suture zone, southwestern Iberia

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Pangea formed in the Late Paleozoic by the closure of the Rheic Ocean, which resulted in the collision between Gondwana and Laurussia and is expressed by the Appalachian (North America) and Variscan (western Europe) orogenies. The

Pangean suture is exposed in southwestern Iberia, where the South Portuguese Zone, a fragment of Laurussia, is spatially juxtaposed against para-autochthonous Gondwana. The suture zone is characterized by fault-bounded units of oceanic meta-sedimentary rocks, mélanges, and mafic complexes. Despite the tectonostratigraphic sequence being well known, there exist a number of key units whose origin and evolution remains poorly understood, including the Peramora mélange, the deepest structural unit exposed in the core of a regional anticline.

Detailed geological mapping of the Peramora mélange (exposed in south-western Spain) reveals a complex pattern of imbricated tectonic and sedimentary mélanges. Petrographic examinations show muscovite, actinolite, and minor biotite (greenschist facies) aligned with the tectonic fabric, S-C fabrics, and crenulation cleavage, indicative of multi-phase deformation. These tectonic fabrics are likely related to the Late Paleozoic oblique collision between the South Portuguese Zone and the Gondwanan margin. Geochemical signatures of the sedimentary rocks display a range in TiO_2 and $Fe_2O_3 + MgO$, and are consistent with derivation from both continental and oceanic arcs. Detrital zircon analyses of key samples will constrain the age of deposition of the sedimentary-derived matrix of the mélange. ^{40}Ar-^{39}Ar dating of micas that define the tectonic foliation, and of amphibole in post-tectonic igneous dykes, will further constrain the timing of deformation events. These data will help to determine the age, origin, evolution, and provenance of the Peramora mélange within the Pangean suture zone and contribute to a better understanding of the processes involved in the formation of Pangea.

An overview of the McCoy Brook sauropodomorph dinosaur bone-bed and description of 3D photogrammetry methods for new research methods and documentation of paleontology quarries and site erosion

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The shoreline exposures of the Lower Jurassic McCoy Brook Formation at Wasson Bluff, near Parrsboro, Nova Scotia, Cumberland County, includes syndepositionally faulted lacustrine, fluvial, debris flow, and aeolian dune facies. In August 1976, Paul Olsen and colleagues discovered the first sauropodomorph 'prosauropod' (c.f. *Ammosaurus*) dinosaur bones at Wasson Bluff, in a location that has become referred to as the "Princeton Quarry". The Wasson Bluff section received legislative protection as a Nova Scotia Special Place in 1990, after Olsen and colleagues identified a rich cache of small vertebrate fossils within the sandstone infill of paleo-talus basalt clasts. Additional dinosaur specimens were discovered; including a specimen located near a basalt talus slope by Neil Shubin and colleagues from Harvard University in 1986, and a small articulated specimen discovered at the Princeton Quarry in 1992-94 by Grantham, Hrynewich, and Adams.

In 1997, Fedak began the study of these dinosaur specimens and through subsequent field work collected skeletal remains of five additional dinosaur specimens at the Princeton Quarry. The Wasson Bluff dinosaur specimens were described in detail, can be recognized as distinct from *Anchisaurus*/*Ammosaurus*, and represent a mass-death bone bed that is the richest preservation of 'prosauropod' dinosaurs in North America, with additional specimens remaining to be collected. Paleontological study of the specimens has been challenging due to the compression and syndepositional tectonic deformation that is exhibited by nearly all dinosaur specimens from Wasson Bluff.

Resolving the taxonomic details of the McCoy Brook sauropodomorphs remains of great interest, particularly because in the past several years many new 'prosauropod' taxa have been described from Utah, Arizona, Argentina, and South Africa. Also, recent paleogeographic and paleoecology studies demonstrate 'prosauropods' were not present in Late Triassic North America ecosystems and that the McCoy Brook specimens represent the oldest evidence of 'prosauropods' in North America. Following a review of the significant findings from previous work, a new research approach for studying the Wasson Bluff dinosaurs is proposed based on a recently completed pilot. State of the art 3D photogrammetry software (Photomodeler) can now be used to document and reconstruct the complex tectonic, sedimentological, and taphonomic details of the specimens in this important dinosaur bone bed. Results of preliminary trials using the photogrammetry techniques and 3D modelling software (Blender) are presented to demonstrate several unique benefits for paleontology based research. The photogrammetry techniques provide high-fidelity views and 3D data visualization for new research studies, and powerful tools for documenting sedimentary features and erosion rates at important paleontological sites such as Wasson Bluff. The methods and results will be of interest to other significant paleontology sites here in the Maritimes and (inter)nationally.

The Paleozoic development of fluvial systems as terrestrial vegetation evolved, and implications for organic evolution

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A range of river styles and avulsion strategies (channel breakout and relocation) arose over 150 million years from the Ordovician to the Pennsylvanian, when rivers diversified as terrestrial vegetation evolved. Cambrian and Ordovician rivers were wide, shallow sandbed systems, in which avulsion may have been largely nodal as rivers fanned out below upland exit points.

Meandering single-thread channels appeared in the latest Silurian, as indicated by heterolithic lateral-accretion deposits, increasing to >30% of preserved fluvial rock units by the late Devonian. This change accords with the incoming of rooted vegetation, which stabilized river banks and promoted systematic channel migration. Within such sinuous channels, local neck and chute cutoff would have become prominent.

From the Pennsylvanian onwards, strategies for dryland colonization, especially by early conifers, lead to increased vegetation cover, enhanced root systems, and abundant large woody debris. These changes probably account for the rise of narrow channels with stable banks, which constitute >10% of fluvial units by the end of the Pennsylvanian. Some examples were probably anabranching. Within Pennsylvanian braided-river deposits, evidence of deep channels with abundant wood and log jams suggest that island-braided or wandering systems had become common. In contrast to many modern rivers from which woody debris has been removed, log jams may have greatly influenced avulsion in these systems.

By the end of the Pennsylvanian, alluvial plains would have had far more active and abandoned channels per unit area, a greater length of riparian corridors, and a wide range of avulsive strategies. Forced by vegetation, these fluvial developments would have promoted in turn the evolution of plants in disturbed riparian zones and stable floodplains and the diversification of soil types and soil-forming organisms. Aqueous vertebrates and invertebrates may have flourished in channels rich in woody debris and scour pools. Complex feedbacks would have operated between rivers, plants, animals, and soils, but have yet to be systematically explored.

The Gil Marquez Pluton, southern Iberia: magmatism during continental collision and the amalgamation of Pangea.

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In most cases, plutonic rocks in continental collision belts are found in the magmatic arc and towards the backarc; however, in rare cases, syn-collisional plutonic rocks are formed and emplaced within suture zones, and their association with orogenic processes is enigmatic. Southern Iberia records the Late Paleozoic collision of Gondwana (Ossa Morena Zone) and Laurussia (South Portuguese Zone), which resulted in the Variscan Orogeny, and is an expression of the amalgamation of Pangea in western Europe. This suture zone is stitched by a suite of igneous rocks (Gil Marquez Pluton) consisting of coeval mafic and felsic magmas that display textural evidence of magma mixing. Details concerning the generation and emplacement of the Gil Marquez Pluton and its relationship to the suture zone are undetermined. Geochemical data, combined with structural and petrographic evidence, indicate a wide range in composition and two distinct sources for the pluton. A widespread granodioritic phase shows a syn-collisional, east-west foliation similar in orientation to the dominant cleavage in the metasedimentary rocks of the Pulo do Lobo Zone, part of the South Portuguese Zone, and likely represents the regional stress field at the time of emplacement. Gabbroic and granitic phases are unfoliated and represent the earliest and latest phases of the pluton, respectively. The various phases of the pluton are well exposed, and field evidence, including textural relationships, reveal that the emplacement of the Gil Marquez Pluton took place in several stages and from disparate sources. Isotopic and geochronological analyses of critical samples are in progress to compare the isotopic signature of the mantle source of the early gabbroic phase with the source for late-stage mafic dykes to determine whether the mantle was emplaced during collision. This study will contribute to the understanding of the sources, evolution, and emplacement of magmas in continental collisional zones.

Analysis of the effect of principle stresses in the Bay of Fundy, Gulf of St. Lawrence, offshore Nova Scotia, and Grand Banks on faults in Nova Scotia and New Brunswick

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Stress patterns were analyzed in parts of Atlantic Canada to determine tectonic regimes and whether reactivation of older faults could cause damage near Point Lepreau, New Brunswick. Point Lepreau is home to a nuclear power plant and seismic risk information in the Bay of Fundy is scarce and out of date. To put this information in perspective regionally, the study area extends from south of Grand Manan Island in the southwest to the Grand Banks of Newfoundland in the northeast.

This study investigated published focal mechanism data for earthquakes from ~1970 to 2011 in the study area. Four main regions of seismicity are the Bay of Fundy, Gulf of St. Lawrence, offshore Nova Scotia, and the Grand Banks. Earthquake and focal mechanism data were obtained from the Global Centroid Moment Tensor Catalogue (1976-present), the Canadian Earthquake Database, the U.S. Geological Survey/ National Earthquake Information Centre database (1973-present), and focal mechanism data from Geological Survey of Canada 1988 and 1989 files. Focal mechanism information is scarce for most regions and earthquake data is scarce for the Grand Banks and Bay of Fundy regions. In order to better characterize the principal stress pattern for the regions, the World Stress Map Data (2008) were included in the study.

Analysis of focal mechanisms showed the thrust-fault stress regime in the Gulf of St. Lawrence. In the Grand Banks region, stress orientations seem random and earthquakes could be the result of salt tectonics or submarine land slides. In offshore Nova Scotia, the stress orientations seem to coincide with the trend for North America and are compatible with the extension perpendicular to the passive Atlantic boundary. The Bay of Fundy region seems to partially mimic the stress orientations of the passive margin but some focal mechanisms show a strike-slip stress regime. Between the Bay of Fundy and the Gulf of St. Lawrence, World Stress Map data show thrust faulting with a strike-slip component closer to the Bay of Fundy and pure thrust faulting closer to the Gulf of St. Lawrence. The effect of these stresses on fault reactivation is currently unknown. Finally, in the St. Lawrence Channel, between Newfoundland and Nova Scotia, there was a chain of earthquakes of unknown source with depths of 18 km and magnitudes up to 4.2 M.

In summary, the preliminary data compilation indicates progressive change of relative magnitude and orientation of the principal stresses in the study area and that locally some of the mapped faults may be seismically active. The available GPS data indicate very slow plate rates and therefore slow stress accumulation rates. Low density of seismic data does not allow firm conclusions but target areas have been identified for future detailed studies.

Current and recent research at the Joggins Fossil Cliffs UNESCO World Heritage Site

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The Joggins Fossil Cliffs UNESCO World Heritage Site is a Carboniferous coastal section along the shores of the Cumberland Basin in the Bay of Fundy. With over 200 species known, biodiversity at the site is high with excellent preservation of biota from all aspects of the food web preserved in their environmental context. The Cliffs provide insight into the Late Carboniferous (Pennsylvanian) world, the most important interval in Earth's past for the formation of coal.

The Joggins Fossil Cliffs has a long history of scientific research and there are more than 100 site-specific publications. Recent research generally falls into one of three broad categories; paleontology, geology, and historical study. Highlighted here are very recent studies (recently published or in progress) that span these three categories, from trace fossil taxonomy to the earliest-known log-jams, to dendrochronology of the on-site mining structures. Much of this work has been undertaken by institutions in the Maritime Provinces, including universities and provincial and federal governmental departments. While research from the past 150 years has made large strides in the understanding of the Late Carboniferous, many questions remain to be resolved and interest in the site is clearly not waning.

Using a portable XRF spectrometer to determine geochemical and spatial correlations between alteration and gold mineralization at the Beaver Dam deposit, Nova Scotia

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The Beaver Dam deposit is a metaturbidite-hosted mesothermal gold deposit, consisting of bedding-parallel auriferous quartz veins containing variable amounts of carbonate, hosted by slate and subordinate metagreywacke. A portable X-ray fluorescence (XRF) spectrometer was used in the analysis of over 4300 samples to determine whether there are geochemical and spatial correlations between alteration and gold mineralization. The samples were collected from over 45 drill holes within and surrounding the mineralized zone, which has a strike length of about 140 m and a width of 50 m. A set of 10 samples was reanalyzed 10 times each to ensure the reproducibility of the data, and 30 samples were analyzed by ICP-MS to test the accuracy of the XRF spectrometer. When plotted against ICP-MS data, the XRF elemental plots created linear trends with a slope close or equal to one.

The coarser clastic metasedimentary rocks are dominated by silica and enriched in denser detrital minerals such as zircon. In contrast, finer grained rocks are relatively depleted in silica, and enriched in elements that reflect higher abundances of micas and clays (e.g. K, Rb, Ba) and redox-sensitive transition elements (Ti, Mn, V, Cr). Bivariate plots of V vs. Ti, V vs. Cr, and Ti vs. Cr show excellent correlation and little to no mobility; sandstones show relatively lower abundances of immobile elements, whereas slates have higher concentrations of these elements, and quartz veins have concentrations approaching the origin. Samples with elevated Mn and Ca (when plotted against Ti and V) likely reflect carbonate either associated with quartz veins, or occurring naturally in the host rock. Plots of K, Rb, Ba, and Sr vs. Ti and V show good correlation, indicating that there is little to no mobility of alkali and alkaline elements. A small proportion of samples show slight elevations in As and Zn when plotted against immobile elements, suggesting that they were introduced during alteration. However, As and Zn show no correlation with Au, and therefore may not have been introduced at the same time; gold may have been introduced at a later stage, or else remobilized during late stage quartz veining. A plot of Au vs. V indicates that fine-grained gold is concentrated in the slates. To determine the spatial distribution of the various elements, the data will be contoured on cross-sections and longitudinal sections.

