Atlantic Geoscience Society

ABSTRACTS

2007 Colloquium & Annual General Meeting

MONCTON, NEW BRUNSWICK

The 2007 Colloquium & Annual General Meeting was held at the Delta Beausejour Hotel, Moncton, New Brunswick, on February 2 and 3, 2007. On behalf of the society, we thank Colloquium Chairs Susan Johnson, Mike Parkhill and Reg Wilson and their organizing committee (Marc Desrosiers, David Lentz, Cyndie Pitre, Toon Pronk, Ian Spooner, Ryan Toole, and Peter Wallace) for providing an excellent meeting. We also wish to acknowledge support of the corporate sponsors: Association of Professional Engineers and Geoscientists of New Brunswick; Blue Note Caribou Mines Inc.; Canadian Institute of Mining, Metallurgy and Petroleum; Corridor Resources Inc.; First Narrows Resources Corporation; Freewest Resources Canada; Potash Company of Saskatchewan (New Brunswick Division); Society of Economic Geologists; Université de Moncton; University of New Brunswick; and Xstrata Zinc Canada

In the following pages, we are pleased to publish the abstracts of oral presentations and posters from the Colloquium, which focused on: Patterns and Geohazards in the North Atlantic; Late and Post-Glacial Climate Change Events in Eastern Canada; Salt Matters: Tectonic, Thermal, and Resource Aspects of Paleozoic to Mesozoic Evaporite Basins; SEG Student Chapter, Mineral Resources Research; Dendrochronology; Current Research in the Atlantic Provinces; a Physical Volcanology Workshop; and a North American Soil Geochemical Landscape Project Orientation Session.

THE EDITORS

Geology, petrology, geochemistry, and economic potential of a Neoproterozoic to Triassic accreted terrane, in southern Sukhbaatar Aimag (province), south-eastern Mongolia

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The southern Sukhbaatar Aimag (province) in southeastern Mongolia is a collage of Paleozoic to Lower Jurassic accreted island-arc and oceanic terranes and Precambrian cratonic basement, that were amalgamated between Neoproterozoic and Triassic times. This study investigates an 11x8 km area in the southeastern portion of the Nuhetdavaa Terrane, a Neoproterozoic to Lower Jurassic sequence of marginal sedimentary rocks, thick volcanic rocks, and late plutonic rocks, which are interpreted to represent mainly back-arc environments. This study describes the preliminary results of field, petrographic, and geochemical studies aimed at elucidating the petrogenetic, metallogenetic, and tectonic history of this poorly understood but economically and scientifically important area.

Three unconformity bound packages of rock occur in the field area: metasedimentary rocks of probable Early Paleozoic age form a basement to a package of Late Paleozoic bimodal volcanic rocks, which are separated from recent (Triassic?) shales and conglomerates by another regional unconformity. The metasedimentary and volcanic units are intruded by several medium sized granite and diorite stocks which are coeval with the Late Paleozoic volcanic rocks. The metasedimentary rocks are hornfelsic which are composed of alternating green, and dark gray layers. They are fine-grained and composed of mosaic quartz and alkali and plagioclase feldspar with minor hornblende and biotite porphyroblasts. Accessory apatite, zircon, and titanite are also present. Quartz and muscovite porphyroblasts are abundant near intrusive contacts. Felsic volcanic rocks occur as coherent domes composed of flow banded, quartz phyric rhyolite which rapidly grades into aphanitic spherulitic rhyolite with abundant lithophysae. Bimodal volcanism is indicated by the spatial association with vesicular basalt. Coeval intrusive rocks are represented by granitoids ranging from diorite to tonalite to 2-mica leucocratic granite. Diorites are fine- to coarse-grained and have characteristic glomeroporphyritic, optically zoned hornblende, ranging from 2 mm to 1.5 cm in length. Plagioclase compositions range from andesite to albite; these crystals are typically altered to sericite. Field relationships suggest that granite emplacement postdated the dioritic intrusive event.

Geochemically, rhyolite and granite have similar compositions with a strong negative slope on a primitive-mantle normalized multi-element diagram $(Th/Sm = 19.97)_{N,\,a}$ strong negative Nb and Ti anomaly and flat Dy - Lu slope. Rhyolites have slightly elevated levels of incompatible elements with respect to granites. Diorites have a slight negative Th - Sm ratio, positive Th anomaly and flat Ti to Lu slope.

The northeast-trending Zuunbayan sinistral strike-slip fault bisects the field area and separates it from the highly economic and potentially coeval rocks of the Oyu Tolgoi Cu Au porphyry deposits situated in similar geological terrane approximately 450 km to the southwest. The occurrence of vuggy miarolitic rhyolite and associated granites in a flow-dome setting spatially associated with structurally controlled chalcedonic quartz veins and breccia exposed over several kilometres indicate an environment favourable for epithermal-type mineral deposits. The alkaline volcanic and intrusive rocks that are dominant in the field area are analogous to those at Oyu Tolgoi and other world-class porphyry systems.

Palynological responses around the Gulf of St. Lawrence to the North Atlantic Preboreal Oscillation and 8.2 cal ka cold events

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An examination of post-Younger Dryas (YD) pollen stratigraphies in the Gulf of St. Lawrence and St. Lawrence estuary region reveals features in the pollen records that represent breaks in the normal vegetation succession, widespread vegetation suppression, and a delay in migration of plant taxa between 9.7 and 7.2 ^{14}C ka (11.2 and 8.0 cal ka). The domination of *Alnus crispa* at sites bordering the St. Lawrence estuary-Gulf region in Gaspésie and northern New Brunswick represents a diversion from the typical vegetation progression from *Picea* and/or *Populus* or *Picea/Betula* to *Pinus* and/or *Betula*, and signifies a shift to a cooler, drier climate. Coinciding with the *Alnus crispa* expansion in that region were other signals of cooling, *viz*., the contraction and replacement of *Picea* populations by the first appearance of tree birch, *Betula papyrifera* in southwestern New Brunswick and eastern and southeastern Nova Scotia, and by a resurgence of shrub birch, *Betula glandulosa*, in western and southwestern Newfoundland where it is reliably dated at 9720 ± 110 ^{14}C BP (10,800–11,240 cal BP). This first post-YD episode of widespread cooling is correlated with the North Atlantic Preboreal Oscillation. Sites exposed to winds from the Gulf of St. Lawrence in eastern New Brunswick, Prince Edward Island, and northern Nova Scotia show a lingering persistence of *Picea* and delay in arrival of *Pinus* to 8.0 and 7.7 ^{14}C ka (9.0 and 8.4 cal ka), yet *Pinus* was dominant as early as 9.4 ^{14}C ka (10.6 cal ka) in southwestern New Brunswick. At the same time, tundra vegetation persisted at high elevations in western and southwestern Newfoundland only to be replaced by upslope migration of shrub-birch heath by 8 ^{14}C ka. Prolonged broad-scale cooling to 8 ^{14}C ka and to as late as 7.7 ^{14}C ka extended up to 200 km inland in areas exposed to the St. Lawrence estuary and Gulf region and was in response to strong, cold, dry anti-

cyclonic winds coming off the retreating Laurentide Ice Sheet in combination with enhanced freshwater runoff through the Gulf of St. Lawrence.

Several sites document a subsequent cold shift, that interrupted regional warming at 7650 to 7200 ^{14}C BP (8400 to 8000 cal BP), and which is variously represented by the suppression of *Pinus* and resurgence of *Picea*, sometimes with *Alnus crispa* (Québec-Maritime region), or by an abrupt decrease of *Picea* and resurgence of *Betula* (western Newfoundland). This second post-YD cool interval is equated with the 8200 cal BP cold event registered in the Greenland ice isotopic record.

Using confectionaries to teach geology

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Teaching geology to post-secondary students is both very rewarding and challenging. Many students take geology for the first time in university and may come with little or no science background. If this is the case they may be intimidated by some of the principles that geologists believe are fundamental.

Demonstrations have long been one of the best tools for teaching geology. Who doesn't remember the oscillations of P- and S- waves likened to a spring? In teaching first-year geology students I have found that using confectionaries as a medium to convey geology principles has led to a greater understanding and appreciation of geology. Examples include the use of various types of cookies to show density differences, methods of classification, and homogeneity and heterogeneity in rock types. Other demonstrations include the use of amorphous candy to show brittle fracture and ductile deformation, and layer cakes to show the different possible exposures of dipping faults in a horizontal surface.

Knowledge of how our world works and basic geology concepts are important for future policy makers and the general public so that they can make informed decisions regarding public policy. As most first-year geology students don't continue on in geology, it is important to impart these principles in a way that will be both understood and retained.

The sedimentology and diagenesis of a Mississippian brachiopod biostrome in the vicinity of Newport Landing, Hants County, Nova Scotia

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A biostrome formed primarily of brachiopods (terebratulids, productids, spiriferids) and bryozoans (delicate branching fenestellids) is present in the Mississippian Windsor Group in the vicinity of Newport Landing, Nova Scotia. This build-up is in the pioneer stage of reef development and records arrested ecological succession. The ubiquitous presence of filter-feeding organisms and the occurrence of disarticulated crinoids indicate biostrome development occurred under mesotrophic, normal marine, non-evaporitic conditions with periods of current reworking. Cathodoluminescent microfabrics and stable isotope data (δ^{13}C and δ^{18}O) from brachiopod valves imply alteration during burial diagenesis. These results demonstrate that the chemistry of some Windsor Group brachiopods is not a reliable gauge of Paleozoic seawater composition.

A petrogenetic model of prospective stratigraphy in the Eskay Rift, northwest British Columbia

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The Eskay Rift records the transition at the Early to Middle Jurassic boundary, from a sporadic and long-lived period of subduction-related island-arc volcanic activity to a brief period of extensional tectonics accompanied by rift-related volcanism. The rift-related volcanic rocks, unofficially referred to as the "upper Hazelton Group", are the youngest volcanic rocks in the Stikine Terrane, in northwestern British Columbia. They host the world-class Eskay Creek volcanogenic massive sulphide (VMS) deposit, as well as more than 60 other VMS prospects. Although the upper Hazelton Group is preserved as 25 separate erosional remnants or separate subbasins, the lithologies, geochemistry, and morphologies of far-separated segments correspond closely to one another. The ubiquitous presence of thick piles of pillow basalt in the rift graben suggests that it was a basin which experienced rapid subsidence and quickly filled with mafic lava. The rapid infilling of the graben with mafic lava overwhelmed the potential for long-lived hydrothermal convection and black smokers, which are essential to the formation of large VMS deposits. However narrow intervals of bimodal volcanic and sedimentary rock, within the rift, represent episodes when conditions were highly favourable for the formation of VMS deposits. While these sequences contain up to 50% pillow basalt, they are characterized by the presence of three distinct lithologies: 1) felsic flows, domes, and cryptodomes; 2) sedimentary and volcaniclastic intervals, locally known as "pyjama beds", which are composed of black pyritic siliceous argillite interbedded on a 5 to 20 cm scale with light coloured felsic tuff; and 3) a distinct variety of basalt, which has a phaneritic, medium-grained texture and forms massive and columnar jointed sills and flow units which are up to 20 m thick. Fine-grained sedimentary rocks within these sequences indicate a time of relative quiescence when the graben was not being inundated with mafic lavas. During these quiescence periods, mafic magmas, which were still being generated in the upper mantle, resided in crustal-level magma chambers and began to crystallize, emitting heat generated from crystal formation. This heat caused a small degree of partial melting

in the upper crust, generating felsic magmas. During tectonic activity, new conduits allowed the eruption of felsic lava, liquid mafic lava, and a crystal mush from the crustal magma chambers. According to this model, the co-occurrence of these volcanic and sedimentary rocks mark prospective stratigraphy because: 1) they suggest a time of quiescence in a graben which is more typically being inundated with mafic lavas; and 2) they represent periods with the greatest potential for vigorous hydrothermal circulation due to the presence of near-surface, crystallizing, mafic magma chambers.

The Zealand Station beryl deposit, west-central New Brunswick: mineralogic, geochronologic, and petrogenetic constraints

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The Zealand Station beryl deposit is located 30 km northwest of Fredericton, New Brunswick, along the northeastern cusp of the Devonian Pokiok Batholith that has been mapped as the Hawkshaw Granite, previously dated at 411 ± 1 Ma by U-Pb titanite. The Pokiok Batholith intruded Early Silurian Kingsclear Group metasedimentary rocks. The Hawkshaw Granite in the Zealand Station area is characterized by pink to grey, medium-grained biotite granite that displays local textural variation. Also present, is a late-stage southeast-trending aplite dyke recently dated at 401 ± 2 Ma by U-Pb in zircon, which is likely related to the Allandale Granite, previously dated at 402 ± 1 Ma by U-Pb in monazite.

At the Zealand Station beryl deposit, the host granite is altered to greisen in pockets (<3 m wide) and along veins that have associated molybdenite booklets and beryl. The quartz-rich veins have two predominant orientations: 135°/90°, and 010°/75°W, and <5 cm wide and traceable for up to 30 cm, with rare molybdenite pockets <1.5 cm thick. Located 50 m from the study area is a small exposure of a pegmatite phase of a similar dyke that is predominately quartz and orthoclase with crystals reaching about 30 cm in size, and coarse-grained muscovite booklets. The euhedral beryl is clear, blue to greenish blue and up to 1 cm in diameter. In addition, there is up to 20 vol.% beryl in the aplitic phase. The beryl in the granites and veins vary from 4 ppm Be to >0.72 wt.% BeO with an average concentration of 0.1 wt.% BeO.

The eight beryl samples analyzed by EPMA at UNB come from the aplite phase, the granite phase, and beryl-bearing quartz veins. The common formula of beryl is $Be_3Al_2Si_6O_{18}$, with Fe^{2+}, Cr, and V as possible chromophores that substitute into the beryl structure. The Cr and V average concentrations were 0.0006 apfu (atoms per formula unit) and 0.007 apfu, respectably. The dominant chromophore must be the substitution of ferrous iron into the channel sites resulting in the characteristic blue colour. Additional elemental substitution into the beryl structure display expected trends against charge-balancing elements. Beryl from the veins and granitic aplite show contrasting features including the vein-beryl rims having greater octahedral-site substitution and higher Cs in channel sites, reflecting increasing fertility during growth. The rims in the granite-beryl and aplite-beryl show the opposite zoning relationships. The channel site abundances are a function of the Li substitution as controlled by the charge balance in the Be tetrahedral site. One sample from a vein-beryl showed oscillatory zoning with expected charge balance trends, but with most significant alternating peaks of Cs/Li and Na/Li.

Initiation and early evolution of salt withdrawal mini-basins

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Salt withdrawal sedimentary basins, termed mini-basins, that are characteristically 10–20 km in diameter and up to 10 km deep are common features of rifted continental margin salt tectonic provinces. In the Gulf of Mexico, for example, they occur as clusters in which the planiform subcircular basins are bounded and divided by salt ridges and diapirs. The most dramatic examples populate the salt canopy region landward of the Sigsbee Escarpment. Their development is generally attributed to buoyancy driven flow in which sinking denser overburden displaces lower density salt which rises into adjacent highs, an example of a Rayleigh-Taylor (R-T) instability. However, this mechanism will not work when the average density of the compacting overburden in the basins is less than that of the salt. This situation typically prevails for clastic sediment until its accumulated thickness is approximately 3 km. An alternative mechanism must therefore be found to initiate the mini-basins and foster their development until the R-T instability can take control. This mechanism has remained a mystery.

We propose a three-component mechanism that initiates and grows mini-basins. It involves the early sedimentation onto the salt layer, the lateral flow of sediment and salt, and the isostatic response of the salt to the sediment load. The key process that is required is early-stage localized convergence (ΔV ~ cm/yr) among laterally translating regions of thin sediment (m's thick, km's radius) resting on the (~km thick) salt layer. This laterally convergent flow typically occurs in the unstable toe of continental slope regions. The convergent zones behave much like pressure ridges between ice floes except that the material that fills the ridges is the salt, not overburden. The dynamical height of these salt ridges controls the whole process. Where the lateral motion of the overburden is uniform it drags the salt in an underlying uniform Couette channel flow.