X-ray diffraction results from the weathering zone above the Bisha volcanic hosted massive sulphide deposit, Eritrea

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Weathering of the Bisha volcanic hosted massive sulphide (VHMS) deposit has produced: (i) a gossanous oxide Au zone above; (ii) a supergene zone of chalcocite replacement of sulphide minerals; over (iii) hypogene sphalerite-chalcopyrite-bearing massive sulphide. These enrichment zones differ from those developed over other VHMS deposits (Ladysmith, Wisconsin; Caribou, New Brunswick; Las Cruces, Spain; and Golden Grove, Western Australia) in that supergene Pb mineralization (galena, siderite) occurs immediately above the Cu enrichment zone, and oxide Au grades are ten times that of hypogene mineralization (in contrast to the two-fold Au enrichment typically observed at other deposits). To understand how these anomalous zones developed, X-ray diffraction analyses were undertaken on samples from a cross-section through the Bisha deposit to gain insight into the mineralogical changes that took place during weathering.

Lithologies within the weathering zone consist of: (i) gossan (principally in situ and transported Fe-oxy-hydroxide minerals); (ii) acid leached rocks (mostly silica); (iii) saprolite (quartz and clay minerals); (iv) supergene sulphide mineralization (chalcocite replacing pyrite, sphalerite, and chalcopyrite); and (v) hypogene massive sulphide (pyrite, sphalerite, and chalcopyrite). Using lithogeochemical compositions of these rocks, ordinary least squares regression methods were used to obtain 'best fit' mineral modes for each weathering zone. These have been plotted on cross-sections to define the weathering patterns present in these rocks, and indicate that lateral groundwater flow is likely responsible for an asymmetric distribution of these zones. With these mineralogical constraints, chemical reactions have also been identified that explain the bulk material transfers that occurred to create each weathering zone.

Placer gold provenance in the Black Hills Creek watershed, west-central Yukon: exploration strategies from grain morphology and geochemical analysis

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Epithermal lode gold sources for rich placer gold deposits in West Central Yukon have been elusive since the 1898 Klondike gold rush. Poor bedrock exposure in an area that escaped Cenozoic glaciation has hindered the effectiveness of traditional exploration techniques. The recent discovery of potentially mineable resources in the White Gold District south of the Klondike has launched a new exploration rush. This study applies morphological and geochemical analysis of placer gold grains at six sites in the Black Hills Creek (BHC) watershed, a south-flowing tributary of the Stewart River, to help identify local gold sources. The flatness index = [(a + b)/2c] of gold particles was determined using a binocular microscope and PAXIT imaging software, measuring the long (a), intermediate (b), and short (c) axes. Bulk-gold fineness is defined by the ratio of [Au/(Ag + Au)*1000] and provides information about source-rock composition and weathering. Fineness values were measured using microprobe analysis. Flatness and fineness are both expected to increase with downstream transport, e.g. high measured flatness values (>5.0) would suggest reworking of grain shape during transport. Contributing areas for each placer site were determined by ArcGIS watershed analysis.

Sites 1-4 are located on northern tributaries that drain areas of 17.3 km^2, 16.4 km^2, 18.4 km^2, and 48.4 km^2 respectively. Over 350 grains have flatness indices from 3.4-7.4, and averages of 5.0, 4.8, 5.4, and 4.3. Mean gold fineness is 706, 713, 774, and 770. Site 5, located in the southern BHC, has a contributing area of 292 km^2, consists of 92 grains with a flatness range of 6.3-9.8 (average of 8.4), and a fineness of 806. A total of 120 grains from Site 6, the southernmost BHC placer operation, represents a catchment of 378.2 km^2 (including watersheds 1-5) with flatness indices ranging from 7.4-12.5 and an average of 8.9, with geochemical analyses pending.

Grains from the four northern placers (Sites 1-4) have similar low flatness indices, suggesting short to moderate transport distances (0-5 km). Additionally, grains from these four sites have low fineness values and narrow silver leached rims, suggesting a low degree of weathering and supporting short to moderate transport distances. Local bedrock sources are implied, within 5 km upstream from the placer operations. In contrast, grains from the southern two placer deposits show a broad range of flatness indices indicating variable transport distances (0-20 km). This variable transport range suggests multiple bedrock sources. High Hg content from microprobe analysis and indications from previous research also suggest that multiple gold occurrences contributed to the BHC placer deposits. Inferred transportation distances, when considered with detailed mapping and analysis of structural controls on mineralization, may be useful in identifying lode gold occurrences.

Stratigraphic and structural relationships of the Norton to Apohaqui areas, southeastern New Brunswick, Canada: preliminary results from 2010-11 field mapping

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Across southern New Brunswick, the subsurface distribution of the Lower Carboniferous Albert Formation has been complicated by multiple episodes of tectonism throughout the Upper Devonian to Upper Carboniferous, approximately 453 to 320 million years ago. The Norton to Apohaqui area has undergone several stages of tectonic overprinting that have exposed the petroleum bearing Albert Formation of the Horton Group. Recent fieldwork and seismic interpretation in the area has revised the structural and stratigraphic relationships. Along with a surface oil seep in the Norton area, paleontological and stratigraphic evidence suggests that the sedimentary units in the study area are younger than the Albert Formation and the hydrocarbon bearing members could occur at depths between 1-2 km. New cross-sections rationalize the stages of Carboniferous deformation along major transpressional structures and reveal potential hydrocarbon traps. These traps are equivalent in area to the McCully and Stoney Creek fields.

The impact of ice sheets on slope sedimentation: a long-term perspective

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In recent years, detailed research on glaciated slope systems has suggested a close relationship between shelf-break ice-sheet dynamics and slope instabilities. Such a link has also been established on the Scotian Slope, where the geological record is used to understand the spatial and temporal variability of slope sedimentation processes during the Quaternary. This record was obtained using high resolution Huntec and lower resolution airgun seismic data: few sediment cores provide ground truth for the shallowest succession and defined areas of plume sedimentation during the last glacial advance.

The general morphology of the Scotian Slope did not change significantly within the glacially influenced Mid to Late Pleistocene, as most canyon systems were initiated during the Early Pleistocene, in many cases inherited from pre-Quaternary morphology: exceptions are found on the Western Scotian Slope and in the Logan Canyon Debris Flow Corridor.

The first shelf-crossing ice sheets, previously dated at ~450 ka, resulted in a significant change in slope depositional centres and erosion rates. The stratigraphic section older than 450 ka is characterized by few mass wasting events and slope deposition occurred preferentially on the lower slope and rise. This is in contrast to the younger succession, characterized by more uniform slope deposition and more frequent mass wasting events. Depositional centers since 450 ka moved seawards to the Sohm Abyssal Plain, where the top of a thick glacial section has been cored.

The most complete Quaternary section is found in the offshore Western and Sable island banks, where little erosion occurred on the upper and mid-slope. Below ~2500 m, large scale erosion has removed most of the Late Quaternary section, with the bounding scarp generally muted by younger deposits. The western and eastern parts of the slope are dominated by mass wasting; intercanyon ridges and other local highs show a more complete stratigraphic record. Removal of parts of the glacially-influenced section (<450 ka) result in regional unconformities. Interglacial accumulation rates are generally an order of magnitude lower compared to glacial rates and are greatest on intercanyon ridges offshore Sable Island Bank.

At times when ice sheets frequently terminated at the shelf break, there was an increase in slope instabilities and linked erosion compared to the early Quaternary, highlighting the importance of shelf ice sheets on slope dynamics. More slope failures are found seawards of ice streams, whereas stagnant ice on shelf banks resulted in till tongue formation on the upper slope and only minor erosion, mostly linked to meltwater discharge.

Using published data from other glaciated systems (mainly the Norwegian Slope), dominant drivers for glaciated slope sedimentation are identified. These include the distance from meltwater plume outlets, occurrence of canyons providing pore pressure drainage, slope angle, and the availability of drainage pathways for meltwater.

Assessing two methods for estimating bulk density of particles in suspension

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Particle density is fundamental for determining clearance rate of a suspension because it affects settling velocity. In most aquatic environments, however, suspended sediment is composed of loosely packed particle aggregates that cannot be sampled

without disrupting the particle packing and, as a result, the particle bulk density. The goal of this study is to compare two methods that estimate particle bulk density without directly sampling suspended particles. A new, fast, but untested method uses a Sequoia Scientific LISST 100x particle sizer, which records beam attenuation (Cp, m^{-1}). The measured beam attenuation obtained from the LISST is proportional to mass in suspension. Volume in suspension can also be obtained from the LISST. Dividing mass in suspension by volume in suspension yields particle bulk density (ρ). A second, more accurate, but more labour-intensive method involves the use of a digital video camera (DVC), which measures particle size and settling velocity. With knowledge of the density and viscosity of the fluid, Stokes Law can be re-arranged to solve for particle density. These instruments were mounted to a Modified in Situ Size Settling Column Tripod (MINSSECT) and deployed in 12 m of water at the Martha's Vineyard Coastal Observatory. The strength of correlation between individual and bin-averaged densities from the LISST and DVC methods will be used to evaluate whether the LISST method offers an accurate alternative to the DVC method for non-invasive, in situ estimation of particle bulk density.

Monitoring coastal areas in Newfoundland and Labrador

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Most communities in Newfoundland and Labrador are built adjacent to or along the coast, with the majority of the population living and working in coastal areas. Storm surge and wave run-up, rising sea levels, slope movement, and human activities are coastal hazards. There have been at least thirty recorded deaths since 1863 in the province, and costly economic damage to individuals and communities as a result of coastal flooding and landslides. Sea level is projected to rise during the next century, which will increase the vulnerability of areas to coastal flooding and erosion. Climate change projections show an increase in the magnitude of mid-latitude storms, heavy precipitation events, and freeze-thaw cycles, which would further increase the risk of flooding or erosion. There is a need to assess rates of coastal recession and the vulnerability of coastal areas towards flooding, so that this information would be available for developing long-term planning and policy decisions.

The Geological Survey of Newfoundland and Labrador initiated a coastal monitoring program in 2011. This project aims to increase the understanding of shoreline migration rates, beach dynamics, delineate areas of high vulnerability to coastal flooding and/or erosion, and to assess the connectivity between coastal stability and anthropogenic, climatic, oceanographic, and geographical factors. During the first field season, forty-five monitoring sites were established on the island of Newfoundland and surveyed using Real Time Kinematics (RTK). Future work will involve yearly monitoring at additional sites, established on the island of Newfoundland, and the expansion of the program into Labrador. Discussions will occur with municipalities, community groups, and other interested stakeholders to identify new areas of concern or of cultural, social or environmental importance, and these sites may be included in the program. A database will be created for the project, which will be maintained by the Geological Survey Branch and available through the on-line Resources Atlas.

The Mabou Group in the Penobsquis area, Sussex, New Brunswick: preliminary chemostratigraphy and correlation

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Lithostratigraphic subdivision of the Mabou Group has previously met with little success due to limited outcrop, the absence of significant marker beds, and poor biostratigraphic control. This study focuses on drill cores in the Penobsquis area, where sedimentary rocks of the Mabou Group comprise a variety of sandstone facies, gravel facies, and fine-grained facies. Most are brown, greyish-brown or reddish-brown coloured, poor to moderately sorted, moderately compacted, ferruginous or calcareous, and mainly horizontally laminated or cross-stratified. Broadly, sandstone, siltstone, and mudstone at the base of the section gradually coarsen upward into conglomerate; this upward coarsening is considered to be the result of active alluvial fan progradation. However, localized horizontally laminated to cross-stratified bluish grey sandstone, containing carbonaceous plant fragments and siltstone rip-up clasts, was also encountered in several cores.

A total of 89 samples from two cores (PCS-02-05 and PCS-02-01) have so far been analyzed using ICP, ICP-MS, and XRD. Chemostratigraphic analysis of elemental ratios (e.g., Ti/Na, Mg/Al, Fe/K, Cr/Na, Nb/Ti, Ta/U, Cr/Sm, and Rb/Cs) has revealed two packages bounded by an interval that correlates with the bluish grey sandstone. The preliminary interpretation is that the upper package accumulated on an unconformity (disconformity), U1, identified by the rip-up clasts. Changes in detrital mineralogy and diagenetic phases suggest variation in the provenance and substrate environment of the alluvial-fan sediment on either side of U1. Ongoing studies of adjacent drill cores will attempt to confirm these trends and the validity of an unconformity-based subdivision of the post-Windsor red-beds, first postulated by Gussow nearly 60 years ago.

Development of a GIS based approach for the assessment of seawater intrusion vulnerability in Nova Scotia

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Approximately 50% of Nova Scotians rely on groundwater for their water supply, and about 60% of Nova Scotians reside within 20 km of the coastline. In areas of the province lacking water servicing, individual, on-site wells represent the only practical means of obtaining a water supply, however, there exist limited mechanisms available to groundwater managers for evaluating the sustainability of groundwater supplies in these areas. Seawater intrusion into coastal aquifers driven by overpumping, or rising sea levels and changes in groundwater recharge resulting from climate change, is therefore a key issue for water resource management in the province.

A GIS based approach for broadly evaluating the vulnerability of bedrock coastal aquifers to seawater intrusion in unserviced areas of the province was developed. The approach uses available provincial spatial datasets to evaluate relative vulnerability based on the following criteria: distance to the coast, land slope, development density, reported static water level, and any well water salinity problems reported by the driller during well construction.

A provincial relative vulnerability map was produced using this GIS approach, and more detailed mapping was prepared for five project locations (Lunenburg area, Avon River area, River Philip area, Yarmouth area, and Halifax area) identified under the on-going Atlantic Climate Adaptation Solutions (ACAS) project. The scoping approach/mapping could be used by groundwater managers to help identify emerging seawater intrusion problem areas, to identify suitable coastal aquifer monitoring well locations and areas for more detailed quantitative analyses, and to help inform land use planning.

Alleghenian deformation in Nova Scotia: revolution, disturbance or localized transpression?

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Alleghenian deformation represents a protracted shortening event of Carboniferous to Permian age in the Appalachian ranges of eastern North America. In many cases, Alleghenian deformation can be interpreted as an "Appalachian revolution" (after H.P. Woodward), possibly produced by the final suturing of Laurasia to Gondwanaland in the assembly of the Pangean supercontinent. In Atlantic Canada, it is less clear how regionally extensive and severe Alleghenian deformation may have been, and it has been considered a more or less enigmatic "Maritimes disturbance" (after W.H. Poole). In Nova Scotia, in particular, evidence has accumulated that appears to link Alleghenian deformation to dextral transpression expressed along the Avalon-Meguma terrane boundary. In this context, Alleghenian motions on the Minas Fault System may have caused uplift and tilting of the Cobequid Highlands to the immediate north, as well as folding and thrusting of the Kennetcook Thrust System to the immediate south. Here, it is hypothesized that the character of Alleghenian shortening revealed in new mapping of the Kennetcook Basin, Meguma terrane, Nova Scotia, is best understood if the Alleghenian Orogeny was a regional event of some severity. The status of Alleghenian deformation in Nova Scotia may need to be upgraded from localized disturbance to regional revolution.

Seascapes of the St Anns Bank and adjoining area, off Cape Breton, Nova Scotia

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Multibeam bathymetric data were recently collected, compiled, and processed by Fisheries and Oceans Canada (Canadian Hydrographic Service) in a proposed Marine Protected Area near St Anns Bank. They are supplemented with video transects, photographs, existing seismic reflection profiles, and seabed samples to map geologic features and seabed texture to provide a basis for future biological habitat classification. The mapped area ranges in water depth from 25 to 275 m, the deeper parts flanking the glacially formed Laurentian Channel and northern flank of St Anns Basin at the southern map boundary.

A wide range of bedrock and overburden types, features, and seabed textures are present. Rugged-relief outcrops (primarily Precambrian) in topographically elevated questas contrast with expansive bedrock plateaus exhibiting broadly folded Carboniferous strata. Thick stacked sequences of tills flanking the Laurentian Channel transition to thin and patchy ground moraine in the shallow areas, generally with a gravelly iceberg scoured seabed. The till surface is locally fluted, drumlinized or exhibits delicate patterns in small and mid-size moraines only metres high. Generally these are thin deposits with intervening bedrock or thin gravels on bedrock. Large, more continuous moraines/drumlins mark glacial margin still-stands, commonly where bedrock scarps, basin flanks or questas govern their trace. The variety, spatial distribution, and pattern of these forms suggest superposition of more than one glacial event but the sequence is not immediately clear. Some elements may indicate a landward direction,

lending some credence to the late offshore ice cap concept. The finer, smaller elements suggest a thin, locally lobate ice margin on retreat.

Local, glacially-carved basins in the bedrock preserve a thin basal till and overlying sequence of glaciomarine and postglacial muds, in addition to the continuous mud cover of the Laurentian Channel. These muds generally display basin center to margin textural facies transitions reflecting wave and current energy magnitude. With decreasing water depth, basinal muds give way to sandy muds, muddy sands, muddy sands with patch gravel, then sands and gravels, and finally bedrock that is washed of most overburden. Above 60 to 70 m water depth most overburden and glacial features are largely modified or removed, indicating a post-glacial sea-level low-stand at this depth. Rare littoral and sub-littoral elements, including beach and washover sands and gravels, are also present. In low current and basinal areas, post-glacial mud with relatively smooth surfaces drapes glacial deposits and features. Non-deposition around iceberg pits and base of escarpments, current-parallel elongation of pockmarks, sandwave formation, and various forms of current-parallel furrowing blur the distinction between modern, Holocene and low-stand relict (palimpsest) facies.

Post 380 Ma granophile mineralization in southwestern Nova Scotia, Canada: evidence from the Clayton Hill and Gardners Meadow mineralized centres

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The southwestern Meguma terrane contains several Sn-Cu-Zn-Ag mineralized centres collectively referred to as the southwestern Nova Scotia Sn domain. It has previously been assumed that mineralization occurred during a single metallogenic event at 380 Ma and is synchronous with widespread felsic plutonism in the Meguma terrane. However, the presence of a younger magmatic event of 360 Ma is represented by the Seal Island and Wedgeport granites. The latter intrusion occurs immediately south of the Dominique Sn-Cu deposit and suggests that this mineralization is similar in age to the granite. This study adds two new mineralized centres to this younger magmatic event, thereby expanding its areal extent and significance.

The Clayton Hill pluton (<1 km^2) is a medium-grained leucomonzogranite (<2% biotite, muscovite) containing miarolitic cavities and transecting aplite-pegmatite dykes. The pluton intrudes the Meguma Supergroup and has a well defined contact aureole. Chemically, the granite is silica-rich (73-76 wt.% SiO_2), depleted in CaO, MgO, and FeO, has K_2O/Na_2O near unity, A/CNK = 1-1.05, Rb = 180-226 ppm, Ba = 133-360 ppm, Sr = 65 ppm, and REE abundances and patterns typical of meta- to peraluminous granites. The intrusion is characterized by the presence of sulphide-bearing miaroles (py-cpy-sph) and molybdenite-bearing quartz-muscovite-sulphide greisens enriched in Cu, As, Zn, Bi, and Au. In addition, near the intrusion are skarn horizons with anomalous Sn-W-Cu-Ag-Zn. The age of the intrusion and mineralization are constrained at 361 Ma by concordant $^{40}Ar/^{39}Ar$ and Re-Os ages for muscovite and molybdenite, respectively, whereas a magmatic reservoir is inferred for the mineralization based on both oxygen ($\delta^{18}O_{H2O}$ = 7‰) and sulphur ($\delta^{34}S_{H2S}$ = 5‰) isotopic data.

Mineralization (Sn-Cu-Zn-Mo) at Gardners Meadow occurs as quartz-carbonate ± fluorite veins and garnet-rich horizons within quartz-rich metasiltstones of the Meguma Supergroup. Absence of hornfels and dyke rocks preclude direct evidence for a causative intrusion. Stable isotopic data on vein assemblages indicate that (at 400°C) $\delta^{18}O_{H2O}$ = 3.6 to 10.5‰ and $\delta^{34}S_{H2S}$ = 5-6‰, whereas fluid inclusion data for aqueous fluid inclusion assemblages indicate homogenization temperatures of 125-220°C and salinities of 5-20 wt.% equivalent NaCl. The data are interpreted to reflect ascent and mixing of magmatic-derived fluids with a second fluid of possibly meteoric origin. Mineralization is constrained to ca. 350 Ma based on Re-Os dating of vein molybdenite.

This study is important in providing additional evidence for a post-380 Ma granophile metallogenic event of significant extent in the southwestern Meguma terrane. Furthermore, both the ages and elemental associations suggest correlation with the Mt. Pleasant mineralized (Sn-W-In-Zn) centre of southern New Brunswick, and suggest that this is a contiguous metallogenic domain.

Late Pleistocene regional unconformity in the Bay of Fundy, coastal southwest New Brunswick

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The physiographic environment of the northwestern Bay of Fundy nearshore has been shaped by a complex history of glaciation, sea level fluctuations, and modern processes. Interactions between a disintegrating ice sheet and changing sea level produced sequences of late glacial and glaciomarine geomorphic landforms, providing evidence of former ice margin positions and sea level changes. Pleistocene sea level lowering during late glacial periods exposed the continental shelf to subaerial erosion to

depths of as much as 89 m. The most recent of these regressions ended at approximately 11 000 yrs BP and was followed by a rapid transgression.

A total of 269 sub-bottom lines representing over 3100 km of seismic track lines from the research vessels CSL Heron and CCGS Frederick Creed, over the 2007 to 2009 survey seasons were examined for the Bay of Fundy area between the St. Croix and St. John rivers. Natural gas obscures sub-bottom profiles for some areas due to acoustic masking. However, where a clear record exists, the stratigraphy mainly represents from oldest to youngest, bedrock, till, stratified glaciomarine, unstratified glaciomarine sediment, sand and gravel, and modern Holocene deposits. The glacial-Holocene sequence is divided by an unconformity at depths ranging from 40 to 89 m below the seafloor, separating a lower sequence of bedrock and glacial/deglacial sediments from modern Holocene marine mud. This erosional surface was associated with the Late Pleistocene to Early Holocene regression/transgression, which was also affected by local isostatic rebound following deglaciation.

Early Devonian regional-contact metamorphism in the Juniper region, central New Brunswick, Canada

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Interbedded metapelites, metasiltstones, and metasandstones of the Cambro-Ordovician Miramichi Group in the Juniper region of central New Brunswick exhibit features and textures characteristic of syntectonic contact metamorphism. The margin of a leucocratic two-mica granite phase of the Nashwaak Granite and neighbouring metasedimentary rocks of the Miramichi Group were mapped and sampled southwest of McKiel Lake with the aim of constraining contact metamorphic P-T conditions and the relationship between polyphase deformation and magmatism.

Metapelitic rocks near (<50 m) the intrusive contact display poikiloblasts of andalusite and pinnitized cordierite ranging from approximately 0.5 cm to 3 cm, with the proportions of andalusite and cordierite changing as a function of distance from the granite contact. Fresh andalusite poikiloblasts preserve internal fabrics that indicate pre- to syn-tectonic contact metamorphism. The peak metamorphic assemblage in metapelitic rocks nearest the intrusive contact is cordierite-andalusite-biotite-muscovite-quartz. Isochemical P-T diagrams constructed using Theriak-Domino and based on whole-rock data for the metapelitic rocks, constrain contact metamorphic conditions to <150 MPa at temperatures between 500-580°C.

The metasedimentary rocks exhibit F_1 and F_2 folds and other regional deformational fabrics, including shear bands and spaced fracture sets. The internal fabric within poikiloblasts locally preserves symmetrical fold hinges (F_1?) whereas the external fabric contains F_2 folds of S_1. This suggests that contact metamorphism occurred during a progressive change in deformation kinematics. As a result, the exposures near McKiel Lake may be ideal for building a better understanding of the relative timing and P-T conditions of metamorphism and associated deformation during Siluro-Devonian collision. Direct in situ dating of these microstructures was carried out using Laser-Ablation ICP-MS on very fine-grained monazite (<20 μm diameter) in metapelitic rocks. Slender monazite grains parallel to the penetrative foliation both within and outside poikiloblasts were dated at 391 ± 4 Ma, consistent with Late Acadian magmatism (Middle Devonian). Other dates obtained for monazite grains include concordant populations at 450 and 410 Ma. These coincide with the initiation of the Late Ordovician Salinic Orogeny (D_1-M_1) and overprinting effects (D_2-M_2) of Early Devonian Acadian deformation and magmatism. This preliminary dataset reveals a complex interplay between magmatism, low-pressure metamorphism, and penetrative deformation during Salinic and Acadian orogenesis.

Petrology of the Indian Lake and Leadbetter Road plutons, Antigonish Highlands, Nova Scotia

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The Indian Lake and Leadbetter Road plutons are located in the Antigonish Highlands of northern mainland Nova Scotia. They are separated by the West Barneys River plutonic suite, a large composite pluton of Ordovician age (ca. 470 Ma). The purpose of this study is to describe the petrography and geochemistry of the Indian Lake and Leadbetter Road plutons, and based on those data, to investigate whether or not they are likely to have been comagmatic with each other or with other dated suites in the Antigonish Highlands.

The Indian Lake pluton is not reliably dated but is interpreted to have formed at about 615-605 Ma like some other plutons in the Avalonian Antigonish Highlands. It consists of a calc-alkaline suite of medium-grained quartz diorite and diorite and medium-grained granodiorite gradational to monzogranite. Both the granodiorite/monzogranite and quartz diorite/diorite contain abundant dioritic inclusions. Preliminary chemical data from 15 samples from the Indian Lake pluton show that SiO_2 content

ranges from about 49% to 74% and reveal trends consistent with crystal fractionation of plagioclase and mafic minerals. The petrographic and chemical characteristics are similar to those of I-type granitoid suites formed in subduction zone settings at active continental margins.

In contrast, the Leadbetter Road pluton consists almost entirely of coarse-grained alkali-feldspar granite with quartz phenocrysts. It is petrographically similar to syenogranitic parts of some ca. 615-605 Ma plutons elsewhere in the Antigonish Highlands, but also to some components of the West Barneys River plutonic suite. Chemical data from 6 samples shows compositions characteristic of within-plate A-type granite. SiO_2 ranges from 75% to 78% and high Zr, Y, Nb, and Ga/Al ratios are distinctive. Also distinctive is the elevated rare-earth element content, with light REE up to 900 times chondritic values and heavy REE up to 60 times chondritic values. These petrological characteristics suggest that the Leadbetter Road pluton is more likely related to the Ordovician West Barneys River plutonic suite than to Indian Lake and other Late Neoproterozoic plutons in the Antigonish Highlands.