In the convergent regions, where the velocity changes, excess salt accumulates and is either pumped vertically into the pressure ridges or expelled laterally in the salt layer as a Poiseuille channel flow. The maximum dynamical height of the ridges is determined by the lateral differential pressures they generate. As the ridges grow vertically, progressively more of the accumulating salt is pumped laterally and they achieve their maximum height when all additional salt is expelled in this way. However, the lateral pressure gradient and associated Poiseuille flow are reduced by sedimentation that fills the accommodation (the nascent mini-basins) between the pressure ridges. Sediment loading therefore leads to a positive feedback mechanism when sedimentation keeps pace with the upward pumping of the ridges because the ridges can continue to grow vertically and create more accommodation.

Lubrication theory, an approximation commonly used in mechanical engineering, can be used to understand the mechanics of this system and leads to a governing equation for the maximum height of the pressure ridge and corresponding depth of the mini-basin,

$$\Delta h = \frac{3\eta \Delta V L}{(\rho_s - \rho_o) g h_c^2}$$

where, η is the salt viscosity, ΔV is the change in velocity of the overburden across the pressure ridge, L is the average half-length (radius) of the adjacent mini-basins, h_C is the thickness of the salt layer, g is the acceleration due to gravity, and ρ_S and ρ_O are the salt density and the average density of the compacting sediment overburden. If the system can achieve a $\Delta h \sim 3$ km, the average density of the compacted sediment exceeds the salt density and the process continues via the buoyancy driven R-T mechanism.

Micro-CT distinction of dolomite, calcite, and porosity in hydrothermally dolomitized carbonate from the Sayabec Formation (Lower Silurian), Gaspé

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Hydrothermally dolomitized carbonate samples from the Lower Silurian Sayabec Formation in northwestern Gaspé Peninsula (lac Matapédia syncline) have been analyzed using X-ray Computed microTomography (micro-CT). This technique records spatial variations in the X-ray attenuation coefficient that may correspond to mineral and pore distributions in the rock.

Preliminary micro-CT scans were undertaken at relatively low X-ray energy (<100 keV) and successfully imaged the fracture porosity. In addition, calcite was manifested by regions of greater X-ray attenuation than dolomite. At such energies the photoelectric effect is primarily responsible for attenuation and the attenuation coefficient is a function of the effective atomic number (Z_{eff}), - with attenuation increasing with Z_{eff}. Consequently, mineral grains that are sufficiently large to be resolved by the instrument, and display contrasting Z_{eff} can be distinguished in a CT scan. In this case, the contrast in Z_{eff} between calcite (15.88) and dolomite (13.94) is sufficient to distinguish between the two minerals, though the presence of Fe in ferroan dolomite would decrease the Z_{eff} contrast.

Micro-CT analysis of samples from potential carbonate petroleum (or groundwater) reservoirs therefore has the potential to not only assist in the non-destructive quantification of porosity, but also to track variation in diagenetic overprinting.

Structure of the Late Paleozoic Pulo do Lobo accretionary prism, southern Iberia: a key to understanding the amalgamation of Pangea

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Determination of the tectonic evolution of accretionary prisms contributes to the understanding of mountain building processes and global plate dynamics. Field mapping and preliminary structural analysis of the Pulo do Lobo (PDL) Formation, associated Beja-Acebuches Ophiolite and suspect "exotic" South Portuguese Zone (SPZ) in southern Iberia suggest that the PDL is an important part of a suture zone associated with the Variscan orogeny, closure of the Rheic Ocean, and the formation of Pangea. Analysis of uplifted strata in the PDL indicates tectonic juxtaposition of diverse deposits such as foreland basin flysch, sedimentary and tectonic mélange, and passive margin shelf, all separated by distinct structural discontinuities. The entire Pulo do Lobo Zone is dominated by a pervasive late stage vertical to sub-vertical E-W cleavage axial planar to isoclinal and chevron folds which overprint earlier deformation fabrics in the older passive margin units. The age of deformation of PDL units is generally considered to be Late Devonian - Early Carboniferous, however further geochronology is needed to resolve the age relationships between individual units.

Numerous local kinematic indicators within the PDL suggest a complex regional deformation with several enigmatic features. For one, structural data produced by local strain partitioning reveal kinematics that contradicts the overall regional structural style (e.g. spatial juxtaposition of both sinistral and dextral fabrics). When viewed at larger scales (i.e. regional map pattern), however, structural data indicate that significant sinistral strike-slip movement occurred in conjunction with episodes of both extension and compression. Stereographic plots of fabric elements from each distinct tectonic domain,

when combined with regional geological constraints, support this hypothesis and are indicative of progressive deformation imposed on the PDL during the Variscan Orogeny. This analysis is also consistent with plate reconstructions, which indicate regional sinistral transpression with local zones of extension. Geochronologic and geochemical work (currently in progress) should constrain the timing of deformation within the PDL as well as resolve contact relationships between the SPZ and the Iberian Massif. These constraints will help to better understand the geological events leading to the closure of the Rheic Ocean and plate dynamics associated with the formation of Pangea.

Metamorphism of impure marble and calc-silicate rocks from southwestern Baffin Island: implications for regional sapphire exploration

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Impure marble and calc-silicate rocks from the Lake Harbour Group, southwestern Baffin Island, exhibit complex mineralogical and textural evidence of high-grade thermal and/or fluid-driven metamorphism. The marbles contain two mineral associations corresponding to their degree of purity. Relatively pure carbonate-rich marbles contain the assemblage forsterite + humite + spinel + calcite + dolomite, and appear texturally equilibrated. Relatively impure silicate-rich marbles contain the mineral association forsterite + diopside + nepheline + phlogopite + calcite, and vary texturally from compositionally foliated to nodular. Inclusion relationships and core-mantle textures indicate the progressive appearance (in relative order) of calcite and phlogopite, diopside, forsterite, and nepheline. Calc-silicates at the contact between the marbles and intruded monzogranites contain two mineral associations. Foliated, essentially monominerallic zones comprising the association diopside + pargasite + calcite are truncated by brittle fractures containing the association scapolite + phlogopite + calcite + clinozoisite. It remains to be determined whether these assemblages resulted from regional granulite-facies metamorphism during the Trans-Hudson Orogeny; contact metamorphism and/or metasomatism during monzogranite emplacement; subsequent fluid-infiltration; or a combination of these. At Kimmirut on southern Baffin Island, intense alteration of nepheline and scapolite has been linked to sapphire formation in calc-silicate lenses within stratigraphically correlative marbles. The scapolite + nepheline association described here may represent a precursor assemblage, suggesting that metacarbonates of the Lake Harbour Group in southwestern Baffin Island may be good targets for regional gemstone exploration.

Physical modelling of the formation and salt tectonics of salt-canopy systems at deepwater continental margins with application to the Jurassic to Early Cretaceous, Abenaki and Sable subbasins, Scotian Margin.

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Now that hydrocarbon exploration is moving into the deeper Scotian Slope, e.g. basinward of the Sable and Abenaki subbasins, a better understanding of the formation and controlling factors of the complex allochthonous salt canopy systems of the deepwater Scotian Slope is needed. The purpose of the study is to use physical experiments with high-resolution strain monitoring techniques coupled with structural modelling and seismic interpretation to develop new concepts for the formation of the allochthonous salt canopy systems of the Abenaki and Sable subbasins to improve seismic interpretation in the specific areas targeted in recent hydrocarbon exploration. The physical experiments are dynamically scaled and use sieved silica sand and viscous silicone rubber to simulate brittle deformation of sediments and ductile salt mobilization. The experiments include incremental sedimentation of a sand wedge with shelf to basinward progradation. Gravity-driven deformation occurs in the experiments under their own time and simulates passive margin salt mobilization with model sedimentation rates adjusted to the Jurassic to Cretaceous in the Central Scotian Margin. All experiments are monitored using Particle Imaging Velocimetry (PIV) technology to record surface flow and deformation. The experiment series presented in this study systematically varies the basement morphology beneath the silicone basin to investigate the control of possible basement architectures, formed by the rifting stage in the Scotian Margin, on the initial mobilization of the syn-rift Argo salt and late-stage formation of the huge allochthonous salt canopy system in the deepwater slope seaward of the Sable and Abenaki subbasins.

This study focuses on the formation of the allochthonous deepwater salt systems and how these structures will affect future deformation in the system. The preliminary results show that sedimentation pattern and basement morphology greatly affects early salt mobilization which strongly controls the late stage deformation of the allochthonous system and late stage salt mobilization. The results from these experiments will provide greater insight into the structural evolution of the Scotian Basin and will improve the structural and seismic interpretation of the deep water, Scotian Slope.

Glacial dispersal patterns in sediments overlying the Mount Fronsac mineralized deposit, Bathurst Mining Camp, northern New Brunswick

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As part of a TGI-III initiative to investigate methods for locating buried mineralized zones, 253 till samples were collected over a 1 km^2 area in the Mount Fronsac region, in the Bathurst Mining Camp, northern New Brunswick. The mineralized zone outcrops on the western edge of the survey area and is located between the uppermost unit of the Nepisiguit Falls Formation and the lowermost unit of the Flat Landing Brook Formation. Bedrock layers dip 45°, and the topography is bedrock controlled. The deposit is overlain by up to 2 m of till deposited by eastward moving ice during the last glaciation. Till clasts are sub-angular to angular, and consist mostly of metamorphosed chloritic sedimentary rocks, volcaniclastic rocks of the Nepisiguit Falls Formation and felsic tuff/tuffaceous sedimentary rocks of the Flat Landing Brook Formation. The relationship of the clast lithologies to local bedrock units and the angular-subangular nature of the pebbles suggest that the till is basal, with minimal transport.

Till samples were collected at 100 m spacing, with 25 m spacing used along four main grid lines. The samples were analyzed for mercury content using cold vapour atomic fluorescence spectroscopy, a method that is inexpensive, rapid, and highly sensitive to low Hg concentrations. Plotted results demonstrate distinct halos of anomalous mercury concentrations surrounding the mineralized zone that are distinguishable from regional glacigenic geochemical dispersal. Geochemical haloes are typically elongate in areas of maximum slope gradient. However, the haloes observed in this survey are not elongate, suggesting that the concentrations are mainly detrital in origin with minimal secondary hydromorphic and/or colluvial dispersion in the till. Research is continuing on the nature of glacial dispersion and if anomalous mercury values in individual samples are coincident with specific physical characteristics of the till.

The southern Nova Scotia wine terroir: a geological and pedological study of the geochemistry of soils from vineyards with a focus on cation exchange capacity

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Terroir is a concept that recognizes five main factors of the natural environment that affect wine grapes during growth (meteorology, geology, pedology, physiography, and viticulture). Among other issues, the study of terroir attempts to explain why different vineyards produce wines of different quality and taste when virtually identical grapes and processing methods are employed. The complex bedrock geology, pedology, and surficial and glacial geology of southern Nova Scotia are believed to influence the local terroir leading to the production of diverse wine in the region. The research focuses on how geology affects some important properties of soils for wine grapes such as cation exchange capacity (CEC), nutrients, and soil pH. CEC (the ability of soils to hold cations and, as a consequence, nutrients) is a relevant soil property as wine grapes tend to grow better in soils with low CEC.

Twenty-five soil samples were taken from 15 vineyards in southern Nova Scotia to investigate the vineyard terroir. The samples were analyzed for pH, organic matter concentration, and grain size distribution, and sent to the ACME Analytical Laboratories in Vancouver, British Columbia for geochemical analysis using hydroxylamine hydrochloride and ICP mass spectrometry. Cation exchange capacities were estimated using Ca, Mg, K, and Na concentrations for each sample. A high variation in CECs was observed. Both the highest and the lowest CECs occur in vineyards from the LaHave River Valley, ranging from 1.68 meq/100 gm (a sample from a vineyard underlain by Bridgewater loam) to 40.92 meq/100 gm (Bridgewater loam - drumlin phase). In the Annapolis Valley, the samples with the lowest CECs are from vineyards underlain by Kentville soil (6.06 to 15.03 meq/100 gm). Samples with the highest CECs are from a vineyard at the base of North Mountain underlain by Pelton soil (up to 37.63 meq/100 gm), and from vineyards underlain by Wolfville soil on the south facing slope of the Wolfville Ridge (up to 34.70 meq/100 gm). Organic matter concentrations exhibit low variation, ranging from 0.63% to 2.93%, whereas soil pH ranges from 4.86 (in Kentville soil) to 7.25 (in Bridgewater loam - drumlin phase). These results illustrate how soil type and soil geochemistry, including CEC, are linked. Future work will attempt to address how soil geochemistry influences wine character.

Andalusite-topaz relations in peraluminous granites: preliminary results from an experimental investigation

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Textural and chemical evidence shows that most andalusite (Al_2SiO_5) in peraluminous granitic rocks is of magmatic origin, and at least some topaz ($Al_2SiO_4(OH,F)_2$) can also crystallize directly from the silicate melt. Highly evolved peraluminous granites normally contain either andalusite or topaz, but rarely both. In some plutons, the evolution from a magma crystallizing andalusite to one crystallizing topaz signals an increase in the chemical activity of fluorine in the magma, and thus represents an important threshold en route to forming some granite-related mineral deposits. In this paper, we attempt to locate the andalusite-topaz transition in T-P-X space, where T = 750-550°C, P = 200 MPa, and X = A/NK (1.1, 1.2, 1.3, 1.4), F (0.0, 0.5, 1.0, 2.0, 3.0, 4.0 wt.%), and H_2O (2, 6 wt.%), and to determine whether the melt-andalusite-topaz relationship is cotectic or peritectic. The experiments use synthetic gels in the system SiO_2-Al_2O_3-Na_2O-K_2O-H_2O-F as starting materials, run times of 2–22 days, and analysis of run products by X-ray diffraction, using Rietveld refinement, and by electron microprobe. Included seeds of andalusite and/or topaz in all runs assist in overcoming kinetic effects. High A/NK favours andalusite or topaz, whereas low A/NK favours muscovite. High T, low F, and low H_2O promote the formation of magmatic andalusite, whereas low T, high F, and high H_2O promote the formation of magmatic topaz. One run (T = 600°C, A/NK = 1.3, F = 4 wt.%, H_2O = 6 wt.%) shows development of topaz reaction rims on andalusite, suggesting that topaz may be the product of a peritectic reaction between early primary magmatic andalusite and late fluorine-enriched melt. Primary (magmatic) textures in some runs resemble those in quartz-muscovite-topaz greisens. In addition, some low-T - high-F runs contain cryolite (Na_3AlF_6), inviting comparisons with cryolite-bearing granites in the Erzgebirge and elsewhere, and with the Ivigtut pegmatitic cryolite deposit in southwest Greenland.

Effects of forestry on the radial growth trends of treed bogs in southwestern Nova Scotia

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Most Nova Scotian wetlands are afforded protection from the effects of forestry activity and other adjacent habitat disturbances through the preservation of 20+ m buffer zones of mostly intact forest along/around watercourses. Wetlands which do not contain watercourses, however, have been excluded from buffer regulations and timber and/or peat harvesting are permitted within them. Treed bogs (a relatively dry wetland) are an example of one of these unprotected habitats. This study contributes to an evaluation of the need to amend Nova Scotia's forestry and buffer regulations in order to protect these treed bog ecosystems.