A revised biostratigraphic and well-log sequence stratigraphic framework for the Scotian Margin, offshore eastern Canada

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As part of a Play Fairway Analysis (PFA) of the Scotian Margin, offshore eastern Canada, quantitative multi-disciplinary biostratigraphic studies of Upper Triassic-Cenozoic sections in 8 wells (Bonnet P-23, Chebucto K-90, Cohasset L-97, Glenelg J-48, Glooscap C-63, Mohican H-100, South Debarres O-76, and South Griffin J-13), was conducted. These wells were chosen to provide good spatial coverage and stratigraphic penetration, plus correlation with seismic. Using the results from these new wells as calibration, an evaluation of pre-existing biostratigraphic data was done to interpret the well-log sequence-stratigraphy of 16 additional wells using a consistent multi-disciplinary event scheme. The scheme comprises 10 regional events from Mid Jurassic to Oligocene and several additional local ones. This study provides accurate well to seismic ties and clarifies the origin of seismic horizons mapped across the area within the PFA project. Key to the dating of some horizons has been integration of the palynology and micropaleontology (most commonly used for biostratigraphy on the Scotian Margin) with new nannofossil and available calpionellid data. Integrating the biostratigraphic, lithofacies, well log, and seismic data, enhanced the resolution over previous efforts and resulted in a better understanding of unconformities and major flooding events in the region. The recognition of pervasive reworking in parts of the Late Jurassic and Early Cretaceous in prodeltaic settings has been particularly helpful during the resolution of previously inconsistent biostratigraphic studies. This component of the PFA should enable better targeting of hydrocarbon exploration efforts on the underexplored Scotian Margin, especially in deeper water.

Ice cap evolution and polythermal ice dynamics derived from multiple terrestrial cosmogenic nuclide (TCN) dating of tors on Cumberland Peninsula, Baffin Island

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Cumberland Peninsula has been a key location for the development of many conceptual models of polythermal ice dynamics and Laurentide Ice Sheet extent. These models are still debated owing to limitations of dating and poor knowledge of the inception and evolution of ice sheets throughout the Quaternary.

Cosmogenic ^{10}Be and ^{26}Al concentrations on the surface of high elevation tors on coastal and interior summits indicate that all but one location (67.7°N, 64.2°W) have been covered by glacier ice. Interestingly, samples collected within confined regions reveal increasing burial durations with increasing altitude, suggesting longest coverage by ice caps and supporting a model of altitudinal control of ice cap initiation. The majority of analyzed samples yielded considerably old exposure durations (minimum single nuclide ages between 117–240 ka (^{10}Be, n = 12)), eight samples have much younger ages [38.3–96.0 ka (^{10}Be)], whereas three samples revealed much older ages [311–564 ka (^{10}Be)], in agreement with previous TCN studies on Cumberland Peninsula. However, because the $^{26}Al/^{10}Be$ (range 2.73–6.57) of all but one sample indicate significant burial durations (minimum burial of 1.4 Ma to 50 ka) the apparent single nuclide ages are considered uninterpretable.

The approach to this common problem of interpreting complex exposure histories in glaciated regions is to collect samples from multiple surfaces of the same jointed tor outcrop, to demonstrate that inter-fiord uplands have been modified by glacial plucking. Fresher surfaces with less pronounced weathering features (interpreted to be more recently plucked) yielded slightly higher $^{26}Al/^{10}Be$ and lower isotope concentrations than more weathered surfaces in all areas. Plausible complex exposure

histories involving several plucking events are modelled using local ice cover histories interpreted from marine sediment and Greenland ice core records. The model shows that the $^{26}Al/^{10}Be$ varies considerably throughout multiple exposure and burial episodes. The variation does not only depend on the duration of individual exposure and burial events, but on the influence of deeply penetrating muons which generate a higher $^{26}Al/^{10}Be$ than their spallogenic counterparts. A more deeply buried and thus more often plucked surface has a consistently higher isotope ratio than a shallower surface. This has implications on interpretations of previously published ratios in similar environments. Not only do the observed $^{26}Al/^{10}Be$ verify predominately a cold-based basal thermal regime on inter-fiord uplands, slight differences in $^{26}Al/^{10}Be$ from different surfaces imply glacial modification of tor outcrops by episodic plucking events. The simulated exposure histories indicate that the last plucking event more likely occurred during Oxygen Isotope Stage 4 or 6 than during Stage 2. This result reconciles many of the apparently incompatible observations and disparate conceptual models for ice sheet cover of Cumberland Peninsula and other high latitude coastal highlands.

Lithogeochemistry of host rocks to the Bisha Cu-Zn-Au volcanic-hosted massive sulphide deposit, Eritrea

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The Bisha volcanic-hosted massive sulphide (VHMS) deposit occurs within the Neoproterozoic Western Nafka terrane of the Arabian-Nubian Shield in Western Eritrea. The deposit totals 28.3 M tonnes in three zones: an oxide zone of 4.7 M tonnes containing 7.0 g/t Au, a supergene zone of 7.4 M tonnes containing 6.4% Cu, and a hypogene zone of 16.3 M tonnes containing 5.4% Zn and 1.0% Cu. Unfortunately, hydrothermal alteration, metamorphic recrystallization, and deformation have made it difficult to identify the primary volcanic compositions and textures of the host rocks. Furthermore, to date, only chloritic alteration has been recognized, so the deposit does not conform to accepted models for VHMS mineralization. As a result, detailed volcanic stratigraphy and hydrothermal zoning models have yet to be developed for the deposit. Drill core logging and a lithogeochemical study of the host rocks to the Bisha and nearby Harena VHMS deposits were undertaken to develop such models. Seven drill cores spanning the largest stratigraphic sequence possible were examined, and 282 samples were collected and analyzed for major and trace elements.

Lithogeochemical results indicate that felsic volcanic rocks constitute the immediate footwall and hanging wall of both deposits. Intermediate volcanic rocks occur deep within the Bisha footwall, and mafic volcanic rocks occur in the Bisha deposit footwall and the Harena deposit hanging wall. The data show that a complicated volcanic stratigraphy exists in the Bisha Mining Camp, and that the two deposits are not located at the same stratigraphic level.

A weak muscovite alteration affects hanging wall felsic and mafic rocks, and is the most widespread alteration style observed within the camp. In felsic rocks, it comprises a quartz + muscovite assemblage, but in mafic rocks it consists of a quartz + muscovite + chlorite ± calcite assemblage. At Harena, metamorphism has resulted in the formation of biotite, epidote, and hornblende as successor minerals. Chlorite alteration is strong to intense, and occurs only in the footwall of each deposit. Two styles of chlorite alteration are recognized: quartz-chlorite alteration is accompanied by pyrite and chalcopyrite, and occurs deep within the Harena footwall and throughout the footwall of the Bisha deposit in both felsic and mafic rocks; chloritite alteration affects felsic and mafic rocks, and consists almost exclusively of chlorite having silica concentrations averaging 32%. This alteration style is restricted to the immediate Harena footwall. In these alteration zones, muscovite is phengitic, with an approximate composition of $[K_{1.40}Na_{0.15}Ba_{0.35}\ Mg_{0.35}Fe_{0.25}Al_{5.45}Ti_{0.05}Si_6O_{20}(OH)_4]$, whereas chlorite is daphnitic $[Mg_{24/3}Fe_{4/3}Al_{16/3}Si_{16/3}O_{20}(OH)_{16}]$. Both of these alteration mineral compositions are similar to those in Bathurst Camp VHMS deposits.

A $\log(\alpha_{K^+}/\alpha_{H^+})$ versus $\log(\alpha_{Na^+}/\alpha_{H^+})$ mineral stability diagram has been used to understand the relationships between the three alteration styles. This thermodynamic model illustrates that the scarcity of muscovite alteration at Bisha is the result of a more sodic volcanic protolith than that observed in other VHMS camps.

Monchiquite dykes on Machias Seal Island, New Brunswick, Canada

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A set of narrow (<1 m), black, fine-grained mafic dykes transect granodiorite on the eastern side of Machias Seal Island, in the northern Gulf of Maine about 19 km southwest of Grand Manan, New Brunswick. The dykes are near-vertical and trend 015º to 025º, with about 700 m between exposures. The dyke rock is notably dark and dense, and thin sections reveal abundant small (<0.2 mm) phenocrysts of brown amphibole, augite, and larger euhedral olivine phenocrysts in a matrix of sparse alkali feldspar and analcite(?). The olivine has been completely replaced by chlorite, but other minerals are relatively fresh. Accessory minerals

include abundant needle-shaped apatite, magnetite, and cubic pyrite. Another small dyke on the western side of the island is less mafic and consists of fine- to medium-grained plagioclase and clinopyroxene, which are highly altered to saussurite and chlorite, respectively.

Chemical analysis and petrography indicate that the eastern dyke is a near-ultramafic monchiquite similar to some lamprophyric dykes of the New England-Quebec igneous province, the nearest known of which is about 110 km to the southwest near Blue Hill in coastal Maine. The freshness of the mineralogy of the Machias Seal Island mafic dyke (except for olivine) is also typical of the New England-Quebec dykes, which have ages around 110 to 125 Ma (Early Cretaceous). The monchiquite dykes may also be analogous with the Triassic lamprophyre dyke at Malpeque Bay on Prince Edward Island, which contains ultramafic or mantle xenoliths. No such xenoliths were observed in the dykes of Machias Seal Island. Another northeast-trending mafic dyke is visible (but not visited) at North Rock, a small island or ledge exposed a few km north of Machias Seal Island. The mafic dyke on the west side of Machias Seal Island is likely much older, based on its extensive alteration.

Ephemeral sedimentation in the Early Triassic Bjorne Formation of the Sverdup Basin Nunavut, Canada

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The Bjorne Formation of the Canadian Arctic is a poorly understood, dominantly sandstone unit that occurs in the Sverdrup sedimentary basin in the northern part of the Arctic islands. Thickness of the Bjorne Formation nears 2000 m in the depocentres and 1000 m along the margins; this formation was deposited entirely in the Early Triassic during three pulses of sedimentation, each of which constitutes a member. Two sandstone-dominant members are separated by a mudstone-dominant member, which is stratigraphically equivalent to the Blind Fiord Formation in the deep basin. Lithological and sedimentological features were observed in outcrops on Ellesmere Island (eastern margin of the basin) and correlated in order to create a depositional model for the three members. This enables the understanding of the shifting basinal environment and dominant depositional regime during the Early Triassic.

Each sandstone member comprises several hundreds of metres of stacked sandstones with some members having red siltstone interbeds. The red siltstone beds have climbing ripples, synaeresis cracks, and slight bioturbation. Shallow scours and mud rip-up clasts are also present along with planar stratification and primary current lineation. These associations of sedimentary features give an indication of episodic and rapid sedimentation, primarily in the upper flow regime of braided rivers. While the three members are part of an ephemeral sedimentation system, there are marked differences between them as the lower member has a marine association with intensive bioturbation in part.

This study will explore whether the Permo/Triassic extinction event affected the subsequent depositional regime of the Bjorne Formation, because vegetation helps stabilize banks and many vegetational taxa were wiped out by this event. Further research will include petrographic analysis, which provides a diagenetic history by looking at compaction, cementation, and alteration. Potential reservoirs, source rocks, seals, and traps will be analyzed to interpret the hydrocarbon potential within this unit. Shale occurs above and within the Bjorne Formation to provide a seal; potential source rocks exist in the underlying Carboniferous and Permian strata and they have a high level of thermal maturity in this area.

Remarkable sharks from the Early Devonian Campbellton Formation, New Brunswick, Canada

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In 1892 A.S. Woodward (Natural History Museum, London) described two “chondrichthyans”, *Diplodus problematicus* and *Protodus jexi,* based on teeth from the Early Devonian Campbellton Formation, New Brunswick, Canada. In 1893 R.H. Traquair (Royal Museum of Scotland) renamed *Doliodus problematicus*, which he reaffirmed was chondrichthyan and noted the selachian nature of the *Protodus jexi* tooth was “proved beyond doubt”. Despite Woodward’s and Traquair's chondrichthyan claims, from the mid-20th century both were placed into Acanthodii. Taxonomic challenges in identifying both *Doliodus* and *Protodus* have largely been resolved placing both species once again as early chondrichthyans.

The Campbellton Formation unconformably overlies the Val d'Amour Formation that is U/Pb dated 407.4 ± 0.8 Ma and contains miospores suggesting an early Emsian to early late Emsian age, older than about 398 Ma. Recent stratigraphic studies of the former formation suggest a coastal deltaic setting for the vertebrate beds. The sharks shared their habitat with cephalaspids (*Yvonaspis* spp.), placoderms (*Phlyctaenius* spp.) and acanthodians (*Mesacanthus semistriatus*, *Cheiracanthus*? *Costellatus,* and

Ankylacanthus incurvus). Large eurypterids (*Pterygotus anglicus*), ostracods, and mollusks are also part of the assemblage.

In 1996 a well preserved, relatively complete, *Doliodus problematicus* was recovered, armed with about 60 functional teeth, most in situ. It represents the earliest undoubted chondrichthyan in which an intact dentition can be investigated. CT-scanning and 3-dimensional imaging has shown the dentition in remarkable detail. The specimen also has a relatively intact braincase as well as pectoral fin spines previously thought to be absent in all sharks, but a characteristic element in acanthodians.

Protodus jexi has been identified by its teeth that exhibit a range of morphologies. The largest are dagger-like in shape with finely serrated cristae and an anteriomedial labial 'blood-draining' groove suggesting an active predator. It probably had a clutching-penetrating or puncturing dentition and supports the interpretation of the species as a predator, or an opportunistic scavenger. *P. jexi* would presumably have been able to attack (or scavenge on) and penetrate the armour of contemporary cephalaspids and placoderms, other various scaled fish such as acanthodians, perhaps even pterygotid eurypterids.

Tracking the crystallization of a magma chamber: rare earth element geochemistry of amphibole, Greendale Complex, Antigonish Highlands, Nova Scotia

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The ca. 610 Ma Greendale Complex, Avalon terrane, Nova Scotia, is an appinitic intrusive suite ranging from ultramafic to felsic in composition that was emplaced during ensialic arc magmatism and crystallized at shallow crustal levels under high pH_2O. Amphibole is the dominant mafic mineral in all rocks and displays extraordinary variability in texture and modal abundance, a characteristic of appinite suites. The sensitivity of amphibole composition (major, trace, and REE) to the evolution of water-rich magma is investigated.

All amphiboles in mafic and ultramafic rocks of the Greendale Complex are calcic, with $(Ca + Na)_B \geq 1.34$ and $Na_B < 0.67$ apfu, and Si^{IV} between 6.1 and 7.3. They range in composition from tschermakite, to tschermakitic hornblende, to magnesio-hornblende, and display a dominance of edenite ($Na,K_A + Al^{IV} = Si^{IV}$) substitution. Each sample exhibits remarkably uniform $Mg/(Mg + Fe^{2+})$ over a wide range in Si and the mafic rock amphiboles have lower (0.5 to 0.7) $Mg/(Mg + Fe^{2+})$ compared to the ultramafic rock amphiboles (0.7 to 0.9). REE profiles of amphiboles from mafic rocks are all bow-shaped, and are characterized by depletion in LREE ($La/Sm \approx 0.61$), a slight depletion in HREE ($Gd/Yb \approx 1.55$) and a negative Eu anomaly, which is attributed to co-precipitation of plagioclase. REE profiles of ultramafic amphiboles are divided into two groups: Group A amphiboles occur in all specimens analyzed and are very similar to the profiles of the mafic rocks. In contrast, Group B amphiboles display relative enrichment in light REEs ($La/Sm \approx 2.05$), have lower ΣREE, and lack a negative Eu anomaly. They are more enriched in Th and U and show a more pronounced depletion in Ta, Nb, Ti, and Y. Group B amphiboles grew in a reaction relationship with olivine and pyroxene. Groups A and B are virtually indistinguishable with respect to the major elements, suggesting that REE and selected trace elements, when combined with textural observations, may provide additional insights into crystallization history.

Investigation of the form and age of the Bloody Creek Crater, southwestern Nova Scotia

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Virtually all terrestrial impact craters exhibit a circular geometry in plan-form; only three impact sites exhibiting non-circular, elongate forms have been identified on Earth. One of these exceptional sites is the Bloody Creek Crater located in southwestern Nova Scotia, an approximately 0.42 km long-axis elliptical crater first identified in 1987 during a regional air photo survey. It was confirmed as an impact crater in 2009 through integrated geomorphic, geophysical, and petrographic data. The structure's rare ellipticity, pristine definition, preservation through shock metamorphic features of anomalously high pressures at the rim, low depth-to-diameter ratio, as well as age remain ambiguous and complicate the interpretation of the origin and evolution of the crater.

The purpose of this study is to quantify the form of the feature in order to better understand the nature and age of impact. To achieve this objective, analytical software was used to assess the shape of the crater rim. An extensive review of the literature was also performed to understand the controls on crater formation as well as to synthesize a model for the geological evolution of the site which would aid in the interpretation of the age of the structure. Results demonstrate that the form of the crater rim is best approximated by an ellipse, as illustrated by comparison of the RMSE (Root-Mean-Square Error) calculated for various geometric

models. This conclusion has resulted in the exclusion of a number of proposed impact models. Though elliptical craters can be formed by the erosion of circular impact features, the tectonic and/or geomorphic scenarios required to produce this outcome are inconsistent with models of evolution of the site. The Bloody Creek Crater was formed by very low-angle impact into a nearly horizontal, homogeneous medium. Impact occurred after peneplanation of the South Mountain Batholith and after Mesozoic sediment cover had been eroded constraining the age to Cenozoic. The pristine nature and near complete preservation of the rim structure likely indicate a much younger age.

The Bloody Creek Crater provides a unique opportunity to study shock deformation and structures associated with low-angle impact into a homogeneous crystalline target. Such research will add to the knowledge of how target geology influences the nature of observed shock effects, which may facilitate future identification of potential impact structures in similar geological environments. Moreover, continued identification of terrestrial impact craters contributes to the statistical data base for estimating past impact rates on Earth. The identification of low-angle impact craters in particular will contribute to discussions of the statistical probability of their occurrence on Earth, as well as the role of the terrestrial atmosphere in filtering such impact events.

Spatial pattern of mercury in stream and lake sediments in Nova Scotia, Canada

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Based on national geochemical surveys for soil and sediments across Canada, elevated concentrations of Mercury (Hg) have been identified in stream and lake sediments in Nova Scotia. This study specifically investigated total Hg concentration (THg, ppb) variations in the context of geological specifications and land cover type, focusing on regional stream and lake sediments geochemical surveys conducted by the Nova Scotia Department of Natural Resources. The overall sediment THg pattern showed that lakes had higher concentrations than streams (p-value <0.0001), with highest and lowest concentrations in south-west Nova Scotia and on Cape Breton Island, respectively. Areas covered by surficial exposed bedrock showed higher sediment THg than other depositional modes such as alluvium, colluvium, and marine deposits. The detailed analyses showed that the high THg concentrations (2040–10,000 ppb; n = 30) were from areas overlain by gold and sulphide-bearing metamorphic rocks and biotite-rich granitoids, where historical gold mines were operating. The THg variation pattern was indeed inversely related to high wet-area to basin area ratio (Aw/AB; %) of the basins above each sampling point. The basins with inclusion of swamp only, swamp and bog/fen had higher THg in downstream sediments (p-value <0.0001). This observation supports the proportional wet-area export of dissolved organic carbon (DOC)-bound Hg in upland areas, where much of the DOC-mobilized Hg within the surface soil is absorbed to the deeper mineral soil.

Architectural elements of Mesozoic rift basin sediments: offshore Scotian margin

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The Mesozoic Scotian and Fundy basins reveal the 250 million year evolution of the Atlantic Ocean from a failed rift zone through to the present passive margin. The stratigraphic successions within these basins comprise early rift sediments of siliciclastics and evaporites, carbonate deposits, through to fluvial, deltaic, and deep water depositional systems.

Exceptional 2D and 3D conglomeratic sandstone outcrop exposures of the Triassic Wolfville Formation along the Bay of Fundy provide a reservoir analogue of a braid channel and sheet sand depositional system representing early fill of the basin. New and innovative technologies (aerial and ground-based LiDAR, Digital GPS, Ground Penetrating Radar, high resolution photogrammetry, scintillometer, and permeameter measurements) have remarkably enhanced the ability to understand gas and fluid connectivity between architectural elements. Integrating these technologies with well and seismic data, outcrop analysis, and thin section evaluation will allow for a comprehensive examination and delineation of architectural elements leading to one of the largest 2D and 3D geological outcrop-derived reservoir models for history-matching producing fields. These data are also applied to understand the potential of hydrocarbon systems within the Scotian and Fundy basins.

Structure and petrology of the Partridge Island block and the tectonic evolution of the Saint John area, New Brunswick

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The Partridge Island block is a component of the tectonic terrane collage of the northern Appalachians in the Saint John area, New Brunswick. It comprises crystalline rocks (variously deformed granitic and intermediate rocks) that crop out mainly on Partridge Island, and the adjacent areas of the mainland around Red Head and Tiners Point. The block impinges on adjacent Carboniferous rocks (Balls Lake Formation) and the problematic Taylors Island–Lorneville assemblage of basaltic lavas and red sandstone-siltstone-mudstone. Detailed petrographic and structural studies have addressed both the primary nature of the rocks of the Partridge Island block, and its relationship to the adjacent Taylors Island–Lorneville assemblage. Geochronological studies have permitted a calibration of this history of intrusion and deformation.

A suite of granitic to dioritic intrusions make up most of the Partridge Island block; they are commonly highly deformed, and include mylonites, blastomylonites, and protomylonites. Around Tiners Point they contain xenolithic enclaves of quartz arenite and siltstone, which may represent the host. One distinctive pluton in this suite, an aegirine-bearing alkali granite of A-type affinity, has yielded a U-Pb zircon age of 346.4 ± 0.7 Ma, whereas amphibole in a mylonitized pluton yielded a $^{40}Ar/^{39}Ar$ age of 332 ± 3 Ma. These ages are interpreted as intrusion and uplift/cooling ages, respectively.

Contact relations between the Partridge Island block and adjacent units is commonly faulted, and most of these faults are the vertical strike-slip faults that cross the Saint John area from west-southwest to east-northeast. However, in the Red Head area the crystalline rocks occupy a thrust sheet above red conglomerate-sandstone-mudstone of the mid-Carboniferous Balls Lake Formation. Within the thrust sheet, an unconformable relationship is preserved between the mylonitic Partridge Island igneous rocks and the basalt-red sedimentary Taylors Island–Lorneville assemblage.

The Taylors Island–Lorneville assemblage, variously termed the "Mispec Group", "Taylors Island Formation" and "Lorneville Group", has defied direct dating and has been assigned ages ranging from late Precambrian to Carboniferous. However, the unconformable relationship with mylonitic rocks of the Partridge Island block constrains its age to being younger than the uplift age of 332 Ma. In the Tiners Point area, basalts of the Taylors Island–Lorneville assemblage are highly deformed and apparently interfinger with mylonitic granitoid rocks, including the aegirine-bearing alkali granite of the Partridge Island block.

The Partridge Island block consists of an early Carboniferous plutonic complex intruded into sedimentary rocks of unknown (older) age. Deformation to mylonite along with uplift followed within 20 Ma; the basalt and red to grey sedimentary rocks of the Taylors Island-Lorneville assemblage were deposited on this basement and were partially deformed along with it. Subsequently, late Carboniferous (Alleghenian) deformation emplaced these rocks as thrust slices above the Pennsylvanian formations east of Saint John, or elsewhere in strike-slip juxtaposition against late Precambrian and Cambrian rocks of the Avalonian Caledonia terrane.

Sisson Brook W-Mo-Cu deposit case study, central New Brunswick: indicator mineral and till geochemical signatures

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As part of the Geological Survey of Canada's (GSC) Targeted Geoscience Initiative (TGI-4) between 2010-2015, GSC and the New Brunswick Department of Natural Resources (DNR) initiated a till sampling program around the Sisson Brook W-Mo-Cu deposit in central New Brunswick, in collaboration with Northcliff Resources Ltd. The purpose of the case study is to document indicator mineral and matrix geochemical signatures in till at varying distances down-ice of the deposit. This case study will be the first to document glacial dispersal of W-bearing minerals around a significant W deposit. The results of this study will be useful for W exploration in the region and elsewhere in glaciated terrain. A total of 750 till samples will be collected in an ongoing DNR regional sampling project north and northeast of the Sisson Brook area.

Eleven bedrock samples were collected from outcrops or diamond drill core that intersected mineralization or surrounding

host rock lithologies. These bedrock samples will be processed to produce heavy mineral concentrates to recover and examine W-Mo-Cu mineralization indicators as well as document background host rock mineral assemblages.

The glacial history and stratigraphy of the deposit area is complex and 3 tills are present; the Illinoian Northumberland till, the Early-Middle Wisconsinan Caledonia till, and the generally geochemically barren Younger Dryas Collins Pond till. These 3 tills presented sampling challenges as they are all deposited by separate ice flows from different source areas and are geochemically distinct but not always easy to distinguish visually and texturally in the field. In 2011, 79 till samples were collected up-ice, overlying, and up to 14 km down-ice (SE) of the Sisson Brook deposit. Till was sampled from road cuts, hand dug holes, one open pit overlying mineralization, exploration backhoe trenches overlying or proximal to the deposit, and from 83 mm diameter drill core from four diamond drill holes. The distribution of sample sites was guided by till geochemical results from previous sampling around the deposit by Kidd Creek Mines and DNR. Daily analysis with a portable XRF to determine W, Mo, and Cu values in 200 g till samples from the 79 sites as well as 61 other test pits in the deposit area, up-ice, and down-ice, helped to focus further till sampling. Preliminary PXRF results (W up to 328 ppm, Mo up to 45 ppm, and Cu up to 459 ppm) show a direct correlation with underlying bedrock and the known extent of the mineralization in the Sisson Brook deposit area. The anomalous PXRF concentrations match previously known DNR anomalous concentrations in the dispersal train extending 14 km to the SSE to SE. All till samples are being processed to produce heavy mineral concentrates for examination of minerals indicative of the W-Mo-Cu mineralization. The <0.063 mm fraction of till will be analyzed to determine the geochemical signature of the mineralization. In addition, 12 oriented till samples were collected for determination of till microfabrics that will aid in understanding glacial transport directions and interpreting glacial dispersal patterns.

Determining the presence of aqueous fluids in Canadian kimberlites

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Lac de Gras is located in the Archean Slave Craton and is host to a plethora of kimberlites emplaced over 1000 Ma. Five kimberlites from the Ekati mine were chosen for this study. H_2O and CO_2 volatiles are an important determinant for emplacement mechanisms of kimberlite magmas; dictating the monetary value of diamonds mined from them. The purpose of this study was to investigate the variations of chemical compositions of indicator minerals found in the groundmass of kimberlites. Spinel, apatite, and phlogopite were selected because they are the best-preserved minerals in kimberlites and because their compositional variability provides evidence of changing conditions in the parent melt. Spinel grains were selected using detailed petrography and then through EDS/WDS microprobe analysis, chemical composition was determined for each individual spinel grain. EDS and WDS microprobe analysis provided results of contrasting chemical compositions of spinel from Grizzly and Misery kimberlites. At Grizzly chromite is the abundant spinel mineral present in the groundmass with minimal apatite. At Misery there is abundant Fe-rich spinel with significant apatite. The compositional variations of these indicator minerals indicate different fluid histories in these kimberlites. The presence of volatiles can affect the density, buoyancy, and rate of ascent and eruption process; in turn affecting the level of preservation and quality of diamonds that are transported from the mantle within kimberlite magmas. Additional analysis of kimberlites from Leslie, Panda, and Bear-tooth will be incorporated in this study.