A dendrochronological analysis of the radial growth trends of both black spruce (*Picea mariana*) and larch (*Larix laricina*) was conducted at six treed bog ecosystems in southwestern Nova Scotia. Three pristine bogs and three bogs in close proximity to forestry activity were sampled. The role of these trees as indicator species of treed bog ecosystem health is being explored in an attempt to determine whether adjacent forestry activity has negatively affected treed bog ecosystems, and if so, to what extent. Preliminary results indicate that changes in tree radial growth is probably as a result of changing water availability associated with forestry activity. Ultimately, the aim of this study is to emphasize the need to conserve treed bogs in the highly forested southwestern Nova Scotia region.

Important geological parameters in the assessment of LOI data for delineation of climate change

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Loss-on-ignition (LOI) is the most commonly used method to measure the organic content of sediments for the delineation of past fluctuations in climate. Recent publications have discussed in detail, suggested optimum temperatures and duration to burn off organic carbon. The accepted LOI procedure is that sediment samples are weighed to calculate original weight (W), then dried (Wd) at 105°C to remove moisture (Mc = W - Wd_{105}), and finally burned at 550°C to calculate LOI (LOI = Wd_{105} - Wd_{550}). It has been demonstrated that the Wd_{550} weight represents ignition of all organic compounds in the sample. However, few studies have considered the possibility of an LOI error due to the occurrence of coal in the sample.

Examination of core samples collected from the Grand Lake - Saint John River valley for LOI analysis were found to contain traces of coal or charcoal in the upper one metre, likely due to historical transport. Samples from known coal deposits at Minto, New Brunswick, were collected and tested to determine combustion temperatures. Tests were repeated for organic residue (collected by hand) to provide a reasonable estimate of coal-free organic matter (LOI). Ignition tests were conducted under various temperatures and duration to identify the optimum combination that would enable distinction between the organic and inorganic (coal) content by LOI.

Results indicate that coal from our study region begins to burn off below the temperature recommended for organic LOI

analysis (300°C). However, in some regions complete ignition of the coal may require higher temperatures. In addition, the transport distance for coal detritus is dependent upon the hardness of the local coal variety (0.5–3.0 Moh's) and the energy of the transporting agent. In our region the coal is soft (<2.0 Moh's) and transport distance is likely limited to a few kilometres. Results presented here indicate that it is paramount that LOI data be supported by knowledge of local coal deposits and an understanding of sediment processes. LOI data published without consideration of the possible contribution of local coal detritus should be considered suspect.

The application of high-resolution laser altimetry to deglaciation dynamics: Bridgetown, Nova Scotia

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The application of high resolution laser altimetry, using light detection and ranging (LiDAR), is a new technique used to study glacial landforms on the North Mountain and in the Annapolis Valley of Nova Scotia. Small scale glacial landforms such as esker flank fans are difficult to identify using traditional methods and may hold clues to the deglaciation dynamics of the project area. High resolution, "bald earth", digital elevation models (DEM's) are produced from LiDAR data and used to identify numerous surficial and glacial landforms that were not detected with previous mapping methods. Manipulation of digital topography data highlights these features, allowing spatial models to be developed of their occurrence and relation to other surficial features. An esker system north of Bridgetown and striae in the Annapolis Valley confirm previous movement of active ice across the North Mountain towards the Bay of Fundy. Numerous wave-cut terraces which have truncated the lower elevations of the esker system north of Bridgetown during late glacial sea-level rise (12–14 ka) are visible on the high resolution DEM's. The presence of wave-cut terraces and the esker system may confirm that the glacial margins were subject to calving and decreased stability allowing more ice to flow towards the Bay of Fundy. LiDAR data provides significant improvements and quality benefits when mapping surficial deposits and landforms that are otherwise undetectable using previous methods. The ability to detect subtle glacial landforms greatly enhances the understanding of deglaciation.

Groundwater and the Pleistocene glaciation in Canada

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Hydrogeological data and models provide insight on both the climatic conditions and glacial dynamics during the end of the last ice age. There is an abundance of isotopic and chemical data in western and central Canada indicating a large influx of subglacial recharge into regional aquifers during the Pleistocene and subsequent evolution of proglacial lakes. Physical evidence of shifts in hydrological conditions has been found by examining geomorphological features created by over pressurization of aquifers and groundwater sapping during the Pleistocene and early Holocene. Few, if any examples of paleogroundwaters are known in Atlantic Canada, but preliminary modelling and examination of research suggests that subglacial recharge may be present in the region. Information from such sources could provide insight into the climate and ice dynamics near the end of the Wisconsinan glaciation in Atlantic Canada.

Tourmaline compositions as an indicator of emerald mineralization at Tsa da Glisza, Yukon Territory

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Tourmaline, a boron-bearing ring silicate, is ubiquitous at Tsa da Glisza (formerly Regal Ridge). It occurs as porphyroblasts in greenschist facies meta-volcanic and ultramafic rocks, as phenocrysts in granite, in quartz-tourmaline veins that cut the schists, and as granular black masses in highly altered gossan or fault zones. Contact metamorphism of the Devonian greenschist facies rocks by Cretaceous granite/aplite/quartz-tourmaline veins is responsible for local emerald mineralization. Tourmaline compositions include solid solutions between Na-Fe schorl, Na-Mg dravite, and Ca-Mg uvite. The quartz-tourmaline veins are particularly important because emeralds form along their selvages, although not all such veins have associated visible emerald mineralization. However, tourmalines of veins and alteration zones associated with emerald mineralization have subtle differences in Mg and Fe content when compared to tourmalines in schists and veins with no known emerald mineralization. Dravitic tourmalines are most common on the property, with Mg content between 0.25 to >3 atoms per formula unit (apfu), Fe contents between 0.4 to 2.25 apfu and Ca content between 0.05 to 0.75 apfu.

Tourmalines associated with emeralds are slightly more iron-rich dravites compared with tourmalines of schists

and alteration zones without emeralds. Tourmalines of the schorl family are not associated with emerald mineralization, although they do occur in nearby aplites and granites. Uvite family tourmalines occur within and in veins cutting the ultramafic country rocks. The chemical variations of the tourmalines correspond quite well to the bulk-rock chemistry of their respective host rocks, but also relate to different equilibrium conditions at the time of emerald and/or tourmaline crystallization. During emerald mineralization, the mafic and ultramafic rocks, which are rich in iron and magnesium, as well as chromium and vanadium (the emerald chromophores) release mobile Fe, Mg, Cr, and V. These free elements are leached and subsequently transported by the quartz-tourmaline and aplite veins, some of which also carry beryllium, ejected from the granite. Because iron is less mobile than magnesium and tourmaline acts as an iron sink, the more iron-rich tourmalines associated with emerald mineralization imply a more iron-rich fluid, perhaps related to higher fluid temperatures of the veins during leaching.

Collapse of the Newfoundland Ice Cap and evidence against the Nunatak Hypothesis

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During the last glaciation, it is likely that Newfoundland supported its own ice cap. At its maximum extent, a non-equilibrium dynamic and mass balance was forced by calving margins everywhere except where the cap abutted the Laurentide Ice Sheet. It is likely that all summits were glaciated, based on measurements of ^{10}Be and ^{26}Al on the highest and most weathered summits in western, central, and southern Newfoundland. However, some cliff faces may have remained uncovered. Although summits with thin ice deglaciated early (20 ka) the majority of the island (excluding the Avalon and Burin Peninsulas) deglaciated rapidly (the cap collapsed in about two thousand years) after 13.5 ka. Areas with thicker ice persisted through the Younger Dryas chron (12.8–11.5 ka). Areas of thinner ice cover and areas under ice divides (or ridges) experienced little or no glacial erosion.

Despite having been covered by the Laurentide Ice Sheet, the glacial dynamics, erosion, and extent in northern Labrador seem similar. On every summit visited, erratics yield ages corresponding to the Younger Dryas chron, moraines date from LGM (26–18 ka) to Holocene, yet summits (protected under thin cold-based ice) have not been eroded. Summit and valley ice separated early in deglaciation. In some locations the intervening ice-free valley walls have been previously misinterpreted as a pre-LGM weathering zone. Nunataks may have persisted near the coast, e.g. in the Four Peaks region, which comprises high coastal pyramids with insufficient catchment for snow accumulation.

On the basis of the cosmogenic nuclide data, ice sheet simulations, and related geological observations, particularly in type-localities used to support the hypothesis, the Nunatak Hypothesis as applied to Newfoundland and Labrador is rejected. To explain the abundance of disjunct floral and faunal species, cliff-face refugia is favoured over summit refugia. Numerous disjunct species in cliff habitats persist worldwide, and the isolation of species in western Newfoundland could be due to marine transgression or glaciation.

Origin of chlorite rims in reservoir sandstones of the Lower Missisauga Formation, offshore Nova Scotia

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Diagenetic chlorite rims on quartz grains preserve porosity and permeability by preventing the formation of secondary, pore-filling quartz overgrowths in wells from the Venture and Thebaud fields. Elsewhere, such chlorite rims have been interpreted as early diagenetic related to a high input of iron (Fe) from rivers or volcanic activity, or alternatively to later diagenesis by basinal fluids. The purpose of this study is to evaluate which of these hypotheses is applicable to the Scotian Basin. It has been suggested that detrital altered ilmenite is responsible for the unusually high titanium (Ti) content of Cretaceous shale in the Scotian Basin and might be an important source of labile Fe.

A set of 45 sandstone samples from conventional cores was analyzed for mineralogy in thin section, mineral composition by electron microprobe, whole-rock chemistry, and mineralogy of the <2 μm fraction by X-ray diffraction. This petrographic data has been integrated with facies description of conventional core and with wireline log data. Electron microprobe analysis shows that the chlorite rims are Fe rich and resemble chamosite in composition.

Seven sandstone types are distinguished: 1) well-sorted with chlorite rims; 2) well-sorted with chlorite rims and pore-filling clays; 3) carbonate-cemented; 4) partially dissolved carbonate-

cemented with chlorite rims; 5) silica-cemented; 6) muddy; and 7) poorly sorted from transgression surfaces. Most well-developed chlorite rims are found in shoreface facies.

Factor analysis of geochemical and mineralogical data shows the following factors: i) detrital heavy minerals; ii) carbonate-cement; iii) K-feldspar ± clay; iv) chlorite rims; v) sulphides; and vi) barite drilling mud contaminant. Using only elements exclusively found in detrital minerals, three types of source are distinguished by factor analysis: a) ultrastable heavy minerals (Zr, Hf, Cr); b) granitic source (Ti, Y, HREE); and c) mafic source (Ni, Co, Sc).

The abundance and thickness of chlorite rims correlates positively with phosphorus (P) and are most abundant in type (4) sandstones. Phosphorus correlates strongly with Ti content of sandstone. Ti is generally immobile during diagenesis and in our samples covaries with elements related to detrital heavy minerals. Sedimentary rocks with higher Ti content due to alteration products of ilmenite can release more labile Fe, which favours the early diagenetic precipitation of phosphorite. High Ti content of sandstones in this study is restricted to the deeper sandstones of the Venture field.

This preliminary data suggests that the abundance of detrital ilmenite, varying stratigraphically and geographically, plays a role in providing labile Fe to the early diagenetic system. This Fe favours growth of early diagenetic berthierine, which alters to chamosite on burial. In marine facies with a low sedimentation rate, the high ambient Fe also favours growth of phosphate minerals.

Investigating vegetation changes in alpine environments in Jasper National Park

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Recent ecosystem analysis of Jasper National Park (JNP) has indicated that the park's vegetation is becoming progressively more homogenous. JNP forests are becoming more conifer-dominated and expanding into new environments due to changes in climate, disturbance regimes and anthropogenic interactions. Competition from conifer species may greatly alter some of the fragile alpine environments. The Cavell Meadows ecosystem, located below Mount Edith Cavell's northern face in Jasper National Park, has been identified by the Park Service as both an ecologically unique and environmentally sensitive site. To investigate the threats to this alpine community's stability, a dendrochronological assessment of the relationship between tree island establishment and climate was undertaken in the summer of 2006.

Sampling at the Cavell Meadows site was accomplished by establishing ages of trees within small tree islands, the common method of vegetative establishment in this alpine environment. Eleven tree islands were sampled across an altitudinal gradient encompassing the range of forest between the upper tree line and the lower contiguous forest. The analysis of each tree island included establishing tree heights and diameter, as well as investigating which method of reproduction, each tree island was currently under.

Early analysis suggests that there is a relationship between tree island establishment and past climate. Preliminary future tree island growth patterns are forecasted using climate change scenarios available from the scientific community which help to predict the future vegetative changes at tree line in the Cavell Meadows.

Temporal variations in sediment flux to the western Gulf of Mexico over multiple glacial-interglacial cycles

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Variability in sediment flux through a stream system over millennia or longer time periods is most commonly attributed to changes in climate, changes in stream base level, tectonic influences, or threshold mechanisms. These changes can induce process fluctuations in 1) catchment erosion, 2) proportions and durations of sediment storage, and 3) stream capacity. Sediment flux variations are therefore important records of landscape response to these changes. Geodynamics models require constraints of sediment flux over these timescales to compute the influence of denudation on orogenic processes, isostatic compensation, and style of crustal deformation. It is now clear that variations in sediment loading of salt-bearing continental shelves are a driving force of salt tectonics. Furthermore, sediment flux is an essential parameter in basin models used for petroleum exploration.

Establishing prehistoric long-term sediment flux rates from volumetric records (e.g., the volume of sand in the Mississippi Delta for a given time period) is problematic due to difficulties in dating subaqueous sediments and precisely accounting for material absent from the delta. We present a pilot study using cosmogenic ^{10}Be to obtain ~20 measurements of sediment flux from two non-glaciated river systems draining into the western Gulf of Mexico. Our results will constrain the magnitude of sediment flux variability over the past 5 million years and quantify the response of non-glaciated catchments to glacial-interglacial climate changes.

The Paleoproterozoic metavolcanic, metasedimentary, and plutonic rocks of the Aillik domain, Makkovik Province, Labrador

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In the Makkovik area (NTS map area 13O/03), 1:50 000 scale mapping has further defined the lithological units that occur within the Aillik domain of the Makkovik Province, which hosts abundant syn- and post-deformational mafic dykes and post-deformational aplitic dykes. Regional bedrock mapping focused on characterizing the Aillik Group (previously termed the Upper Aillik Group), a package of Paleoproterozoic volcano-sedimentary rocks that dominate the area. The Aillik Group is intruded by abundant, syn- and post-deformation Paleoproterozoic intrusive suites.

The Aillik Group comprises upper-greenschist to lower -amphibolite facies, felsic tuff, flow-banded to non-banded rhyolite, quartz-feldspar-porphyritic granite, volcaniclastic breccia/conglomerate, tuffaceous sandstone, thin-bedded to laminated metasandstone and siltstone, and lesser components of metabasalt (with locally preserved pillow selvages), mafic tuff, and porphyritic granites. The degree of deformation and grade of metamorphism is variable throughout the map area. Paleoproterozoic intrusive suites include the syntectonic Makkovikian (ca. 1840–1800 Ma) plutonic rocks of the Long Island Quartz Monzonite and the Kennedy Mountain Intrusive Suite; the post-tectonic Makkovikian (ca. 1800–1720 Ma) plutonic rocks of the Strawberry Intrusive Suite; and the Labradorian (ca. 1670–1630 Ma) plutonic rocks of the Monkey Hill Intrusive Suite and the Adlavik Intrusive Suite.

The map region lies within the Central Mineral Belt of Labrador, an area known to host an abundance of base-metal and uraniferous showings. Previous studies in the area, have illustrated the strong economic potential of the Aillik domain, and this study has identified several previously unreported mineral occurrences.

Volcanogenic massive sulphides of the southern Tulks Volcanic Belt, central Newfoundland: environments and styles of mineralization

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The Tulks Volcanic Belt, of the Victoria Lake Supergroup, central Newfoundland, is dominated by quartz ± feldspar porphyritic felsic volcaniclastic rocks and lesser amounts of mafic volcanic rocks and intercalated sedimentary rocks. The belt has traditionally been viewed as a single stratigraphic sequence of ca. 498 Ma age, but recent geochronological studies imply that it may be a composite and include rocks as young as 453 Ma.