A microbial mat and associated trace fossil assemblage at Coal Mine Point, Nova Scotia: paleoenvironmental significance and evidence of a previously unrecorded transgression

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The Coal Mine Point (CMP) headland, within the UNESCO World Heritage Site at Joggins, contains a prominent Poorly Drained Floodplain lithofacies (PDF). New ichnological and sedimentological evidence has shed new light on the paleoenvironmental interpretation at CMP. The presence of aquatic trace fossils and an associated microbial mat suggests a previously unrecognized transgression event with a possible marine connection.

In 2009, two associated sandstone blocks were liberated from the upper part of the fluvial-channel body at CMP by erosion. One of the blocks has since been turned over and both are otherwise somewhat obscured by debris, and are survived only by photographs. The sandstone blocks preserve wrinkle structures consistent with a fossilized microbial mat, in addition to several tetrapod (*Pseudobradypus (?), Dromillopus*) and terrestrial invertebrate trackways (*Diplichnites cuithensis, Diplichnites gouldi*). Substrate stabilization and increased cohesiveness is evidenced by the interaction between the microbial mat and large arthropleurids which traverse the wrinkled surface exhibited by the large *Diplichnites* trackways. Trackways are not underprints and trackway emplacement was post-mat growth, as the imprints are sharp and show no sign of extramorphological distortion.

In combination, these terrestrial trace fossils are indicative of the known PDF assemblages at Joggins. However, preserved with the sandstone beds are paired mud drapes, which are interpreted as possible tidal rhythmites, and aquatic ichnofossils (*Cochlichnus, Skolithos*, *Arenicolites, Rhizocorallium*, and *Protichnites*). Collectively, the microbial mat and overlying ichnofossil assemblage, suggest a transgressive event and marine influence preserved in the upper Coal Mine Point sandstones. Deposition of fluvial sands was followed by channel abandonment and the formation of microbial mats, after which a minor transgressive event established brackish conditions in the uppermost part of the channel fill. Microbial mats are uncommon in the Phanerozoic record, and the CMP occurrence is one of very few examples from a fluvial or tidal channel body.

Field relations and petrology of the Trafalgar plutonic suite, northeastern Meguma terrane, central Nova Scotia

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For this study, field data, samples, and petrological data from previous studies are used in combination with new field observations and petrological data to provide new insights into the tectonic setting, origin, and evolution of the Trafalgar plutonic suite. This suite intruded metasedimentary rocks of the Goldenville and Halifax groups at about 374 Ma, based on published U-Pb (zircon) and $^{40}Ar/^{39}Ar$ mica ages. The host rocks were regionally deformed and metamorphosed to greenschist facies during the mid-Devonian. Both plutons and their host rocks were deformed in a major mylonite zone along the northeastern margin of the study area.

The Trafalgar plutonic suite consists of 19 separate plutons composed of 8 different lithologies ranging from quartz diorite and tonalite to monzogranite and syenogranite. Based on cross-cutting relations, quartz diorite and tonalite are the oldest units and they occur only in the western part of the suite. They were intruded by medium- to coarse-grained granodiorite of the Twin Lakes pluton. Subsequently, muscovite-biotite granodiorite to monzogranite, characterized by the presence of microcline megacrysts, intruded the suite. The eastern part of the suite is dominated by large plutons composed of medium- to coarse-grained equigranular muscovite-biotite monzogranite. A small body (South Brook Pluton) in the central part of the suite is similar but contains a higher proportion of large quartz grains. In the largest pluton (Long John Lake), small mappable bodies of distinctive fine-to medium-grained monzogranite with K-feldspar and quartz phenocrysts are present. The youngest component is fine- to medium-grained muscovite monzogranite to syenogranite, which intruded the larger monzogranite plutons. A separate small body of fine-grained equigranular muscovite-biotite monzogranite east of Rocky Lake is of uncertain age.

All of the plutons are peraluminous, and SiO_2 contents range from 47 to 77%. Overall, CaO, MgO, $Fe_2O_3{}^T$, TiO_2, and MnO show positive correlation with SiO_2 and Na_2O and K_2O show negative correlation. Most trace elements in granodiorite, monzogranite, and syenogranite samples of all textural varieties also show negative correlations with SiO_2; however, some scatter occurs, especially in the Twin Lakes and Lower Rocky Lake plutons. The quartz diorite and tonalite samples show no correlation with SiO_2 and wide scatter in trace elements. Discrimination diagrams indicate that the plutons formed in a syn-collisional and/or volcanic-arc setting. Most of the plutons are chemically similar to other granitoid plutons of the Meguma terrane except for the tonalitic and quartz dioritic plutons that have lower SiO_2 than other tonalitic plutons such as Barrington Passage.

Quantitative mapping in the Parry Sound domain for structural analysis

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The Parry Sound domain (PSD), a granulite nappe in the Central Gneiss Belt of the ca 1.1 Ga Grenville Province gives insight into structural processes in mid-crust of a doubly-thickened orogen. The Twelve Mile Bay Shear Zone forms a boundary of the PSD along which interior granulite facies PSD structures are transposed at amphibolite facies metamorphism. The focus of the study is to create a quantitative map so that measurements can be obtained for further structural analysis, to better understand how the lower crust deforms. In the summer of 2011 a Dalhousie team set about creating this unique map by using a camera on a pole to shoot very low aerial photos of a few islands. The islands were selected because they were transitional from foliated granulite facies rocks to transposed sheared amphibolite facies rocks of the same composition, with the intention of understanding how these shear zones form and propagate. The Leica DGPS system was used to set up a grid of points in combination with the pole-camera to shoot the grid systematically. Photos are now in the process of being merged together to create the map through experimenting with several different photo software suites. Once the map is complete, data such as change in thickness of a layer as it enters a shear zone and layer displacement across a shear zone can be collected. This data can be used to quantify the shear strain show how the islands have changed in shape over time.

TGI-4 intrusion related mineralization project: identifying new vectors to hidden mineralization

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Targeted Geoscience Initiative 4 (TGI-4) is a 5 year Government of Canada program to help produce the next generation of innovative geoscience knowledge and analytical techniques that will result in more effective targeting of buried mineral deposits. The Geological Survey of Canada in collaboration with provincial and territorial surveys, industry, and academia will conduct thematic, knowledge-driven projects based around ore systems. The thematic nature of TGI-4 means that individual projects are not defined by geographic region, but instead integrate data and knowledge from multiple sites across Canada, to optimise ore system categorization.

Intrusion related (e.g., porphyry) deposits are the most important sources for Cu, Mo, W, and Sn, along with Au, Ag, and PGEs. Porphyry deposits are large, low- to medium-grade deposits in which mineralization is hosted within and immediately surrounding distinctive intrusive phases within larger intrusive complexes that commonly have a complex and prolonged emplacement history. The metallogenic contents of intrusion related deposits are diverse, reflecting a variety of tectonic settings.

The purpose of this project is to develop more effective exploration criteria to identify and evaluate fertile intrusive mineralizing systems at depth. Studies into Cu-Mo/Au and W-Mo-Sn systems will focus on answering the following questions: (i) Are there distinctive proximal and distal footprints for each deposit type that will allow identification of, and vectoring towards hidden economic deposits?; (ii) Is there evidence within the root systems of fertile intrusive phases that conditions were met that triggered a hydrothermal-magmatic system of size and duration sufficient to develop a large porphyry deposit? To help answer these questions studies are being undertaken at sites associated with the Triassic-Jurassic porphyry deposits of the BC interior and for the array of mineralized Canadian Appalachian Siluro-Devonian intrusions, for which the fundamental geoscience knowledge is often lacking.

The alteration halos and vein systems associated with intrusion related mineralization can represent a much larger exploration target than the actual economic orebody itself. In the right circumstances alteration and other vectors can be applied to identify hidden deposits. A common problem facing Cordilleran and Appalachian exploration is how to detect mineralized sequences through the extensive surficial coverage. Consequently research activities are focusing on surficial geochemistry, biogeochemistry, up-flow of volatiles, indicator mineral dispersal, and the geophysical characteristics of intrusion related deposits. Indicator mineral dispersal is well established for diamond exploration, but has the potential to be applied to other mineralizing systems within glaciated terrains. Furthermore, utilizing mineral trace element fingerprinting, it might be possible to develop methods for common phases. Also as trees collect various elements through their roots, the chemistry of their bark can be used as a natural probe into the subsurface to help pinpoint buried mineral deposits and increase the effectiveness of deep mineral exploration.

Archival documentation of the 1755 maremoto de Lisboa, on the shoreline of Brazil

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The tsunami, or maremoto in Portuguese, caused by the November 1, 1755 Lisbon earthquake is known to have been highly destructive and tragic to those caught by the waves all along the coast of Portugal, western Spain, and the Atlantic coast of Morroco. While it is difficult to know the real death toll it was over 10 000 persons and was comparable to the March 11, 2011 Japanese earthquake. The Lisbon tsunami is known to have been observed on the Atlantic coast of France, and in southern Ireland and England where the reports of the daylight arrivals of the tsunami waves are often confused with the earlier surface wave effects that often set up seiching events in enclosed bodies of water including some nearly enclosed marine harbours. The tsunami was observed on the mid-Atlantic in the Azores and in the Canary Islands. It was also observed in the early to mid-afternoon of Saturday, November 1, 1755 along the shorelines of many of the islands of the eastern Caribbean and as far west as possibly Cuba. These observations give a trans-Atlantic velocity of the Lisbon tsunami of 700 km/hr. There are as yet no observations along the sparsely inhabited coast of eastern America including Nova Scotia. The tsunami was observed in northeast Newfoundland in the Bonavista area. No deaths are known along the western shores of the Atlantic.

The authors have found three original hand-written Portuguese-language letters produced by Portuguese colonial government officials in Brazil reporting back to the Portuguese authorities and one penned by the Bishop of Bahia, each describing aspects of the tsunami's arrival along about 2200 km of the Brazilian coast from the Capitania of Pernambuco in the area of Recife southwestward to the area of Rio de Janeiro. The tsunami is recorded as arriving in daylight hours and destroying the simple beach homes of fishers and slaves. Two persons were still missing three months after the event in one community. In one locality the waves are described as penetrating one league (~5 km) inland though the authors suspect that this may refer to the tsunamis'

passage up a river.

One of the most challenging aspects of the work has been to read the cursive script of the 1756 letter writers and to understand all the abbreviations, grammar, and spellings used in the style of the day. Several scholars working in the period assisted greatly with this process. These are the first reports of the Lisbon tsunami being seen in South America and interestingly at least one of the documents was published in Brazil in 1913 but its value to seismologists was not realized at the time and the document's existence was lost to science for the past 99 years. The significant waves along the Atlantic coast of Brazil were widely noticed late in the afternoon of November 1st and remarked upon locally at the time, but their significance and their connection to events in Europe were not understood by the Brazilians for well over a month until the first ships from Portugal with the news of the tragic earthquake arrived at Brazilian ports in late December 1755. The letters found by the authors are dated from February to May of 1756. The authors believe that other historical Brazilian reports may yet be located.

Cooling history of shock melts in meteorites: constraints from finite element cooling models

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Pockets of silicate glass heterogeneously distributed throughout shock metamorphosed Martian meteorites represent local hot spots (up to 2000°C) formed during shock melting. They contain a dissolved sample of Martian atmosphere and often host high pressure minerals such as ringwoodite. The distribution of melt in meteorites NWA 4797, LA, DaG 476, and DaG 1037 is defined using a finite element model (geodynamics.lanl.gov/Wohletz/Heat.htm) to calculate their cooling history. Ideally, melt pockets cool conductively to the background temperature of the meteorite with no interference from nearby pockets. This ideal behaviour is seen in NWA 4797, which contains a 7 mm long, 1 mm wide vein that cooled to the solidus in 4.5 seconds. The other three samples have cooling times from 1.4 to 100 times longer than in the ideal system. This deviation is the result of interference between the thermal haloes of nearby melt pockets and in the case of DaG 1037, a large melt vein.

Previous models suggested a cooling time of 0.2 seconds for a 1 mm^2 pocket; if such rapid cooling occurred, there should be no diffusive loss of atmospheric gas and no back reaction of high pressure phases. The data from this study call this conclusion into question. In small pockets 1 mm wide, the loss of 2.2% Ar and 5.2% Xe by diffusion over the 1.5 second cooling time results in a small change in the Ar/Xe ratio of the gas dissolved in the pocket over that originally trapped. With longer cooling times due to the effects of nearby veins or pockets, there is significant fractionation of Xe from Ar and the Ar/Xe ratio increases rapidly. For the largest pockets, there is less variation of the Ar/Xe ratio over the cooling time, so even though they have a longer cooling time, larger, isolated pockets are more likely to preserve the original trapped gas composition than smaller pockets that have elevated cooling times due to thermal effects of nearby veins and pockets. Preservation of high pressure phases requires that pressure and temperature decrease at similar timescales. If this were the case, it is expected that high pressure phases preserved only rarely, as melt pockets must be small enough to cool over 0.01 to 0.001 seconds. These models indicate that the pockets would have to be of the order of 100 microns wide and be completely isolated from external effects to give such a cooling time. Therefore, although the search for a pristine sample of Martian atmosphere should focus on the center of large melt pockets, only the smallest pockets should be examined for high pressure phases that record the pressure excursions experienced during shock metamorphism.

Laser-ablation ICP-MS analysis of freshwater ferromanganese nodules

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Freshwater ferromanganese nodules are common in New Brunswick lakes. Their growth is gradual over 100s to 1000s of years by precipitation of Fe and Mn oxides around a pebble nucleus. With a concentric growth pattern, they have the potential to contain time-series records of aquatic-chemical and climate data for the region in which they are found. In order to extract this time series data an understanding of the chemical composition of the nodules is essential. Laser-ablation ICP-MS provides a way to obtain high spatial resolution analytical profiles across the nodules for a large range of elements, but the method requires development of LA-ICP-MS standards. Thirteen ferromanganese nodule samples with a range of Fe:Mn ratios, and two USGS marine manganese nodule standard reference materials, were selected for the preparation of LA-ICP-MS standards. Approximately 100 mg of powdered nodule material were added to 25 mL of a 0.5 M solution of oxalic acid. This mixture was placed in a water bath at 80ºC for 24 hours until all Fe and Mn oxide powder was dissolved. The solution was then filtered (0.45 μm) to remove undissolved silicate particles and the filtrate was taken to a final mass of 50 g with 2% HNO_3. Samples were analyzed by ICP-MS for As, Ba, Ca, Co, Cu, Ni, Pb, P, Sb, Sr, Th, U, V, Zn, as well as Fe and Mn. Having determined the major and trace-element

concentrations, pressed pellets were prepared for LA-ICP-MS standards from subsamples of each powder material. Once the approach to laser ablation analysis has been optimized, work will proceed to analyze nodule thin sections, concentrating on line profiles along the nodule growth directions.

The paleogeography of glacial lake Shanadithit in the Red Indian Lake Basin, Newfoundland

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Central Newfoundland has potential for the formation of ice-marginal lakes due to its topography and diachronous pattern of deglaciation. The spatial distribution and elevation of features such as deltas and shorelines, along with the presence of fine-grained sediments, enable the delineation of ice-marginal lakes, the largest of which was glacial lake Shanadithit, which occupied over 116 km of the Red Indian Lake Basin at its greatest extent. The location of topographic lows and the pattern of glacial retreat suggest that glacial lake Shanadithit experienced four phases of ice-marginal lake development. These were: the Lloyds River Phase at 310-330 m above sea level (asl); the Star Lake Phase at 310 m asl; the Hinds Lake Phase at 302 m asl, and the Joe Glodes Pond Phase at 195 m asl.

Delevelled shoreline features and corresponding outlets indicate that the basin has undergone a minimum isostatic tilt of 0.22 m km^{-1}. This indicates that the Newfoundland Ice Cap influenced the amount glacio-isostasy on the island of Newfoundland, and was not overshadowed by crustal depression associated with the Laurentide Ice Sheet, as previously suggested.

The development of ice-marginal lakes within the Red Indian Lake Basin suggests that drift prospecting programs should pay close attention to the material being sampled to ensure that it has not been deposited or washed in a glaciolacustrine environment. Similarly, the presence of mineralized boulders on till surfaces found below the maximum elevation of the ice-marginal lakes level may be unrelated to ice flow, having been deposited by ice rafting.

Fracture studies in the Horton Group, Windsor-Kennetcook subbasin, Nova Scotia

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The Mississippian Horton Bluff Formation dominantly consists of sandstone and shale, commonly interpreted to have been deposited in a lacustrine environment. The formation occurs in both the hanging wall and the footwall of the Kennetcook thrust system, a transpressional structure associated with dextral motion on the Cobequid-Chedabucto Fault Zone. Rocks in the footwall of the Kennetcook Thrust are possible targets for hydrocarbon exploration. Fracture studies permit a better understanding of deformation history of footwall rocks exposed on the east and west sides of the Avon River, Nova Scotia; the type locality of the Horton Bluff Formation. The area between Horton Bluff and Blue Beach has two kilometres of continuous cliff and wave-cut platform with continuous exposure; the rocks in this section have fractures in a variety of orientations. Fracture studies were performed at ten localities in this section on large areas of exposed sandstone. Circular scan-lines were measured using two measurement techniques to avoid directional sampling bias. At most localities, two orthogonal fracture sets are predominant, with mean strikes of 165° and 075°. This indicates that there was a common stress regime throughout the area. In other locations, dominant fractures are interpreted as conjugate sets, with dominant strike directions of 160° and 090°. In rose diagrams with two dominant orthogonal strikes, a third peak is commonly observed with a roughly E-W strike, which may be related to overall strike-slip movement on the predominantly dextral Cobequid-Chedabucto Fault to the north. It is likely that these fracture systems extend eastward in the footwall of the Kennetcook thrust system, where their orientations may affect fluid migration pathways.

Partial digestion geochemistry of Nova Scotia soil samples: monitoring digestion conditions to understand how samples leach

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Partial digestions have been used in exploration geochemistry over the past 15 years to detect surface anomalies associated with buried mineralization. Vertical migration of elements from a primary mineralized source at depth to the surface is necessary to create these anomalies. Within the anomalous soils, elements transported from depth by groundwater typically reside in loosely bound sites on the surfaces of minerals. Partial digestions are designed to only leach such elements from the surfaces of

these minerals, as they do not dissolve the minerals themselves, and thus do not liberate any elements contained within those minerals. As a result, partial digestions tend to suppress geochemical background and increase geochemical contrast, features that should make partial digestion results more interpretable and visually compelling than total digestion results. However, unlike strong digestions, soil matrices overwhelm weak digestions and thus it is necessary to carefully monitor the digestion conditions.

To investigate what happens during partial digestion geochemistry, B-horizon soil samples from study areas in Nova Scotia were leached using deionized water (probably the weakest partial digestion possible) and analyzed by ICP-MS. The partial digestions were analyzed for a suite of metals every 30 seconds for at least the first 30 minutes of leaching, and compared with results obtained over 2 hour batch digestions. During these temporal studies, the pH and pE of the solutions were also measured every 30 seconds to monitor digestion conditions. These results have also been compared with the results of analogous partial digestions obtained using an argon atmosphere to avoid any oxidation effects resulting from exposure to ambient air.

The results of these experiments have provided significant improvements in the understanding of how partial digestion conditions change over time, and how these changes can result in unintended, and sometimes, completely disastrous results. Special consideration of the condition of soil samples before collection, after drying, and during deionized water leach provides a unique understanding of the behaviour of labile elements during digestion. Essentially, the results conclusively demonstrate how the matrices of soil samples simultaneously buffer both the pH and pE conditions of the digestions, precisely because these buffers overwhelm the chemical controls exerted by these weak partial digestions. As a result, samples with different matrices will commonly undergo leaching under vastly different chemical conditions, undermining interpretation because the consequent results can't be rigorously compared. Interestingly, the results also demonstrate that partial digestion concentrations obtained with less than 10 minutes of leaching are typically less impacted by these matrix effects, and thus provide more accurate exploration results and better geochemical contrast than conventional (longer) leach times.

The smallest known tetrapod footprints: *Batrachichnus salamandroides* from the Carboniferous of Joggins, Nova Scotia, Canada

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A new trackway of *Batrachichnus salamandroides* from the classic Carboniferous section at Joggins, Nova Scotia, records the smallest example of tetrapod footprints known in the fossil record. The track maker was a juvenile, quadrupedal temnospondyl or microsaur with a trunk length of 3.55 mm and an estimated body length of 8 mm (skull, presacral vertebrae, and caudal vertebrae). The most conservative measurements, which include extramorphological features (i.e. toe drags), measure the manus and pes to have an average length and width of 1.58 mm x 1.65 mm and 2.38 mm x 2.54 mm, respectively. When the relative size of this trackway is compared with other previous described examples of *Batachichnus salamandroides* and other small vertebrate ichnotaxa from Joggins, it clearly is substantially smaller than previously described specimens. The 48-mm-long trackway preserves a high degree of extramorphological variation along its course, including a gait change associated with a change in direction, together with an increased stride and pace, and the appearance of overstepped imprints, in the latter part of the trackway. These morphological changes suggest the tetrapod changed from a walking gait to a running gait.

Based on previous work, the case for a temnospondyl (branchiosaur, *Eryops,* or *Dendrerpeton*) track maker of *Batrachichnus* is strong. More than 100 fragmentary remains of *Dendrerpeton* have been prepared from the tree stumps recovered by Dawson in the late 19th century, and one articulated skeleton was collected and prepared from a siderite nodule. Previous work by Haubold compared skeletal reconstructions of the manus and pes anatomy of *Dendrerpeton* to that of *Batrachichnus* and made a compelling case for their similarity. Given the size ranges of *Limnopus* and *Batrachichnus* at Joggins, and the known skeletal remains, *Dendrerpeton* (or some other, similar temnospondyl) is a strong candidate for the track maker of both ichnogenera at Joggins. Body proportion measurements, taken from the only known articulated temnospondyl represented at Joggins, an adult temnospondyl *Dendrerpeton* were used as a model to estimate the skull and body lengths of the track maker for the recently discovered Batrachichnus specimen.

Occurrence and origin of ring schlieren in the Halifax Pluton, South Mountain Batholith, Nova Scotia, Canada

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The Late Devonian Halifax Pluton (HP), which crops out along a coastal section of Halifax County, contains a biotite monzogranite (Peggys Cove lithological unit) that is host to a variety of schlieren structures, including more than 150 centimetre- to decametre-scale ring schlieren. Ring schlieren are alternating melanocratic and leucocratic bands in granitoid rocks, which form open to closed, nested, circular to elliptical, concentric to eccentric, prolate to oblate structures with cross-cutting relationships

indicating a younging direction toward the centre. The purpose of this investigation is to develop a field-based model for the formation of ring schlieren in the HP.

Geographically, ring schlieren occur in clusters, with significant groups of structures occurring near Aspotogan Point (n = 7), near Peggys Cove (n = 61), near West Dover (n = 14), near Pennant Point (n = 41), and near Prospect (n = 8). Geometrically, the number of rings in a single structure and their shapes define three ring schlieren groups: 16 structures have one ring, 79 structures have two or more rings, and 58 structures have complex shapes including ladder dykes, snail-shaped rings, ladle-shaped rings, and convoluted rings. The local disruption of regional flow foliation in the host granitoid by the rings suggests that the rings are late magmatic structures, created when the degree of crystallinity of the magma was 55-75%, a condition permitting both deformation of the mush and retention of the deformed state. Rare three-dimensional exposures of ring schlieren reveal that these structures are vertical cylinders. As such, ring schlieren structures appear to represent vertical fossil pathways of solids descending from the roof of the pluton, or of the ascent of bubbles created by the late-stage degassing of magma at greater depth. Shear flow at the margin of descending xenoliths or ascending bubble (fluid) trains can produce flowage differentiation between silicate melt and solids of various sizes by the Bagnold effect, which can explain the particle sorting textures in ring schlieren structures. A miarolitic cavity in one multi-ring structure suggests a rising bubble train may have produced the rings. Natural (bubbling mudpits, volcano vapour rings) and synthetic (concrete, petroleum gel) analogue systems provide qualitative support for this model.

Withdrawal of Windsor evaporites and the stratigraphy of the Maritimes Basin

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The Lower Windsor Group in the central Maritimes Basin of New Brunswick and Nova Scotia, and the equivalent Codroy Group of Newfoundland, contain thick evaporites that are poorly preserved at the surface due to dissolution, but which show dramatic variations in thickness where preserved in the subsurface. Structures in both the surface and subsurface show that salt mobilization occurred during the evolution of the basin. In the Cumberland subbasin of Nova Scotia, seismic profiles show that evaporite withdrawal occurred at different times in different parts of the basin. Basin geometries recording differential subsidence suggest that at least 2.5 km of Lower Windsor evaporites were initially present. In parts of the subbasin, localized evaporite-withdrawal basins are imaged that correspond in their stratigraphic position to the Middle Windsor Limekiln Brook Formation, suggesting that evaporite flow began very soon after deposition of the Lower Windsor evaporites.

Major lateral thickness and facies variations also occur in the Middle and Upper Windsor stratigraphy, and in the overlying Viséan-Serpukhovian Mabou Group. Major omissions in the Windsor-Mabou stratigraphy have previously been interpreted as products of a major, post-depositional movement on a subhorizontal extensional detachment. Comparison with evaporite successions on passive margins suggests an alternative model. In this model, locations where the Lower Windsor Group is absent represent evaporite welds, where evaporites were withdrawn early, allowing deposition of thick Middle Windsor to Mabou successions in a series of minibasins. Simultaneous flooding of these minibasins during sea-level high-stands led to the deposition of comparable successions across multiple minibasins. In contrast, locations where Middle Windsor to Mabou Group strata are condensed or absent represent areas of salt inflation and diapirism, in which limited accommodation space was available for the deposition of Middle Windsor to Mabou Group sedimentary rocks.

This model leads to specific testable predictions for the stratigraphy and facies of Windsor and Mabou rocks in areas of evaporite flow, which merit further investigation.

Coastline change detection utilizing ground-based laser scanning

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The study area is Cape John, Nova Scotia where the coastline consists of sedimentary bedrock headlands separating an embayment which transitions in relief and material type from steep bedrock cliffs to a glacial till bank and finally into a dune and salt marsh environment. The focus of this study was to examine the change of the glacial till bank, which is comprised of red fine grained unconsolidated sediments and clay with few clasts, after the 2010 winter storm season. The local relief of the bank is 5-7 m and consists of a grass pasture landward of the coast. The area has been studied utilizing traditional airphoto change detection methods and rates calculated. However, because the airphotos are acquired on a decadal scale, it is difficult to quantify the effects of a single storm event or storm season. Airborne lidar has been acquired over the site yearly since 2006, however the rates of erosion and steepness of the terrain have been at the precision limit of change detection for the surveys. A ground-based lidar unit, Optech ILRIS, was used to survey the glacial till bank in June, July, October, and December, 2010 and in January, 2011 to monitor change. In addition to the lidar and GPS surveys, a weather station and water level sensor were deployed to capture the

environmental conditions. A strong winter storm, a classic Nor' easter, affected Maritime Canada on December 21, and to a lesser extent again on December 28, 2010. The storm surge caused extensive coastal flooding and erosion for many coastal communities with shorelines exposed to the north and east. The tide gauge indicates a maximum water level of 2.2 m and the debris wrack line elevation is 2.4 m. The ILRIS scans were geocoded and derived surface models were compared. The points and surface models were used to assess the gradual erosion from June to December and the catastrophic erosion on December 21 and 28. The erosions vertical limit of the bank is between 4-5 m based on the longitudinal and transverse profiles. Along a 150 m section of the bank, 771 cubic metres of material was removed between December 16 and January 4. The pattern of erosion is typical of coastal areas with an increase in the bank slope and a lowering of the beach elevation adjacent to the bank and raising the beach farther seaward. The steep bank slope remained stable while the ground was frozen but slumped in the spring as a result of thawing and increased saturation levels in the soil.