The southern portion of the belt is host to three important clusters of VMS deposits known as the Tulks East, Tulks Hill, and Boomerang deposits, as well as a number of smaller sulphide prospects. The major deposits are characterized as "replacement-style" massive sulphides, hosted by felsic pyroclastic and volcaniclastic rocks. In contrast, the Curve Pond and Dragon Pond showings are more typical classic exhalative-type sulphide mineralization associated with exhalative horizons and regional iron formations. As such, the southern Tulks Volcanic Belt contains a continuum of VMS deposit types. The recent discovery of the high-grade polymetallic Boomerang deposit cluster, coupled with additional exploration data, resulting in higher grades and improved understanding of the Tulks Hill and Tulks East deposit clusters, highlights the exploration potential of the belt. It has been suggested that the Boomerang mineralized horizon occurs within a younger stratigraphic panel than the Tulks East and Tulks Hill deposits. Geochronological studies have been initiated to test this hypothesis, the results of which may have significant implications for exploration.

VMS deposits in the southern Tulks Volcanic Belt are interpreted to have formed in volcaniclastic-and sediment-rich basins during transitional tectonic regimes as conditions changed from convergent (e.g., active-arc environment) to extensional (e.g., back-arc or arc-rift). The change from compressional to extensional regimes would allow for active rifting, conduit formation, and high levels of focused heat flow, which are ideal conditions for the development of large and potentially ore producing hydrothermal systems.

Fluid circulation depth and crustal-scale faults

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Large-scale faults in the Canadian Cordillera place important controls on fluid fluxes from depths of a few kilometres in the Earth's crust. These faults act as conduits from these depths to the surface and also appear to have low permeability zones which act as barriers to deeper fluid flow. Understanding the hydrogeology of these faults is important in the assessment of low-temperature ore deposits, geothermal energy and water resources. Stable isotope data indicates that these waters are of modern meteoric origin. Previous estimates of circulation depth have used chemical geothermometers and estimates of background geothermal gradients. However, advective heat transport has not been explicitly considered and could have important implications to equilibration depth for chemical geothermometers. Modelling results indicate that upward groundwater flow may place equilibration depths several hundred metres shallower than previous estimates. This reduction in estimated circulation depth suggests that areas of

higher temperature are located closer to the surface and this may allow for greater development of geothermal energy resources in this region.

Establishing potential for leaching of Hg and As from soils in the Montague Gold District, Nova Scotia

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The soil horizons of the Montague Gold District, Nova Scotia were sampled to analyze for possible elevated levels of metals, in particular, Hg and As. Arsenic contamination is a serious concern in the surrounding environment due to the naturally high levels of As within the local metaquartzites and slates of the Meguma Supergroup. Horizons were carefully selected from locations up-ice, down-ice, and at the mill site within the District as well as one horizon outside the District, to determine background levels outside the study area. At each of the four sample sites, 8–11 samples were taken from horizons to a depth of 1 metre. Each horizon sampled included samples from the uppermost A_{00} layer continuing down into the glacial till layers of the C horizon. Samples were taken at approximately 10 cm depth intervals, although care was taken to select samples from within each horizon rather than at horizon boundaries. In contrast, there were no well-developed layers present at the mill site, so sample depth was the primary control on sampling. For comparative purposes, a homogenized sample from the top 5 cm and from the top 30 cm was taken at each of the 4 sites, which is the typical process used in environmental sampling procedures. All samples were sieved to sizes <63 microns and <2 mm for geochemical analysis. The resultant geochemical data indicate where the toxic elements are concentrated within the horizons as well as determining the influence of glacial transport and anthropogenic disturbance on these concentrations.

An infrared spectral reflectance study of the hydrothermal alteration minerals from the Campamento Au/Ag deposit, southern Mexico

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The Campamento Au/Ag deposit located within Linear Gold's Ixhuatán project was discovered in June 2004. It is located in the state of Chiapas, southern Mexico. The deposit is situated in a sequence of highly fractured Pleistocene-Pliocene andesitic volcanic rocks intruded by a complex feldspar porphyry. Campamento is a high-grade, gold-silver deposit situated at or near the surface. It has a resource estimate of 1.0 million ounces of gold, 4.4 million ounces of silver in the measured and indicated categories, and 0.7 million ounces of gold and 2.3 million ounces of silver in the inferred category, all at a cut-off of 0.50 grams per tonne gold.

Previous work on the deposit by Linear Gold has indicated that the deposit shows upper porphyry to epithermal style of Au/Ag deposition. To further evaluate the deposit, the Portable Infrared Mineralogical Analyzer (PIMA) was used. This is a technique that has been recently applied in the exploration industry. It can detect energy generated by vibrations within molecular bonds that show bending and stretching modes with the 1.3–2.5 μm interval. The spectra collected are analyzed for many alteration minerals and mineral combinations specific to various ore deposits. No sample preparation is required and it can identify alteration clay minerals on site faster than the conventional x-ray diffraction method.

The results from the Campamento PIMA survey show the zoning of temperature sensitive clay minerals (smectite, interstratified illite/smectite, illite, biotite, and muscovite). The appearance of the higher temperature minerals biotite and muscovite on the surface implies a lowering of the paleosurface by approximately 725–1200 m. In addition, the PIMA data also indicates telescoping of alteration assemblages suggesting high rates of erosion or a sector collapse during the formation of the deposit.

What geological history tells us about global warming

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It is generally assumed that the current trend of global warming is detrimental to humanity and ecosystems in general. This is partly due to the fact that most scientific assessments on the issue of global warming only bring into focus its negative aspects and are therefore biased. Due to this lack of unbiased assessments on the pros and cons of global warming, the Kyoto Protocol may be a premature international effort.

One way of assessing the outcome of global warming is to look at the geological record, the message of which is very clear: the global ecosystem thrives on a greenhouse Earth and declines on an ice age Earth. This well-established fact is never part of the debate on global warming, which is usually constrained to the last few hundred years, or thousands of years at best. Clearly, this does not bring enough perspective, as we have to go back 35 million years to get out of the current ice age, which started with the birth of an ice sheet on Antarctica. Since then, ecosystems have been experiencing tremendous stress due to the gradual deterioration of global climate.

The current trend of global warming is but a small notch in a large scale trend of global cooling that started over 100 million years ago, when mid-oceanic spreading rates returned to

normal after millions of years of exceptionally rapid rates that were due to the post-Pangean runaway release of heat from the mantle. The Pangean assemblage had been "jamming" the plate tectonic machine, which is the main way by which the mantle manages to release the heat that it receives from the outer core. When Pangea finally broke up, in Jurassic times, the plate tectonic machine was unlocked, and the excess heat that had been accumulating in the mantle during Carboniferous to Early Jurassic times was allowed to be massively released in Late Jurassic to Early Cretaceous times through increased mid-oceanic spreading rates and hot spot activity. Increased mid-oceanic spreading rates imply a parallel increase of subduction rates and therefore of the volcanic release of carbon dioxide to the atmosphere through the subduction and partial melting of carbonaceous sedimentary rocks. This period of faster continental drift brought the carbon dioxide levels of the Early Cretaceous atmosphere to more than six times those of today, allowing life to flourish more than it had ever done since the early Paleozoic (i.e., since the last greenhouse age).

When mid-oceanic spreading rates came back to normal, still in Early Cretaceous times, carbon storage in Cretaceous chalk and black shale started to exceed the rates of carbon release at subduction zones, and a new cooling trend was onset. This cooling trend was aggravated in Cenozoic times by several orogenic events, which increase the erosional rates of calcium and magnesium from the crust to the oceans, and which therefore promote the long-term storage of carbon into carbonate rocks. Most of these orogenic events are still going on today (Himalayas, Alps, Rockies, Andes, etc.), and the current ice age is therefore destined to continue – unless we release a sufficient amount of the atmospheric carbon that is presently locked in fossil fuels. In conclusion, greater involvement of the geological community in the global warming issue is greatly overdue.

Spectral gamma-ray, XRD, and organic geochemistry of an offshore lacustrine succession, Albert Formation, Moncton Basin, southern New Brunswick

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Four roadcuts southwest of Sussex, New Brunswick, expose a nearly 70 m-thick stratal package from the Hiram Brook Member of the Albert Formation (Horton Group, Tournaisian). Detailed sedimentological logging and analytical work has been undertaken on the southernmost of the roadcuts. Interbedded sandstone and mudstone in the lower and upper intervals of the succession have been interpreted as the deposits of lacustrine deltas, shorelines, and fluvial systems. The medial interval is almost entirely of mudstone and interpreted as offshore lacustrine.

A log of the total gamma ray (GR) shows a typical response; low readings are most frequent in the upper interval where coarser-grained sandstone is more prevalent. Higher readings occur in the muddier parts of the lower interval, and the medial intervals that lack a diagenetic carbonate overprint. The response is mirrored in the spectral readings for potassium (K) and thorium (Th). However, several peak uranium (U) readings anomalously correspond to low spectral K and Th values and thus, also, to total GR readings since U is of an order of magnitude less abundant than K in the rock. The anomalies correlate well with beds observed to be darker and more dolomitic. Such beds also record highest total organic carbon (TOC) – ongoing XRD analysis will also determine if there is covariance with any mineralogical changes.

It is generally accepted that U values vary in a positive relationship with organic-rich strata, since dissolved U compounds are scavenged by anoxic-decaying organic matter. However, because Albert Formation (and other) lacustrine strata contain abundant K- and Th-bearing minerals, organic-rich shale frequently does not correspond to peak total GR and may be misinterpreted in standard petroleum well logs where only total GR is recorded.

A study on the Kingnait Moraine system and coinciding eskers, Foxe Peninsula, Baffin Island

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The size and location of the Kingnait Moraine system on western Foxe Peninsula, Baffin Island, suggests the presence of late stage glacial retreat. This area of Baffin Island is of particular interest due to its proximal location to both the Hudson Strait as well as the Foxe Basin, two major centers which controlled ice dynamics in the region. It is hypothesized that the Kingnait Moraines as well as the associated glacial landforms are the result of advance during the Cockburn age (9.6 ka), rather than the Younger Dryas, or GRIP 8200 cold event. This hypothesis is based on the overwhelming size of the Kingnait Moraines compared to other glacial landforms in the region. This hypothesis was tested using terrestrial cosmogenic radionuclide dating on eskers as well as a raised ice-proximal delta to chronologically constrain the retreat of ice cover from these landforms. Dates derived from esker material, can then infer the age of the moraines, as the eskers cross-cut the moraines. This relationship implies that the eskers maintained the same drainage location despite moraine creation on the ice front. Dates received from delta material allow for age constraints to be applied to the marine transgression that was believed to occur during the retreat of ice from the region.

Petroleum and aqueous fluid inclusions in Mesozoic and Carboniferous rock salts from Atlantic Canada

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Fluid inclusions are known to exist in rock salts in various forms, phases, and compositions. Fluid Inclusion Assemblages (FIA) represents a group of such inclusions with similar composition which have been trapped at the same time, under approximately the same temperature-pressures; so they represent a "Fluid Event" in the history of the depositional system and they also represent the original fluids available at the site where they were trapped in this material. Rock salt samples of Mesozoic age taken from wells in offshore Nova Scotia and Newfoundland as well as Carboniferous rock salts from the Pugwash salt mine (Cumberland County) were studied for their fluid inclusion contents. They were studied under transmitted and fluorescence microscopes in addition to using the specialized heating-cooling stage. The study showed that they contain many FIA representing both aqueous and petroleum fluid inclusions. Both exist in many forms and phases (liquid, vapour, liquid-vapour, as well as solid (crystals) in some of them). The aqueous inclusions have generally regular shapes (cubes, rectangular parallelepiped, or cylindrical), while the petroleum fluid inclusions are mostly elongate and tubular (single or network-like). Microthermometric studies of these fluid inclusions showed a wide range of homogenization temperatures and also different compositions. These data suggest that different FIA have formed at different times and under various temperature-pressure conditions during the long depositional, burial, and post-burial tectonic history to which the salts were subjected. Abundant fluid inclusions also suggest that the salts allowed the introduction of fluids into their structure; thus under certain burial conditions they became porous-permeable material, in agreement with supporting experimental studies by others suggesting that the salt become porous and permeable to fluids at depths of more than ca. 3 km. The study also shows that colouration of salts is due to either staining material such as iron oxides along cleavage and/or fractures, or due to the existence of various colouring material trapped in fluid inclusions.

Petrology of the Triple Seven Zn-Cu volcanic hosted massive sulphide deposit, Flin Flon, Manitoba

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In 1993, Hudson's Bay Exploration and Development Ltd. (HBED) discovered the Triple Seven Zn-Cu volcanic-hosted massive sulphide (VHMS) deposit just outside Flin Flon, Manitoba. The deposit occurs in the Flin Flon Volcanic Belt (FFVB) of 1.90–1.87 Ga age, in basaltic and rhyolitic volcaniclastic rocks and flows and correlates stratigraphically with the Flin Flon and Callinan VHMS deposits. Fourteen geochemical samples and 21 thin sections from drill core 4Q71W15 through the massive sulphide and host bimodal volcanic layers were used to study the sulphide and Au petrology and geochemistry of the deposit. This study is expected to provide new information that can be used to improve gold recoveries from the Triple Seven Zn-Cu deposit.

The rocks that host the deposit are chlorite- and sericite-altered porphyritic rhyolite, and these lie between basaltic volcanic breccias and flows in the footwall and hanging wall. Massive sulphide comprises two stacked zones. The lower zone is zinc and precious metal-rich consisting of pyrite, sphalerite, chalcopyrite, and pyrrhotite with minor galena and arsenopyrite. The upper zone is copper-rich, significantly smaller, and characterized by chalcopyrite, pyrite, and pyrrhotite with minor chalcocite. Stockwork mineralization consisting of chalcopyrite and pyrrhotite exists beneath massive sulphide, which exhibits local brecciation and minor layering. Microprobe analyses confirm the presence of native silver, which is associated mostly with arsenopyrite. Microprobe and geochemical data have been collected for the study of the sphalerite geobarometry and determination of where gold occurs within the massive sulphides.

Tiering in Ediacaran fronds from Mistaken Point, Newfoundland

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The Ediacara Biota is a distinct group of soft-bodied organisms that flourished in the late Precambrian oceans some 575 to 543 million years ago. Recent work has revealed that the diversity of organisms that constitutes the core of the Ediacara Biota represent stem/crown group animals, in addition to unique "failed experiments" that have no known modern counterparts. Within the diverse assemblage of Ediacaran organisms, the leaf-shaped fronds are among the most widely recognizable forms due to their complex, multi-structural morphologies. Ediacaran fronds are characterized by an elevated soft-bodied leaf attached to a stem which was anchored to the seafloor by a circular basal holdfast. Fronds gathered nutrients from the water column through direct nutrient absorption resulting in the onset of Phanerozoic-style ecological competition complete with denizens occupying distinct tiers in the water column.

In contrast with the younger and mainly fragmentary material known elsewhere, Mistaken Point, Newfoundland is unique in preserving hundreds of complete fronds that represent the oldest specimens of Ediacara Biota known anywhere (575–560

Ma). The diversity of frond types at Mistaken Point highlight the ever-present competition for nutrients in this deep water (below the photic zone) Precambrian ecosystem. Within the shared frond bauplan, several distinct feeding strategies are present, and each unique feeding style represents a different evolutionary life history. *Arborea*-type branching is characterized by a bifoliate sheet composed of pea-pod like primary branches which house several secondary branches within the protective sheath. Rangeomorph fractal branches are self similar over three branching orders and includes two separate categories of fronds: *Rangea*-type branching consists of multifoliate fronds composed of several overlapping primary fractal branches attached to a straight central stalk whereas *Charnia*-type branching results in a zigzagging central axis due to alternating of sigmoidal overlapping primary branches. Each branching style has representatives from several trophic levels, and therefore suggests that the branching arrangement is not governed by ecological pressure and rightfully represents a shared derived ancestry. Communities dominated by direct nutrient absorbers are restricted to the terminal Neoproterozoic, never to be seen after the onset of the "Cambrian Explosion" of filter-feeding ecosystems.