A new geological interpretation of the Antigonish Highlands, northern mainland Nova Scotia

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A revised interpretation of the geology of the Antigonish Highlands has resulted from field mapping combined with petrological and geochronological data. The oldest units recognized are Late Neoproterozoic calc-alkaline volcanic and associated sedimentary rocks of the Keppoch, James River, Livingstone Cove, Morar Brook, and Chisholm Brook formations, all assigned to the Georgeville Group. Previously published U-Pb detrital zircon ages indicate that the Georgeville Group was formed between ca. 621 to 612 Ma. The Georgeville Group is intruded by a suite of co-magmatic, calc-alkaline, dioritic to syenogranitic plutons, some of which were previously considered Devonian to Carboniferous in age and some of which were mapped as volcanic rocks. New and published U-Pb zircon data indicates an age range from ca. 615 to 605 Ma for intrusion of these plutons.

The dominantly sedimentary Bears Brook Formation, previously included in the basal part of the Ordovician to Devonian Arisaig Group, is now interpreted to be Late Neoproterozoic. In addition, the Malignant Cove Formation, previously included in the basal part of the Cambrian sedimentary-volcanic succession, is now considered to be part of the Bears Brook Formation, based on their similar lithologies. This interpretation is further substantiated by previously published detrital zircon U-Pb ages from the redefined Bears Brook and former Malignant Cove formations, which indicate pre-585 Ma ages.

The redefined Iron Brook Group in the northern Antigonish Highlands consists of a fault-bound package of sedimentary rocks that has yielded Early Cambrian microfossils. The previously interpreted interlayered mafic flows in this group are mafic sills whereas the volcanic rocks (Arbuckle Brook Formation) are now considered to be Late Neoproterozoic and not part of the Iron Brook Group. All of the Neoproterozoic and Cambrian rocks are intruded by the previously unrecognized but widespread ca. 485 to 470 Ma West Barneys River plutonic suite, which consists of syenite to alkali-feldspar granite and tholeiitic transitional to alkalic gabbro formed in an extensional setting.

In the northern Antigonish Highlands, north of the Hollow Fault, extension continued until at least ca. 454 Ma with the deposition of the bimodal Dunn Point and McGillivary Brook formations. The contact of the latter formation with the overlying Early Silurian to Early Devonian Arisaig Group appears to be conformable. The Dunn Point and McGillivary Brook formations are absent south of the Hollow Fault, where the overlying Arisaig Group rests with an angular unconformably on older units, including the Bears Brook Formation.

These new field observations, petrological data, and ages have dramatically changed the previously published geological map and hence the understanding of the tectonic evolution of this part of Avalonia in the northern Appalachian orogen.

Paleolimnological records of post-glacial wetland evolution from the Chignecto Isthmus region, eastern Canada

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The Isthmus of Chignecto on the New Brunswick-Nova Scotia border is the location of the Tantramar, Missaguash, and Amherst marshes, which together form a large coastal wetland system that has been the focus of much ecosystems research and habitat modification, even though little is known about systems evolution. In this study, lithostratigraphic and chemostratigraphic lake sediment records from three lakes are used to provide a high resolution record of post-glacial environmental change for the region.

Lake sediment stratigraphy indicates rapid fluctuations in lake productivity and sedimentation rates. Basal dates for the lakes range from >10 000 cal. yr BP to <4000 cal. yr BP. Chemostratigraphic proxies indicate rapidly fluctuating salinity and oxygen levels in two of the three lakes and show that multiple, prolonged saltwater incursions took place. Analyses of metals indicate anomalously high pre-historic concentrations of Hg (~900 ppb) that coincide with stratigraphic proxies of salt water influx. Historic concentrations of Pb and Hg provide evidence for significant atmospheric deposition from industrialization in the region during the late 1800s and early 1900s.

Collectively, these data suggest that a more sophisticated model is required to adequately explain the physical evolution of this extensive wetland system. Periods of sustained saltwater influx into freshwater systems were likely a fundamental driver of systems change. Additionally, both anthropogenic and natural disturbances of the lakes and wetlands have the potential to increase the bioavailability of contaminants. Management of these wetlands must take into account the sensitivity of the wetland system to environmental disturbance.

Petrological comparison of Devonian megacrystic plutons: Cameron Brook pluton, Nova Scotia and Gaytons pluton, New Brunswick

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Cameron Brook in northeastern Cape Breton Island and Gaytons in southeastern New Brunswick are both megacrystic granitic plutons of similar age (U-Pb zircon ages of 402 ± 3 Ma and 390 ± 0.5 Ma, respectively), and both are inferred to be located in Ganderia. Both plutons consist mainly of coarse-grained megacrystic monzogranite gradational to quartz monzodiorite with large (up to 3 cm long) microcline and less abundant plagioclase phenocrysts in a medium- to coarse-grained groundmass of plagioclase, microcline, quartz, and variable amounts of amphibole and biotite. The Gaytons pluton tends to contain less quartz and is mainly quartz monzonite to quartz monzodiorite whereas the Cameron Brook pluton tends to have more quartz and is mainly monzogranite to granodiorite. In both plutons plagioclase phenocrysts are zoned and range in composition from oligioclase to albite. Graphic intergrowths of quartz and K-feldspar occur in some samples, and myrmekite is common where groundmass plagioclase is in contact with K-feldspar. Titanite, apatite, and zircon are moderately abundant accessory phases.

Strongly foliated megacrystic monzogranite is also a component of the Neils Harbour Gneiss, north of the Cameron Brook pluton, and yielded an identical previously published U-Pb (zircon) age of 403 ± 3 Ma. These rocks are interpreted to represent dykes that were deformed with their metamorphic host rocks. The host rocks of the Gaytons pluton are not exposed and hence are unknown.

In addition to megacrystic rocks, both plutons include fine- to medium-grained granitic units of similar mineralogy. In the case of Cameron Brook, the relationship to the dominant megacrystic granite is uncertain but at Gaytons, fine grained granite intrudes megacrystic granite and forms the northwestern part of the Gaytons quarry, east of Memramcook River. The fine grained unit is more felsic than the megacrystic unit, with microphenocrysts of quartz as well as plagioclase and microcline in a fine-grained allotriomorphic groundmass of the same minerals, plus minor biotite.

Whole-rock chemical data are available for 10 samples from Cameron Brook pluton and 9 samples from Gaytons pluton. Major element oxides show similar trends, consistent with similar origin and crystal fractionation processes in both suites of samples. Both plutons have calc-alkalic I-type granitoid characteristics, and tectonic discrimination diagrams suggest a volcanic-arc setting for both. Chondrite-normalized REE patterns are similar in both plutons, with strong enrichment in the light REE (up to 400 times chondritic values) and strong depletion in heavy REE (about 10 times chondritic values). Similarities in age, composition, and tectonic setting suggest that these plutons formed during the same subduction-related tectonic event in Ganderia.

Paragneisses, migmatites, and anatectites of the central Miramichi Highlands: a distinct Ganderian basement block?

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The central Miramichi Highlands are underlain mainly by metasedimentary rocks of the Miramichi Group, Ordovician to Devonian felsic and mafic intrusions, and a dismembered belt of high-grade rocks referred to as the Trousers Lake Metamorphic Suite (TLMS). The TLMS consists mainly of thinly banded paragneiss and lesser volumes of amphibolite, and is intruded by intensely foliated plutonic rocks, including the Moose Lake Gabbro and the 451 + 15/-1 Ma Fox Ridge (augen) Granite. In places, the paragneiss is observed to grade into migmatite, or alternatively into a granitoid anatectite locally containing nebulitic, partially assimilated “rafts” of paragneiss and/or a relict foliation inherited from the paragneiss. Large pods, veins, and lenses of unfoliated, muscovite-rich, locally garnetiferous granite and pegmatite have commonly intruded the paragneiss/migmatite.

It is generally held that the TLMS is a higher-grade equivalent of Cambrian to Early Ordovician sedimentary rocks of the Miramichi Group; however, preliminary observations and comparisons suggest that this may not be the case. The Miramichi Group has experienced high-grade metamorphism (garnet, andalusite, or sillimanite are commonly present), but primary bedding in the form of alternating psammitic (quartzite) and pelitic beds is easily identified. In contrast, the paragneiss is homogenous and displays no relict primary bedding; in particular, the thick quartzite beds that characterize the lower part of the Miramichi Group are absent from the paragneiss. Semi-quantitative analyses by XRF (although lacking accuracy in absolute terms) show significant geochemical differences between shales and siltstones from the Miramichi Group, and paragneisses from the TLMS. Amphibolites in the TLMS have been shown to be chemically analogous to Ordovician mafic volcanic rocks of the Tetagouche Group in the northern Miramichi Highlands, but the amphibolites are considered to be dykes or sills, most likely cogenetic with the Moose Lake Gabbro, hence their occurrence in the paragneiss does not imply any age correlation between the latter and the Tetagouche Group. Similarly, the age of the Fox Ridge Granite sheds no light on the age of the paragneiss. Preliminary geochronological work on the TLMS (M.L. Bevier, unpublished data) indicates the presence of inherited zircons ranging in age from 850 Ma to 1.2 Ga; concordant ages of 434 Ma from monazite in the leucosome probably date peak metamorphism in the Silurian, very similar to the peak date established in Newfoundland. Considerable study, including detrital zircon profiles for the TLMS and Miramichi Group, is required to evaluate the possibility that the TLMS may represent a distinct Ganderian basement block, perhaps correlative with basement gneisses in the Hermitage Flexure area of Newfoundland.

Biotite analysis of felsic intrusive rocks near the Sisson Brook W-Mo-Cu deposit, west-central New Brunswick

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Four intrusive units have been found in the vicinity of the Sisson Brook W-Mo-Cu deposit: (1) medium-grained, equigranular muscovite-biotite granite with brown biotite that is slightly altered to chlorite along the rim and foliation; (2) biotite granite with ca. 20% greenish brown to reddish brown biotite and accessory zircon, apatite, monazite, magnetite, titanite, sulphide, and ilmenite; (3) biotite-bearing granite dykes with similar mineralogical features as the biotite granite, except these dykes are more highly evolved (higher Zr/TiO_2) and have apatite as the main accessory mineral as inclusions in biotite; and (4) porphyry dykes with phenocrysts consisting of approximately 23% plagioclase up to 1 cm, 10% quartz up to 7 mm, 8% biotite up to 0.3 mm in length, and 7% K-feldspar. The distinctive colour of the biotite in the biotite granite sub-class may signify that the magma crystallized under variable redox conditions.

The electron probe micro-analyzer (EPMA) data of biotite phenocrysts from all units indicates >0.5 Fe/(Fe + Mg) and a large range of ∑Al values. Compared to the Nashwaak pluton, biotite in the highly evolved, altered dykes has lower TiO_2, Zn, K_2O, Na_2O, and higher Al_2O_3. The Mn and Ca contents are generally low and constant. These biotite compositions are consistent with biotites from the entire Gander Zone of New Brunswick and are similar to biotite from I-SCR (strongly contaminated and reduced I-type) granites. On the MgO-FeO*-Al_2O_3 diagram, the biotite analyses plot in the calc-alkaline and peraluminous fields, which may be related to subduction and collision regimes, respectively. In these environments, the biotite composition is controlled by substitution of Mg-Fe and 3Mg-2Al. The *f*HF/*f*HCl ratio of all of the biotites are higher than porphyry Cu deposits and lower than porphyry Mo deposits, but similar to the CanTung tungsten deposit.

Geophysical modeling in the Cabot Strait - St. Georges Bay area between Cape Breton Island and western Newfoundland, Canada

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In this study geophysical methods are used to investigate the pre-Carboniferous rock units under Cabot Strait and St. Georges Bay to try to correlate them with onshore units in both northeastern Cape Breton Island and southwestern Newfoundland. Filtered magnetic and gravity maps of the study area were generated using UNIX-based GMT software. The magnetic and gravity data were further enhanced using 1st and 2nd vertical derivatives, high pass – low pass filters, and horizontal and vertical gradients. The best results are produced by the 1st and 2nd vertical derivatives of magnetic data, as the first vertical derivative allows for sharper resolution of near-surface features, and the 2nd vertical derivative enhances local anomalies otherwise obscured by regional trends and helps with edge detection of source bodies. Based on the compiled maps and further constrained by seismic interpretations, 2D subsurface modeling is in progress with GM-SYS 4.2 2D modeling software; three models extend across the Cabot Strait, two models cover an enigmatic circular magnetic anomaly located 25 km offshore from Ingonish in eastern Cape

Breton Island, and one model is in St. George's Bay in Newfoundland.

The 1st vertical derivative of the magnetic data show a linear magnetic high associated with Ordovician to Silurian metasedimentary and metavolcanic rocks of the Money Point and Cape North groups extending offshore to St. Paul Island. The Money Point Group also extends across the Cabot Strait to the Port aux Basques area of southwestern Newfoundland. The 2nd vertical derivative map reveals that the offshore Ingonish magnetic anomaly is composite and some components may link to units inshore. A linear magnetic high associated with the Neoproterozoic George River Metamorphic Suite extends offshore towards the anomaly, as do similar linear magnetic highs associated with the Neoproterozoic Birch Plain granite, Indian Brook granodiorite, and Ingonish River tonalite, and the Devonian Ingonish Island rhyolite. It is not yet clear which of these units contribute to the anomaly, or whether any of them can be inferred to extend to Newfoundland.

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