Hydrocarbon systems in the Paleozoic of northern New Brunswick: are all the elements there?

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Since 1999, fundamental and hydrocarbon-oriented research by the Geological Survey of Canada and the New Brunswick Geological Surveys Branch has generated data that serve as the cornerstone for new exploration activities in northern New Brunswick.

Source rock: maturation – generation – migration: Rock-Eval analysis identified potential hydrocarbon source rocks in the Paleozoic succession of northern New Brunswick and adjacent southern Gaspé: Middle Ordovician oceanic black shale (TOC: 10.7%; Mictaw Group and Popelogan Formation), Upper Ordovician successor basin shale (TOC: 1.4%; Garin Formation and Ritchie Brook Member of the Boland Brook Formation) and Lower Devonian coals (Val d'Amour and Campbellton formations). GC-MS and GC-IRMS analyses were done in order to link potential source rocks with recently produced oils in nearby Gaspé. Oil in Lower Devonian reservoirs in Gaspé can be tied with either Middle or Upper Ordovician black shales.

Recent maturation studies provided a regional framework that clearly supports the prospectivity of large segments of northern New Brunswick, in particular the northeastern sector, where field samples are within the oil window. This domain is surrounded by an even larger area within the condensate to gas zones. The regional variation of the maturation data documents three major tectonic blocks that were active in Silurian time. The detailed organic matter petrography has documented the presence of migrabitumen in most of the sedimentary pile and that generation and migration occurred both vertically and laterally within individual tectonic blocks before the peak of the Salinic orogeny.

Reservoirs: clastics – carbonates: In the adjacent Gaspé Peninsula, small but economic accumulations of oil and gas are hosted in Devonian sandstones and hydrothermal dolomites. In eastern Gaspé Peninsula, oil occurs in sandstones of the Lower Devonian York River Formation. The sandstones of the Devonian Val d'Amour and Campbellton formations share some depositional characteristics with the producing Gaspé sandstones. The Devonian hydrothermal dolomite breccia in eastern Gaspé is host to natural gas (Galt field). Although these Devonian carbonates are absent in northern New Brunswick, recent research has documented the presence of bitumen-rich hydrothermal dolomites in the Lower Silurian La Vieille Formation. Moreover, work in progress on the Late Silurian reefal facies of the LaPlante Formation documents significant subaerial karst development as well as local hydrothermal imprint. The abundance of early faults in the hydrocarbon prospective area is strong evidence for the early formation of hydrothermal dolomite reservoirs.

Traps and seals: the missing data: The actual high level of exploration in adjacent Gaspé Peninsula is largely fuelled by the availability of modern seismic data (public and private) which were instrumental in documenting a number of shallow-to mid-level structural traps. Such seismic information is lacking in northern New Brunswick. However, field data clearly support the presence of Salinic and Acadian deformation in this area and both orogenic phases are involved in the development of sub-surface structural traps in adjacent southern Gaspé.

Source(s) of magnetic and gravity anomalies south of Cape Breton Island, Nova Scotia, and onshore-offshore geological correlations

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The area offshore southeastern Cape Breton Island is inferred to be part of the Mira terrane, a component of the Avalonia realm of the northern Appalachian orogen. The Scatarie Ridge Magnetic Anomalies (SRMA) are a prominent belt, approximately 100 km long by 25 km wide, of northeast-trending magnetic anomalies that characterize this area. Magnetic values typically range from 300 to 600 nT; however, the centres of the anomalies reach highs of 900 nT to 1400 nT. In addition, positive gravity anomalies correspond approximately to the area of the magnetic anomalies, with gravity values ranging from 10 to 30 mGal. Like other parts of Avalonia, the onshore part of the Mira terrane is characterized by prominent linear total field magnetic anomalies that appear to be related to the linear belts of Neoproterozoic volcanic,

sedimentary, and plutonic rocks that form much of the terrane. The Canso Fault is interpreted to offset the Mira terrane to southern New Brunswick, 100 km to the north, relative to mainland Nova Scotia, suggesting the possibility that the area of the SRMA offshore southeastern Cape Breton Island could correlate with the Antigonish Highlands. The purpose of the study is to investigate the source(s) of the anomalies utilizing magnetic, gravity, and seismic data, and to determine whether the offshore anomalies are caused by Neoproterozoic Mira terrane units, other Avalonian units such as those of the Antigonish Highlands, or some other as yet unrecognized sources. The high magnitude of the offshore anomalies is in contrast to lower surrounding signatures caused by widespread Carboniferous sedimentary basins and crustal thinning associated with the Orpheus Graben to the south. Lithoprobe East seismic interpretations suggested that the adjacent Meguma terrane has been thrust over the Avalon terrane, with the Orpheus Graben marking the suture zone between the two terranes. In the onshore, this boundary is marked by the Cobequid-Chedabucto fault system, but its position in the offshore (north or south of the Orpheus Graben) is somewhat uncertain. The area is further complicated by the recognition of Carboniferous detachment faulting on Isle Madame in the southernmost part of Cape Breton Island, and the possibility that Meguma terrane basement extends into that area.

This study will evaluate and model the source(s) of the offshore anomalies, based on a compilation of existing magnetic, gravity, and seismic data. The models will be constrained by physical property data (i.e., specific gravity, magnetic susceptibility) measured in samples collected from relevant onshore areas in the Mira terrane and offshore exploration wells. Stratigraphic units in the models will be constrained by interpretations of industry and Lithoprobe East seismic lines in the study area. The modelling will ascertain the depth and extent of the anomalies source(s). By providing a better interpretation of the offshore geological units, this study should help to decipher the geology of the area and whether or not the Mira terrane units exposed onshore extend out under the shelf.

Physical modelling of the initial salt mobilization and salt tectonics in late syn-rift and post-rift basins with application to the Early to Late Jurassic Abenaki and Sable subbasins, Scotian Margin

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Unsatisfactory results from the latest round of hydrocarbon exploration in the deepwater slope of the Scotian Margin exhibits an inadequate understanding of the tectonic and sedimentary framework of the shelf-slope-basin transition. Problems associated with the geology in this area are associated with complex salt deformation beneath the shelf and slope, which is documented by features that record highly variable tectono-sedimentary environments with high rates of sedimentation and progradation during the Jurassic and Early Cretaceous. The incomplete geological understanding of the Scotian Basin is attributed to the deficiency of scientific drill holes and acoustic shadowing from the complex salt structures present in the substrata. Particularly, the imaging problems hamper the structural interpretation of basement morphology beneath the rift-related salt basins. It is crucial to improve the understanding of the tectonic and sedimentary evolution as related structures are a major contributor to the determination of petroleum reservoirs, migration, and traps.

To address these problems innovative 3D physical simulation methods and structural modelling techniques were coupled with interpretation of public seismic data of offshore Nova Scotia. Dynamically scaled analogue models consisting of materials like silica sand and silicone rubber simulate sedimentation, salt mobilization and deformation of the brittle overburden sediments and ductile salt. The presented set of experiments systematically investigates the control of different rift-related basement morphologies on the structural and depositional evolution during the two stage development of initial salt mobilization. Recently published results from regional seismic analysis of salt structures along the Scotian Margin emphasize the importance of basement morphology of the rift-related salt basins at the Scotian Margin and variable sedimentation patterns and rates during the Jurassic and Early Cretaceous as main control factors of the salt tectonic domains. Similar to salt mobilization at passive margins, the silicone in the experiments is mobilized by incremental model sedimentation in the shelf and landward salt basin areas due to differential loading. Subsequent basinward flow of the silicone causes early landward extensional and basinward compressional deformation in the overburden. The thin-skinned deformation due to this silicone mobilization and migration of depositional centres in the model shelf-to-slope sedimentary sequence is fully quantified with 3D optical strain monitoring techniques (Particle Imaging Velocimetry), a technique which uses particle recognition to quantify incremental and finite strain.

The first results and preliminary interpretations show that basement morphology does affect structural evolution during initial salt mobilization and is a major control in the types of structures present in autochthonous salt and overlying sediments. Basement geometry is also found to control the extent of down-dip allochthonous salt sheets and the respective structures present.

The enigma of the Younger Dryas: just what might have been the trigger?

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The Younger Dryas (YD) was an interval from ca.11.0–10.3 ^{14}C ka (12.8–11.6 cal ka), when glacial conditions returned to the northern hemisphere, and there was a complex varying pat-

tern of multiple outlet discharges of both meltwater/icebergs into the oceans, resulting in significant widespread atmospheric and oceanographic changes. There is evidence that thermohaline circulation (THC) and the formation of North Atlantic Deep Water (NADW) ceased, and changes in the levels of atmospheric CO_2 occurred. Debate has recently intensified as to what triggered the YD.

The first hypothesis that the YD was triggered by a specific forcing mechanism was published in 1989, when it was suggested that an eastern Lake Agassiz drainage outlet opened into the Gulf of St. Lawrence (GOSL), and the transport of meltwater and icebergs northeast in a pre-conditioned Gulf Stream, produced a freshwater "cap" in the Norwegian-Greenland seas (NGS). In the 1990s, others argued that there is no isotopic evidence of reduced salinities and temperatures in the Gulf at this time. Some recently presented evidence supports a closed eastern outlet at YD onset, and concurrently compiled contradictory evidence suggests that there were discharges from both the Hudson and St. Lawrence rivers at YD onset.

In 2005, a model providing a radically different theory was published based on evidence that significant Keewatin Ice Dome meltwater discharge into the Arctic Ocean occurred throughout the YD, discharge more than twice that of the Laurentide Ice Sheet into the Atlantic Ocean during the same time. This discharge originated from Lake McConnell and possibly Lake Agassiz, flowed via the northwest (Clearwater River) outlet into the Arctic Ocean, through Fram Strait and into the NGS. Geomorphologic evidence of northwest drainage is clear, but others challenge the timing, believing it occurred post YD. Yet another hypothesis is that only the addition of large tabular icebergs to meltwater in the Arctic Ocean provided enough freshwater to "cap" the NGS and explain the lack of sudden YD-onset sea-level changes. The most recently published evidence suggests that part of the answer may encompass a larger area, that enhanced Arctic Ocean outflow via the East Greenland Current during the Allerød intensified SE Greenland Ice Sheet (GIS) retreat, and increased meltwater influx into the Atlantic Intermediate Water that was then transported to the NGS by the Irminger Current. A pivotal role by the GIS may account for the very strong isotopic signal in the Greenland ice cores.

Modelling and evidence of possible external forcing mechanisms may prove invaluable for improving understanding of abrupt climatic change and for evaluating models that simulate THC response; as predicted increases in freshwater input to the North Atlantic following increasing atmospheric CO_2 levels may cause changes to THC. Preparing for the climatic consequences of external forcing by societal impact on global systems requires understanding what triggered the YD and other sudden onset climatic changes.

The geological library of the Natural History Society of New Brunswick: supporting early scientific research in the Maritimes region

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The Natural History Society of New Brunswick (1862–1932) was a leading scientific organization of its time. Members studied and published in all areas of natural science and developed large specimen collections. Their collections formed the basis for the present New Brunswick Museum. How did an amateur society, operating in Saint John away from the major centres of science in Canada, produce an impressive body of work that included significant scientific (especially geological) discoveries? It has been speculated that Sir J.W. Dawson's taxonomic problems arose from his isolated position on the edge of the British Empire, and his difficulties accessing relevant literature. If Dawson had trouble accessing literature in Montreal we might imagine his colleagues, like George Matthew, in Saint John suffered even more so with only the resources of a small natural history society. Saint John did not have any large academic or government institutions like a geological survey to support research. The only libraries with scientific resources belonged to the Natural History Society and the local Mechanics' Institute. It is clear from library reports in the Society's Bulletin that, from the beginning, the intent was to provide members access to a first rate science library necessary to support their research activities. The library was particularly important as the Great Fire of 1877 destroyed personal libraries while the Society library was untouched.

In 1885, the Society reported 657 bound volumes and pamphlets in the library. The final report in 1913 stated the library contained 12 500 books and pamphlets. The average increase from the time of the first Bulletin in 1882 is about 387 items per year. The library grew from donations by its members and friends, and from items acquired in exchange for the Society's Bulletin. Additional items were purchased to fill deficiencies, such as the acquisition of volumes of the *American Journal of Science and Art* bought in 1887 and in 1893 the first volumes of *Canadian Naturalist*. Back numbers of the journals were purchased specifically for the benefit of those interested in geology and other natural sciences since, in the early days of the Society, papers of interest had been published in these journals.

The research and public education output of the Society was impressive. George Matthew alone published more than 200 scientific papers. Between 1862 and 1917 the Bulletin of the Natural History Society records 709 lectures read before the Society and 105 elementary lectures for a broader audience. Lectures were often at the leading edge of scientific discovery, such as Matthew's 1890 report of the first authentic Precambrian fossil.

Continental mafic magmatism of different ages in the Antigonish Highlands, Nova Scotia: constraints on the evolution of an enriched mantle source

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Models for the petrogenesis of continental rift-related basaltic rocks typically involve a combination of partial melting of the sub-continental lithospheric mantle (SCLM), low pressure fractional crystallization, and chemical contamination by either continental crust or coeval felsic magmas. The SCLM can underlie a region for a long period of time during which it can be chemically modified by tectonothermal activity prior to any rifting event. The geochemistry of several continental rift basaltic suites indicates heterogeneity of the mantle source and contamination of the mantle source. As a result, the chemical and isotopic imprint of the mantle source on rift-related basalts is uncertain.

Most petrological studies are confined to suites with a limited range in age. However, important insights into the genesis of continental rift-related basalts and the evolution of its mantle source can be gained by focusing on terranes where rift-related magmatism occurred repeatedly over a long period of time.

The Antigonish Highlands, Avalon terrane, Nova Scotia, contain four distinct episodes of continental rift-related magmatism: Neoproterozoic, Cambrian, Middle Ordovician, and Late Devonian. All four magmatic suites are composed of basalts and subordinate crustally derived felsic rocks. The mafic rocks of these suites, which do not appear to be significantly contaminated by continental crust, display similar geochemical and Sm-Nd isotopic characteristics consistent with an enriched mantle source that was metasomatically enriched prior to the oldest rifting event, probably between 0.8 and 1.1 Ga. These suites display similar geochemical and isotopic patterns indicating a remarkable degree of inheritance from a mantle source that was enriched in the early Neoproterozoic, i.e. prior to the oldest rifting event. These data also imply that the Avalonian crust and its sub-continental lithospheric mantle remained coupled during four magmatic events. As the earliest phase of magmatism occurred when Avalonia was located along the Gondwanan margin, and the latest phase after Avalonia accreted to Laurentia, the coupling of crust and mantle in the Antigonish Highlands suggests that the migration of Avalonia did not completely detach its lithospheric mantle from its crustal cover. More generally, the analysis of suites of different ages in the same terrane helps to constrain the chemical characteristics inherited from its mantle source and evaluate the coupling between the crust and mantle over that time span.

Landform evolution in the south central Andes: determining the major mechanisms of formation of the great escarpment between 32 and 38 degrees south, Argentina

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Between 32 and 38 degrees South, (Southern Argentina) lies a massive N-S trending escarpment with an average rise of 170 m, and a riddle of past and present stream channels cross-cutting W-E over its substantial extent. Because this region is within the dynamic transition zone of the Andes Mountains, potential mechanisms of escarpment formation are many. The goal of this research is to determine whether the processes which formed this great escarpment are fluvial or tectonic in nature, and to then assign a relative age of formation to the landform. This study tests three major hypotheses. The first states that the great escarpment may be the foot wall of a large graben which extends to the east, with the central area being the rift basin. The second suggests that the escarpment may have formed through fluvial erosion by a large river system running through the central region. The third hypothesis proposes that the escarpment is simply the result of a large faulting event.

Digital Elevation Models used in conjunction with GIS software allowed detailed analysis of the local river networks (both paleoflows and present channels). Both 2d and 3d models were created for further examination of the topography and geology of the area, and used to overlay variables such as changing climate trends. In closely examining the channel profiles of river flows on the escarpment, possible knickpoints have been identified, indicating a significant change in base level. The distance of the knickpoints from the escarpment line also confirms that the escarpment is not newly formed. The migration rate and pattern of these knickpoints were used to determine the rate of change, and provided evidence as to the directional propagation of erosion. Influences such as river system migration, and changes in flow strength were modeled based on climatic history and precipitation trends. This information, combined with the area's tectonic history and present condition, aids in modelling the reconstructed geomorphologic history of the region. Thus far, these models show likely relationships between faulting events and similar formations, and also the presence of significant directional erosion and fluvial migration. These results suggest that a combination of both tectonic and fluvial influences have lead to the formation of this great escarpment

Precambrian phosphorite accumulation in the Paleoproterozoic Baraga Group, Michigan, USA

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The Paleoproterozoic Baraga Group of northern Michigan is an ~1200 m thick sedimentary succession of marine clastic, iron formation, and phosphatic sedimentary rocks that accumulated during the world's first phosphogenic episode. Vertical and lateral lithofacies stacking patterns are interpreted to record the inundation and flooding of the Nuna continental margin during two sea level cycles. The base of the first sequence is marked by a transgressive lag directly on Archean basement. This lag is transitional into a highstand accumulation of tidal sandstone. Supratidal phosphatic chert with numerous subaerial exposure surfaces characterizes the bottom of the second cycle. This chert grades upwards into transgressive subtidal deposits composed of interbedded organic-rich mudstone and delta deposits. The top of the second cycle is formed of a thick highstand accumulation of laminated mudstone that is overlain by progradational deltaic sandstone.

The precipitation of sedimentary apatite is interpreted to be the result of iron-redox pumping in conjunction with the microbial degradation of organic matter just below the sediment-water interface within lowstand cherts and transgressive deposits at the base of the second cycle. Such shallow-water phosphorite accumulation contrasts many Phanerozoic depositional systems where phosphogenesis occurs in a mosaic of middle and distal shelf environments. This fundamental difference likely reflects the dissimilarity in the oxygenation state of the seafloor. In the Phanerozoic, phosphorite forms in the full spectrum of shelf environments because the entire seafloor is generally well-oxygenated. In the Precambrian, iron-redox pumping and thus, phosphogenesis, was restricted to shallow-water settings where photosynthetically produced oxygen oases impinged on the seafloor.

Detrital zircons as provenance indicators in the Cretaceous Chaswood Formation

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The morphology and internal structure of detrital zircon in sandstones can be used to recognize different source rocks. Such characterization is an important preliminary to expensive dating of detrital zircon. Different types of igneous and high grade metamorphic rocks show different types of zoning and inclusions and zircons reworked from older sedimentary rocks are generally highly abraded.

Current models for the provenance of the fluvial Chaswood Formation of New Brunswick and Nova Scotia are based on gravel clast petrology, bulk heavy mineral assemblages, and detrital monazite geochronology. These studies suggest that at least three discrete rivers supplied coarse-grained sediment to southern New Brunswick, central Nova Scotia, and eastern Nova Scotia respectively. The purpose of the present study is to test these models of provenance and sediment dispersion using detrital zircon.

Polished thin sections of heavy mineral separates were prepared from loosely consolidated sandstones from the Vinegar Hill pit in southern New Brunswick, borehole RR-97-23 from the Musquodoboit Valley, boreholes from Brierly Brook near Antigonish, and from Diogenes Brook in western Cape Breton Island. Backscattered electron (BSE) and cathodoluminescent (CL) images were obtained from almost 800 grains by scanning electron microscope. The grains were classified on the basis of external morphology, type of zoning, and the type, size, and abundance of inclusions.

Grains from Vinegar Hill are dominated by euhedral first-cycle igneous zircons that lack prominent zoning and inclusions. The uppermost stratigraphic unit at RR-97-23 is dominated by first-cycle igneous zircons with prominent concentric zoning, whereas the base of the Chaswood Formation at RR-97-23 has a wider range of igneous zircon types and a higher proportion of abraded second cycle zircons. A similar stratigraphic contrast is present at Brierly Brook. Detrital carbonate from the Windsor Group is a significant component of the deeper section at Brierly Brook, consistent with the abundance of abraded zircons perhaps derived from Carboniferous sandstones. The Diogenes Brook sandstones have a wide range of types of igneous zircons, including some that resemble those at Vinegar Hill and some similar to those in the uppermost unit at RR-97-23 and at Brierly Brook.

This study has demonstrated the value of detrital zircon as an indicator of provenance in the Chaswood Formation, but also shows that further work is needed to compare observed zircons with those in potential source rocks. It confirms previous interpretation of three principal rivers, although there is evidence that in upper Chaswood times, Brierly Brook and RR-97-23 might have been supplied by the same river system. It also shows that the older parts of the Chaswood Formation had a higher proportion of second-cycle zircon, presumably derived from Carboniferous rocks uplifted in horsts, which were progressively eroded to reveal crystalline basement rocks.

Southwestern Nova Scotia's hidden old-growth forests: extending tree-ring chronologies through historic churches

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Old-growth forests in their traditional form are rare in southwestern Nova Scotia, due to hundreds of years of deforestation by settlers and industry. However, old-growth forests abound in historic churches in the region, as they were among the first buildings constructed by settlers and have been maintained by their parishioners. As such, historic churches in southwestern Nova Scotia are not only rich in cultural history, the wood used to construct them holds a wealth of information on the environment of the region up to the time of initial settlement. Dendroarchaeology is the study of tree rings in beams within historical structures. It is used to determine cut dates of trees used in the construction of these historic structures, as well as to gain insight into the growth patterns of trees from that time.

In this project, samples were collected from eight historic churches within southwestern Nova Scotia to improve our understanding of how several tree species were growing in the region at the time of settlement. Master chronologies were constructed of radial growth from each tree species at each church, with the goal of adding growth patterns to existing regional chronologies to extend radial growth records for each tree species in the region.

This project successfully extended master chronologies and improved sample depth of master chronologies for red spruce, white pine, and eastern hemlock in Nova Scotia and New Brunswick. Master chronologies specific to southwestern Nova Scotia were also constructed for these three species. Project implications include increased confidence in historic structure dating in southwestern Nova Scotia through dendroarchaeological methods, as well as having master chronologies that will be useful in creating climate prediction models for the region.

Late Tournaisian 'pop-up' and collapse in a transpressional strike-slip zone: the Indian Mountain Deformed Zone, southeast New Brunswick

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The structural history of the Indian Mountain Deformed Zone in southeast New Brunswick is intimately related to late Tournaisian stratigraphy, particularly the deposition of the Sussex Group. The Sussex Group consists of three formations: the Stilesville Formation, a basal conglomerate-megabreccia resting on a paleosol on crystalline pre-Carboniferous basement is upward-fining into a grey-red-green mudstone dominated Gautreau Formation, which is overlain by an upward-coarsening Briggs Cross Formation, starting out as conglomerate, but eventually containing megabreccia. The megabreccia of the Briggs Cross Formation contains clasts recording extensive recycling of the Stilesville Formation. Clast-size (up to 10 metres diameter) implies a distal relationship between breccias and source.

Early deformation of the lower part of the Sussex Group (Stilesville and Gautreau formations) is related to thrusts bringing basement slices over cover, and Stilesville Formation over Gautreau Formation. Thrusts are predominantly northward-verging, but southward- and eastward-verging structures are also seen. This thrusting appears to be associated with the recycling of basement and Stilesville Formation clasts in the upper part of the Briggs Cross Formation, and this is consistent with the plastic nature of folds developed in some lithologies, indicating deformation before dewatering was complete.

Thrusts throughout the Indian Mountain Deformed Zone are overprinted by normal faults showing downthrow to the south, east, and west. These same faults cross-cut the Briggs Cross Formation and therefore post-date it. The structural history correlated with the stratigraphy indicate rapid uplift of basement during the end-Sussex Group period, with basement thrust slices over-riding their own debris, followed by collapse of the same 'pop-up' structure. The timing of this collapse is not well constrained, but is most probably early Visean.

Northwestern New Brunswick till geochemical database project

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The Quaternary mapping and till sampling project in northwestern New Brunswick continues in parts of 11 NTS sheets (21 N/1, 2, 3, 6, 7, 8, 9, and 16 and 21 O/4, 5, and 6) in order to increase the surficial geology database for the region, including municipalities, and to obtain data needed to develop a glacial dispersal model for all of northern New Brunswick. Till is thin and locally derived in all parts of the area except the Saint John River valley and is a good sample medium to provide a regional dataset for background geochemical concentrations. In 2005–2006 a total of 300 till samples were collected in the Grand Falls, Grand River, and Sisson Branch Reservoir areas (21 O/4, 5, and 6). Approximately 75 pebbles were collected at each site to determine glacial transport distances. Basal till samples were also collected at 32 sites at 10 km spacing over the Devonian Témisqouata Formation in northwestern New Brunswick (21/N). Future work is planned in the 21/J area

and over the Carboniferous sedimentary rocks in the Acadian Peninsula (21/P) area as well, to complete coverage across all of northern New Brunswick. All published till geochemical data are now available digitally at minimal cost. The till data will continue to be incorporated into a database of background metal concentrations in basal till, which is part of the federal government's Metals in the Environment (MITE) program initiated last year in New Brunswick and Nova Scotia. Re-analyses of 400 samples from across the province has been done to assist in levelling the New Brunswick data.

Potential for uranium mobilization from weathered outcrops of uranium-bearing sedimentary strata, southern Nova Scotia

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Nova Scotia has a number of uranium occurrences within sedimentary sequences of the Carboniferous Horton Group. These occurrences pose a potential risk to human health if the uranium enters drinking water supplies. This research focuses on a uranium-bearing occurrence of the Horton Group strata to establish both the nature of the uranium distribution in the Horton Group and to determine whether uranium in the strata may become chemically mobile under present day conditions. The main outcrop section of interest is currently undergoing active weathering and is located upslope from a small stream. Samples were taken from two sandstone and two siltstone layers, as well as from unconsolidated outwash material located at the base of the outcrop. The samples were analyzed to determine major, trace, and rare earth element geochemistry.

Geochemical data indicate that there are differences in uranium values between the samples, but does not indicate that values are linked to rock type within the formation, as the highest uranium value is from one of the siltstones (212 ppm) and the second highest value is from one of the sandstones (109 ppm). Geochemical data also indicate that higher uranium values correspond to higher values of copper, vanadium, and titanium. Values for uranium, copper, vanadium, and titanium are all lowest in the sample taken from the outwash material near the stream, suggesting removal of uranium during weathering. Experimental weathering of these rocks is currently underway in order to determine whether dissolved uranium is likely to enter surrounding waters under present-day conditions.

Magnetic mineralogy and susceptibility of magnetostratigraphic / stratigraphic units in the Goldenville Group, eastern Meguma terrane

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The Meguma Group has traditionally been subdivided into the upper Halifax Formation and lower Goldenville Formation. Locally these formations have been further subdivided, prompting their elevation to Group status. Previously, subdivision in the eastern Meguma terrane has been restricted to the Halifax Group. However, high-resolution airborne magnetic data reveal patterns that mimic known stratigraphic trends. This data can be grouped into 'magnetostratigraphic units' that suggest discernible stratigraphic packages exist in the Goldenville Group.

Current mapping was designed to evaluate stratigraphic contrasts between magnetostratigraphic units. Preliminary results suggest three stratigraphic units within the Goldenville Group. The lowermost unit, the Moose River Formation, consists of thinly interbedded grey to black slates and green metasiltstones and displays moderate magnetic response. The Tangier Formation is dominated by metasandstone cycles with predominantly black slate caps. This unit is characterized by low magnetic response. The uppermost Taylors Head Formation is also dominated by metasandstone cycles, however fine-grained caps are predominantly green metasiltstones. Magnetic response of this unit is bimodal, characterized by alternating high and low bands.

Magnetic susceptibility data collected in the field support airborne magnetics. Susceptibility data for the Moose River Formation are moderate and uniform. Data for the Tangier Formation are generally low with few isolated higher values. The Taylors Head Formation has bimodal susceptibility, consistent with airborne patterns. Susceptibility data indicate that the high susceptibility values occur within metasandstones, with the highest values from metaconglomerates. Preliminary petrographic evaluation suggests a correlation between magnetic susceptibility and opaque mineral content. The random distribution and crystal habits of opaques support a mainly metamorphic origin. Preliminary petrographic and electron microprobe data of opaques indicate various species of magnetite, ilmenite, and rutile.

Post-collisional shoshonites: product of dehydration melting of subduction-enriched metadiorite underplated at base of crust

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Post-collisional volcanism of the Aegean region is a Neogene analogue of middle Paleozoic volcanism of the Appalachians. The most voluminous Neogene Aegean volcanic rocks consist of trachyandesite to trachyte of shoshonitic character that outcrop principally in the islands of Limnos, Lesbos, and Samothraki, and in northwest Anatolia. The post-orogenic tectonic setting and the Cenozoic volcanicity of the Aegean region have been argued by many previous authors to be sourced in lithospheric mantle enriched by older subduction, as a result of dehydration melting by thermal anomalies from asthenosphere advection, which resulted from either delamination or slab break-off. Experimental studies show that such decompression melting of such a source mantle will produce small volumes of trachytic magmas.

New geochemical and isotopic analyses of rocks from Limnos and Lesbos, together with literature data from Samothraki and northwest Anatolia, show that the enriched lithospheric mantle source is untenable. In Limnos, where the shoshonitic rocks are most homogeneous, the most mafic rocks have >58% SiO_2, and a similar lack of mafic shoshonitic rocks characterizes other volcanic centres. The degree of REE fractionation in the rocks from Limnos would require about 10% partial melting of enriched mantle lherzolite, which is difficult to reconcile with the observed extreme enrichment in incompatible elements. A mantle source is also difficult to reconcile with strongly negative ε_{Nd} values for Limnos trachyandesite and the geochemically related voluminous Miocene granite of Samothraki. The large volumes of the shoshonitic stratovolcanoes in Limnos, Lesbos, and elsewhere (>10 km^3) are in strong contrast with very small volumes of enriched lamproite magma (<0.1 km^3) of clearly mantle origin in Lesbos and elsewhere and probable mantle-derived trachytes in Samos, Kos, and elsewhere (<1 km^3).

A source from either subducted oceanic crust or delaminated continental crust can be excluded on various geochemical grounds. Rather, the trachyandesites of the shoshonitic suite are derived from small degrees of partial dehydration melting from an enriched metadiorite source. This source is inferred to be diorite that underplated the crust during earlier subduction. Partial melting was favoured by orogenic thickening and the thermal anomaly from asthenospheric advection. Similar geological circumstances are to be expected in the post-collisional stages of other orogens.

Radial-growth forecasts of five conifers in southeastern New Brunswick

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Although many accept predictions that our climates are changing rapidly, very little empirical work has been conducted that gives specific information on how these changes will affect natural systems. In nature, with past climate changes, certain species often became winners, while others losers.

This project developed radial-growth forecasts for five of the most ecologically and economically relevant conifer species as chosen by regional stakeholders in southeastern New Brunswick. Using dendrochronology the five species were sampled and their radial growth increments were developed into master chronologies for each species. Regression models were then constructed using local historical monthly weather data to ascertain which factors were important to tree growth in the past. R^2 relationships indicate that the models that were developed explained a large portion of the variance in past growth (0.68 to 0.79), and so Coupled Global Climate Model (CGCM) data was used to forecast how each tree species will react to future climates.

The models reveal the direction of natural adaptation by the studied conifer species to predicted future climates, and indicate that our forests will begin to shift species composition from a spruce/fir dominated forest back to a pine/hemlock forest. This type of forest has not been dominant in our region since the Hypsothermal approximately 4–7 ka BP. This information advances our knowledge of the potential changes in forest composition, and gives specific reasons on how each species would react to predicted climatic change.

Character and timing of late Quaternary earthquake-triggered submarine landslides, Orphan Basin, offshore eastern Canada

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The catastrophic 1929 "Grand Banks" earthquake and submarine slide off southern Newfoundland provides evidence for the style of earthquake-triggered failure offshore eastern Canada. In Orphan Basin, a widespread slope failure known as the Sheridan failure took place at about 7 ka. Like the 1929 failure, it affected several discrete drainage systems apparently simultaneously. The failure was predominantly retrogressive. It also produced a sandy-gravelly turbidity current as a result of retrogressive failure of upper slope sands and/or till. Piston cores <10 m long from Orphan Basin can be readily correlated and dated by distinctive Heinrich layers. They preserve a record

of rare turbidites similar to that from the Sheridan failure. In some cores, there is also evidence for sediment failure at the same horizons. Although failures from the last glacial maximum and younger took place under rising sea level conditions, earlier failures appear to have occurred preferentially at times of sea level fall.

Widespread failure at discrete horizons occurs ubiquitously on the southeastern Canadian margin. Regional failures appear to be synchronous in multiple drainage systems and many cannot be accounted for by retrogression from a single point failure. Such synchronous failure over a large area probably results from earthquake triggering, although glacial meltwater discharge and consequent canyon widening is a possible mechanism in certain rare situations.

Estimating the frequency of past large earthquakes is important for assessing seismic and tsunami risk and as input into the National Building Code, which currently appears to overestimate seismic risk for coastal areas of Atlantic Canada. A crude magnitude-frequency relationship is observed, with small failures on the continental slope having a recurrence interval of perhaps $5x10^3$ yr whereas large failures have a recurrence interval of $>2x10^5$ yr. There does not appear to be a systematic relationship between failure frequency and regional gradient, although on a local scale, steeper slopes are more prone to failure, as shown by the greater abundance of small failures on active fault scarps created by salt tectonics. Failures are more common on continental slopes adjacent to glaciated continental shelves, compared with slopes of similar gradient that also receive muddy plume sedimentation far offshore, for example at Orphan Knoll. Regional failures appear no more abundant in areas of active salt tectonics than elsewhere. The decrease in frequency of failures offshore and the greatest abundance of failures during deglaciation suggests that some of the seismicity was induced by glacio-isostasy. Several factors may precondition sediments to fail more readily, including underconsolidation due to high sedimentation rates from proglacial plumes and the availability of shallow gas.

How to get into deep water: sand transport seaward of early Cretaceous deltas in the Scotian Basin

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In early Cretaceous time, high-energy braided rivers deposited complex deltas on the Scotian shelf. The manner in which sand was transferred from these deltaic systems to deep water is important for identifying exploration targets on the deep-water continental margin. We have logged conventional core from the Tantallon M-41, Thebaud I-93, Thebaud 3, Thebaud 5, and North Triumph G-43 wells, emphasizing sedimentological features that indicate either hyperpycnal river-mouth flow or prodeltaic slumping of sandy facies. The relative importance of slump-derived and hyperpycnal turbidity currents is critical for predicting sand distribution in deep water. Slump-derived turbidity currents generally evolve into highly turbulent flows that deposit only on low gradients of <0.2° on the basin floor. More concentrated hyperpycnal flows may deposit on higher gradients of 0.4°, and will thus give thick sand deposits more proximally.

In the wells studied, hyperpycnal flow facies in conventional cores with deltaic and shelf facies are found stratigraphically below major channel sandstones. They show abrupt alternations of granule conglomerate, fine sandstone, and mudstone. In prodeltaic (shoreface) environments, sharp-based laminated to cross-laminated fine sandstone beds with abundant wood fragments or mudstone chips are also interpreted as the products of hyperpycnal flows. They can be distinguished from storm-resuspended sandstone beds by their better sorting and lack of reworked shelly fossils.

In conventional cores from prodeltaic settings, large slide blocks, tens of metres thick involve a wide range of primary sedimentological facies. These facies are recognized as allochthonous by the presence of a basal foliated mudstone and variably deformed contacts between sediment blocks, some of which include spaced shear zones. Preserved facies are predominantly shale-prone: we speculate that failure of sand-prone successions could have generated sandy turbidity currents. Prodeltaic slopes in many cases developed at growth faults on the shelf, so that failure would not have transferred sediment to the continental slope.

In the Tantallon M-41 well on the present continental slope, conventional core from the Middle Missisauga Formation shows overbank turbidites with characteristic sparse bioturbation, Bouma Tb-c sequences, and fading ripples. In some sandstones, abundant woody fragments, sorted mudstone chips, and transported siderite nodules suggest a source from river discharge. Reverse grading at the base of some sandstone beds suggests hyperpycnal flow.

Present data is insufficient to fully evaluate the relative importance of slump-derived turbidity currents and hyperpycnal turbidity currents in sand transport to deep water in the early Cretaceous. There is evidence that both types of current were present. The widespread evidence of hyperpycnal flow deposits interbedded with shelf sediments strongly suggests that some hyperpycnal flows reached deep water and like modern hyperpycnal flows could have deposited sand in relatively proximal settings.

Saskatchewan potash geology, with emphasis on disruptions to "normal", flat-lying Phanerozoic stratigraphy

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Much of southern Saskatchewan is underlain by the Prairie Evaporite Formation, a Middle Devonian layered sequence of salts and anhydrite which contains the Western World's largest reserve of potash. The potash beds occur near the top of the 100 - 200 m thick evaporite sequence, and the potassium extracted from the predominantly sylvinite ore has its main use as fertilizer. The Phanerozoic stratigraphy of the Williston Basin in central Saskatchewan is remarkable in that units are flat-lying and relatively undisturbed over very large areas. However, there are areas of local, sometimes severe, disruption to "normal" Phanerozoic stratigraphy in the Williston Basin region of west-central North America: the collapse structure. Collapse structures are localized regions of considerable, sometimes complete, destruction of original geological layering. These features are thought to result from dissolution of Prairie Evaporite Formation salts at depth, with associated brecciation and collapse of overlying (mostly carbonate, then shale) strata into the resulting washout caverns. Collapses are often assumed to take the shape of sub-vertical cylinders, 100–1000 m in diameter, extending from depths of over 1000 m right to surface. Earth scientists working in the Saskatchewan potash industry have a strong interest in mapping collapses because of the hazard these disruptions pose to mining operations. Use of 3D surface seismic methods and the recent practice of depth migration of these data have resulted in a more detailed view of the shape of these features than ever seen before. While some collapses are consistent with the existing washout/brecciation model, others are not. 3D images of some collapses look more like carbonate-karst features than washout-breccias. With proper depth migration of the seismic data, "collapse-areas" become much smaller and more focused than previously thought. One area that had been mapped as a single, large collapse zone is shown to be made up of three en-echelon, chimney-like disturbance zones. Some of these disturbances are underlain by washouts in the Prairie Evaporite Formation, but some are not. The absence of any disruption within Prairie Evaporite Formation salts below a disturbed zone in overlying carbonates is inconsistent with the washout/breccia model for how these carbonate "collapses" are formed. This observation is, however, consistent with existence of porous (karst) zones in these carbonates, zones that might have nothing to do with underlying salts. The relationship between these postulated zones of karstification and disruption of underlying Prairie Evaporite Formation salts is currently unclear. The salt disturbances seen in Saskatchewan might by a model for some of the disruptions to "normal" geology seen above salts of the Cassidy Lake Formation of the Windsor Group in the Moncton Subbasin.

Deglaciation of Nova Scotia – a chronostratigraphic approach

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Deglaciation of Atlantic Canada is well studied and has been reconstructed based on extensive sets of onshore and offshore data. The records show that during the initial rapid deglaciation of the region, ice caps were isolated and persisted as local ice domes throughout the late-glacial. The regional pattern of deglaciation in Nova Scotia is much more complex than the steady ice retreat that has been documented for the New England coast. Ample field evidence, radiocarbon ages, and pollen studies by others suggest that after widespread climate amelioration during the Bölling/Alleröd, the local ice caps advanced during the Younger Dryas cold event.

Glacial erratics and glacially polished bedrock were dated with cosmogenic nuclides along a transect from southern Nova Scotia to the Cape Breton Highlands. Use of ^{10}Be surface exposure ages shows that: 1) deglaciation at the Atlantic coast occurred around 15 ka BP; 2) the Cape Breton Highlands were glaciated with warm-based local ice during the Wisconsinan and deglaciated likely around 15–14 ka BP; and 3) the Younger Dryas glacial advance must have reached the southern part of Nova Scotia and was therefore much more extensive than thought earlier. The results tie in very well with field evidence for glaciation. The results are critically discussed in comparison to output data from ice sheet and climate models for the deglaciation of Nova Scotia.

The geology of a building: the multiple layers of the Sinclair Inn, Annapolis Royal, Nova Scotia

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Many old buildings that are found in the Maritimes have a complex history, having gone through repairs and renovations throughout the years. The Sinclair Inn in Annapolis Royal, Nova Scotia, is one of the most complex structures encountered by the Mount Allison Dendrochronology Lab and has been the object of a thorough dendrochronological investigation to unlock the mystery of its several lives.

Samuel de Champlain founded Port-Royal in the early 1600s and it became the administrative and military centre of Acadie. It was later renamed Annapolis Royal by the British when it was captured in 1710 and is considered to be the oldest permanent

European settlement in North America north of Florida. Many old buildings survived through time and are still being used today. Among them is the Sinclair Inn located at 232 St. George Street, an old two storey wood frame building that was possibly made in the late 1700s by Frederick Sinclair out of the joining of two earlier houses that are thought to be dated in the late 1690s to early 1700s.

From fragmentary historical records, the Annapolis Heritage Society developed the hypothesis that the front part of the inn could be the remnants of the former Soullard House suspected to have been built on the current property. The lower back section of the inn could be the former Skene House, which was not originally built on the current property but possibly transferred there later by Frederick Sinclair. The inn itself was possibly built in 1781 on the current site by the joining of the Soullard two-storey house already on the spot and the Skene one-storey house which was moved. A second storey was later added to the Skene section and also a new roof covering both parts.

Our objective was to verify the hypotheses, by establishing the date of the three parts of the Sinclair Inn with the use of newly built regional tree-ring chronologies from the Fundy area of Nova Scotia. Cores were extracted from chosen beams using an increment borer then taken to the laboratory where ring-width of samples was measured to the nearest 0.01 mm. Growth patterns were crossdated with our regional reference chronologies. Excess fragments of selected cores were set aside for wood identification. The observation of wood anatomical structures was conducted with the Scanning Electron Microscope (SEM) at the Mount Allison Digital Microscopy Facility.

Results indicate that the trees used to build the structure of the front (Soullard) part are spruce and fir and the youngest cut date is 1707. The beams from the back (Skene) part are spruce and white pine and trees were cut in 1709. They confirm the age and hypotheses made by the Annapolis Heritage Society. The inn itself might be older than previously thought and could be as old as the late 1760s.

"Caprock"

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In southern New Brunswick two marine transgressions resulted in Windsor Group evaporites being deposited in local subbasins. The main evaporite sequence is composed of a basal limestone unit (Macumber Formation) a few tens of metres thick, overlain by up to 200 m of massive anhydrite (Upperton Formation), which in turn is overlain by up to 500 m of salts (Cassidy Lake Formation). The various members of the salt sequence, progress from the deep water clean basal halite, through the argillaceous middle halite, and potash (sylvinite ore zone ± carnallite), to the shallow water heterogeneous finely laminated halite + sylvinite + anhydrite + borates.

A second, less pronounced, transgression resulted in a refilling of the basin and the deposition of a 10 m anhydrite unit with minor limestone, 100 m of halite (Penobsquis salt), and a grey claystone, up to 20 m thick. This marks the end of marine deposition in New Brunswick.

The anhydrite unit is of particular practical interest from a mining point of view as it represents an important component of the impervious barrier between the underlying soluble salts and the overlying water-bearing Mabou Group. In informal mining terms this barrier is referred to as the "caprock". This caprock ranges from a massive microcrystalline anhydrite, as part of the normal stratigraphy, to a strongly deformed anhydrite/claystone breccia in a clay matrix intermixed with clasts from the overlying Mabou siltstones together with insolubles left from dissolution of the underlying salts.

The caprock helps tell the story of the depositional and structural history of the uppermost Windsor Group evaporites in this part of the Maritimes Basin. Stratigraphically it records details of the second, minor, marine flooding of the subsiding Penobsquis/Picadilly subbasin, on the finely laminated shallow water salts at the top of the Cassidy Lake Formation.

The caprock also helps record details of the structural history. Within the subbasin, salt withdrawal in the north and its up-dip migration was encouraged by remobilization of the Petitcodiac Fault and insertion of a wedge of Horton Group sedimentary rocks within the evaporite package. While the salt body as a whole acted as a mobile unit most movement took place within the potash horizon. This led to development of a strong fabric, together with km-scale recumbent folding, coalescing limbs and nappe structures.

Buckling of the mobile salt body formed a salt wall, while shearing of the potash horizon continued, extending upwards, through the caprock and overlying Mabou Group sedimentary rocks. This breaching of the caprock allowed dissolution of the crest of the salt wall, followed by karst development and eventual collapse to form an elongate graben-like feature filled with brecciated siltstone. This history is recorded in the caprock directly overlying the collapsed salt wall. Here, the caprock retains evidence of the shearing initiated in the potash, together with collapse of the salt wall, leading to incorporation of Mabou Group sedimentary rocks, and dissolution of much of the Cassidy Lake Formation sequence, leading to incorporation of the insolubles from these salts.

The use of tsunami-laid deposits to hindcast the magnitude and hazard of the event

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When one finds a historic or palaeo tsunami-laid deposit in the geological record it is most often a sandy to coarse silty layer. If one is able to fully document it and its full extent survives in the record, one is left with certain geological parameters such as grainsize and thickness. With their variation over

the deposit, one may have the deposit's areal extent and the change of elevation over the deposit. One does not have the magnitude, the run-up height, or the run-up distance of the parent tsunami as it inundated the land surface. By thinking of a tsunami-laid deposit as the result of a moving, settling tube it is possible to use sediment dynamics to hindcast certain of the tsunami's parameters.

Tsunami deposits tend to thin landwards and each grainsize component of the deposit tends to decrease landwards; the deposit fines as the run-up distance increases from the original shoreline. Surveys of modern tsunamis show that the landward horizontal extent of the run-up and the vertical height of the run-up of the water exceed the equivalent run-up measurements of the tsunami deposit. It is of course the run-up distance and run-up height of the water that defines the potential hazard to humans and their communities.

Examples in Tamil Nadu, India from December 26, 2004, Burin Peninsula in Newfoundland from November 18, 1929, and from the Storegga Slide tsunami of about 8000 sidereal years BP, serve to illustrate the potential of this sort of analysis of tsunami deposits.

Local stratigraphy and groundwater chemistry in the Grand Pré region, Nova Scotia: contamination sources and mitigation strategies

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Grand Pré, Nova Scotia, is located in the Annapolis-Cornwallis Valley, and is underlain by Carboniferous Horton Group sedimentary rocks that comprise the local groundwater aquifer. Two suites of 26 groundwater samples were collected two months apart and analyzed for the concentrations of 72 cations. In nine samples, the concentrations of the anions (Cl^-, NO_2, Br, NO_3, SO_4, and PO_4) were also determined. Samples were analyzed by ACME Analytical Laboratories, Vancouver, British Columbia, using ICP mass spectrometry.

Concentrations of uranium (U up to 0.0508 mg/L), iron (Fe up to 0.605 mg/L), selenium (Se up to 0.0277 mg/L), lead (Pb up to 0.0541mg/L), and manganese (Mn up to 2.2822 mg/L) exceed the maximum allowable concentrations defined by Health Canada in some wells. A natural source for these contaminants is likely. The source of U and Se is believed to be the peraluminous South Mountain Batholith granite, the source of clastic grains in the mineralogically immature Horton Group sedimentary rocks.

Both highly permeable arkosic arenites (channel facies) and moderately permeable carbon-rich shales (overbank facies) serve as local aquifers. The different geochemical environments within these sedimentary facies control groundwater element mobility. Thermodynamic modelling and construction of pe/pH stability diagrams gives insight into the contaminant speciation and effects of facies stratigraphy on groundwater geochemistry. Preliminary results suggest that carbon-rich (reduced) facies in Horton Group sedimentary rocks result in conditions favourable to sequestration of uranium and selenium. The opposite is true for wells that derive their water from (oxidized) highly permeable channel sand facies.

A review of published documents from provincial, federal, and international organizations, including the World Health Organization, provides information on specific groundwater management approaches and guideline development. Cooperation between the Nova Scotia Department of Environment and Labour and the residents of Grand Pré is necessary to create a strategy to mitigate the groundwater hazards in Grand Pré, and will also act as a framework for achieving desirable drinking water in similar communities.

Geochemistry of late Neoproterozoic and Cambrian sedimentary and metasedimentary rocks in the Caledonian Highlands, southern New Brunswick

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Neoproterozoic though Cambrian clastic sedimentary and/or metasedimentary rocks occur in the Hammondvale Metamorphic Suite (>ca. 620 Ma) and Broad River (ca. 620 Ma), Coldbrook (ca. 560–542 Ma), and Saint John (ca. 540–490 Ma) groups in the Caledonia terrane (Avalonia) of southern New Brunswick. Petrography, whole-rock chemical data (major and trace elements), and Nd isotopic compositions are used to compare and contrast the units and to investigate their provenance and tectonic setting during deposition.

Petrographic study indicates that many of the samples are mechanically mature but chemically immature, suggesting that the amount of chemical weathering was low and/or that the sediments were deposited relatively close to their source area(s). The presence of microcline and perthite orthoclase in many of the Broad River Group metasedimentary rock samples suggests they are not derived from the associated volcanic rocks, but have a plutonic source. The oldest plutons in the Caledonian Highlands are 620 Ma in age, and thus these rocks were not derived from local Avalonian plutons. Samples from the younger Coldbrook and Saint John groups have less K-feldspar and more plagioclase, suggesting that the source rocks had changed.

Samples from the high-grade Hammondvale Metamorphic Suite are chemically most similar to phyllite samples from the Broad River Group, suggesting that they were derived from similar sources. The Coldbrook Group samples have major element patterns similar to those of the Hammondvale Metamorphic Suite and the Broad River Group metawacke samples, but have more varied trace element patterns, indi-

cating more varied sediment sources. The Saint John Group, sedimentary rocks have varied geochemical patterns that overlap all of the older groups. They had varied source rocks and may have been derived from a mix of Broad River Group, Hammondvale Metamorphic Suite, and Coldbrook Group sources.

Preliminary Nd isotopic results from this study combined with previously published data show that the Hammondvale Metamorphic Suite and Broad River Group metasedimentary rocks, as well as sedimentary rocks of the Saint John Group have mostly negative ε_{Nd} values, falling outside the Avalonian isotopic window established from igneous rocks. In contrast, sedimentary rocks of the Coldbrook Group show more positive ε_{Nd} values, falling within the Avalonian isotopic window. Previously published Nd isotopic data from igneous units in the Broad River and Coldbrook groups have mostly positive ε_{Nd} values, consistent with sedimentary rocks in the Coldbrook Group having been derived from those rocks. The positive values from the igneous units are not consistent with the more negative values for the Hammondvale Metamorphic Suite and Broad River Group metasedimentary rocks and the Saint John Group sedimentary rocks. The Hammondvale and Broad River sedimentary rocks must have had an isotopically mature source, likely outside Avalonia. The Saint John Group sedimentary rocks may have been derived from a mix of Broad River metasedimentary rocks and Broad River Group and Coldbrook Group igneous rocks.

The Gaspereau Ice Centre and the Younger Dryas glaciation of central New Brunswick

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The Gaspereau Ice Centre, centred over the western part of the New Brunswick Lowlands, was originally defined as one of several local ice centres that interacted during the earlier part of the Late Wisconsinan glaciation of New Brunswick. Subsequent investigations have suggested that the main Late Wisconsinan glaciation of New Brunswick was effected by a single migrating ice centre or ice divide of regional extent, rather than by multiple independent ice centres. However, the results of recent till geochemistry investigations in the western part of the New Brunswick Lowlands and adjacent parts of the Miramichi Highlands, to the northwest, suggest that the Gaspereau Ice Centre was active in this area during the Younger Dryas.

In 1986, a Geological Survey of Canada trenching program uncovered organic materials beneath 2+ m of surface till at a site near Todd Mountain, in the southern Miramichi Highlands in central New Brunswick. ^{14}C dating of the organic material revealed that it was formed during the warm Allerød oscillation, indicating that the overlying till was formed during the subsequent Younger Dryas cold period. Till fabric measurements in the discovery trench and at a second section nearby suggest that the Younger Dryas till was deposited by a northwest, flowing glacier. The results of till geochemistry investigations carried out in 2004 suggest that these sites lie within but near the northern limits of an area characterized by northward to northwestward glacial dispersal.

To the southwest, in the Napadogan Brook area, till of eastern provenance has been tentatively attributed to westward ice flow during the Younger Dryas. To the southeast, the till in the area to the northwest of Grand Lake commonly exhibits chaotic intermixing of material of two differing shades. This suggests that an older till, probably of Late Wisconsinan age, was remobilized by a later till but not completely intermixed. A till fabric measurement at a site in this area revealed a generally diffuse fabric with a small peak suggesting ice-flow toward the northwest. At a second till site, near the western shore of Grand Lake, westward ice flow is suggested by the presence of an angular clast of maroon rhyolite, probably derived from the Cumberland Hill Formation to the east.

The current interpretation is that the Gaspereau Ice Centre was active during the Younger Dryas, rather than during the main Late Wisconsinan glaciation. Its exact extent during the Younger Dryas is unknown, however, as no ice-marginal features have yet been identified. It may have been contiguous with a proposed late-stage ice cap over the Caledonian Highlands of southeastern New Brunswick. To the west and southwest, geological and palynological data restricts it to the area to the east of the Nashwaak River. It almost certainly occupied the Grand Lake basin, blocking southward drainage in the Saint John River valley and thereby creating Glacial Lake Acadia in the central part of this valley.

Long Lake uranium deposit, north-central New Brunswick: a granite-hosted uraniferous polymetallic vein system in the Canadian Appalachians

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The Long Lake polymetallic vein-type uranium deposit is located in north-central New Brunswick, approximately 31 kilometres northeast of Plaster Rock. The uraniferous veins are hosted by late-to post-Acadian granites of the Lower Devonian North Pole pluton and occur in hydrothermally altered and highly brecciated, northwesterly-trending fractures. The centre of the mineralization is associated with an area of the pluton that is coincident with high airborne radiometric eU, eTh, and eK anomalies and a strong negative (less than -48 mgals) Bouguer gravity anomaly. The uranium mineralization is commonly associated with chalcedony (jasperoid) veins, although

there is a significant amount of uranium present in the highly altered granites surrounding these siliceous veins. Furthermore, there are economically significant amounts of other elements present, such as copper, lead, zinc, molybdenum, bismuth, tungsten, tin, antimony, indium, silver, and gold.

The North Pole pluton was emplaced at shallow depths, discordantly into the metasedimentary rocks of the Miramichi Anticlinorium, late in the tectonomagmatic sequence. In terms of petrology, the North Pole pluton consists of three, probably comagmatic phases; biotite granite (older phase); biotite-muscovite granite; and quartz-feldspar porphyry granite (youngest phase). Existing petrochemical data for the North Pole pluton suggest that it is an 'S-type' and to a lesser extent an evolved crustal 'A-type' granite. Based on geochemical data from the area, the uranium is likely derived predominantly from the two younger phases of the pluton.

Exploration of the Long Lake area dates back to 1956 when the Anthonian Mining Corporation, followed by COMINCO, began a nine-year effort to develop the prospect, consisting of geochemical, geophysical, and drilling surveys (33 holes totaling 4040 m) in the Cheavers Lake region. In 1963, three holes were drilled by Consolidated Mining and Smelting after conducting soil and electromagnetic surveys southwest and northeast of the Anthonian work. Canadian Occidental Petroleum's involvement in the area began in 1971 (2 holes, totaling 305 m), but was abandoned from 1974 to 1978, then reactivated in 1979 to 1982 (24 holes, totaling 3011 m). Their three year mapping, trenching, and drilling campaign yielded grades up to 3440 ppm U over 0.15 m from drill core, and 8800 ppm U from float. The area was staked again in 1983 by Kidd Creek Mines to evaluate tungsten and molybdenum anomalies delineated by a federal government silt survey. Finally in 1986, CEGB Exploration (Canada) Ltd. obtained a grade of 5420 ppm U from a boulder when they staked sixty claims over favourable geological and geochemical targets.

Global warming, climate change, and geoscientists: a volatile mix

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Climate change refers to the variation in the Earth <http://en.wikipedia.org/wiki/Earth>'s global climate <http://en.wikipedia.org/wiki/Climate> or in regional climates over time. Unseasonably warm weather, recent increases in hurricane strength and recurrence, and reduction in polar ice volume have been attributed by many to climate change (global warming) associated with increases in greenhouse gas emissions.

Debate over the degree to which human activity has influenced climate has been increasingly contentious and combative. Geoscientists have been an important part of this debate, but have also been seen as unacceptably equivocal about the connection between human activity and climate change.

The authors will highlight how politicians, the media and geoscientists have come to view climate change in very different ways. An open discussion with the audience will follow.

Documenting the physical changes and thermodynamic effects of geochemical reactions: a metasomatic example in Gale vector space

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Metasomatic reactions associated with many geological processes (e.g., hydrothermal alteration, diagenesis, weathering, etc.) are typically difficult to specifically define because some reactants and products (soluble species) may be added or removed by the fluid, and evidence for their involvement in a reaction may thus be absent from a suite of rocks. As a result, given a known (observed) reactant and product mineral assemblage, one is commonly able to identify a myriad of possible geochemical reactions. Determining which reaction actually operated to produce the observed change in mineral assemblage may thus be intractable without other mineralogical, geochemical, or physical constraints.

Matrices of row and column vectors may be used to describe both the compositions of minerals and aqueous species, and the coefficients of these minerals and species in geochemical reactions. As a result, a number of matrix operations can be undertaken to provide insight into the nature of geochemical reactions involving minerals and species. One important result is a geometric representation of the geochemical reactions in a multi-dimensional Gale vector space. This space hosts points defining all possible reactions among the minerals and species under consideration, and thus can be used to systematically describe the feasible geochemical reactions. Because changes to physical characteristics (mass, volume, and density), and thermodynamic properties (ΔG_r, ΔH_r, ΔS_r) can be determined for each possible reaction, Gale vector space can be used to conclusively identify all possible reactions consistent with constant volume, density, mass, adiabatic, or isothermal constraints. As a result, investigation of geochemical reactions in a Gale vector space provides a comprehensive and systematic way to identify all feasible chemical reactions using such constraints. An example involving the serpentinization of olivine is used to illustrate the features and power of using a Gale vector space in this application.

Correlating geological properties with durability of construction aggregate

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Physical testing of crushed bedrock material for construction applications is a common engineering practice. Micro Deval and Los Angeles Abrasion, tests used to determine the durability of coarse aggregate, are considered time-consuming and expensive. Mineralogy and texture of a rock are among the main geological factors that impact its mechanical behaviour and therefore its suitability for road surfacing and related construction materials. Despite this generally recognized connection, correlation between the geological properties of rocks and standard aggregate durability testing has not been examined in New Brunswick.

Petrographic analysis and whole rock chemistry will be used to correlate quantifiable geological data with durability values obtained from micro Deval and Los Angeles abrasion testing from a suite of plutonic and volcanic rocks in northern New Brunswick. This type of investigation has the potential to serve as an accurate and reliable means of pre-screening proposed aggregate material for various end uses, resulting in savings of time and money.

Using climate data, landscape parameterization, and a LiDAR generated digital elevation model to map flood risk in Oxford, Nova Scotia

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From September 21–23, 1999, remnants of Hurricane Harvey converged with another active storm and 302 mm of rain fell in a 30-hour period in the area surrounding the town of Oxford, Nova Scotia. The town site is situated on the flood plain of the River Phillip at the confluence of River Phillip and Black River. This event resulted in the flooding of River Phillip and severe damage to infrastructure in the town. The damage associated with this flood event (and a subsequent event in March 31, 2003), has led to the need to better understand the interplay between weather, landscape, and river stage in this area.

In this study we reconstruct the climate factors that preceded the September 1999 flood. We have focused on this flood event as complicating factors such as the presence of snowpack and river ice do not need to be considered. For the upper catchment we classify landuse using multispectral Landsat ETM+ imagery in conjunction with surficial geology maps and assign hydraulic properties to each. In the floodplain, we calculate vegetation heights from the digital elevation model (DEM) which was acquired via airborne LiDAR (Light Detection and Ranging) to calculate surface roughness and coefficients of friction. We also use our DEM to provide a platform for flood inundation models.

Preliminary results indicate that changes in the parameterization of land use play a significant factor when modelling the relationship between weather and river stage and must be carefully considered when modelling hydrological events. DEMs derived from LiDAR are a valuable source of data for understanding the subtle behaviour of water flow within ditches and along roads within a town landscape which are very difficult to map using traditional larger scale DEMs. However, modelling using higher resolution LiDAR-derived DEMs come with its own difficulties such as file size and flow obstructions which are not otherwise encountered when working with traditional scale DEMs.

The taphonomic implications of a new fossil tree from Joggins, Nova Scotia

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The classic Carboniferous section at Joggins is most famous for the discovery of standing fossil trees that bear the skeletal remains of tetrapods (reptiles and amphibians), first discovered in 1852 by Lyell and Dawson. In more than a century since the intensive exploration by Dawson, primarily at Coal Mine Point where 15 productive trees were documented, only 5 other tetrapod-bearing trees have been discovered. We report here for the first time the discovery of a sixth productive tree (NSM006GF065.001) recovered in November 2006 with the aid of community members and Saint Mary's University geology students. Notably, 3 of these 6 trees have been discovered since 1995 from one horizon: 544 m above the base of the Joggins Formation, below Coal 20 (Forty Brine Seam), making this the second major tetrapod-bearing fossil forest horizon known at Joggins. As such, this horizon is of particular significance in understanding the nature of the entombment of the tree fauna. All three fossiliferous trees conform to the general model described by Dawson, with tetrapods occurring near the basal fill of trees that record evidence of wildfire. An in-depth analysis of the variation in fire damage and taphonomy of the entire tree horizon will be undertaken elsewhere. In this paper, we document the history of the new tree, with its exceptional

cross-sectional exposure showing the relationship between the skeletal record and its entombment and infilling.

Because of its location at the base of the cliffs, its prompt recovery, and its intact nature, the context of this tree has potential to be better understood then any other recently collected. The trunk flares downward from a diameter at breast height of 38 cm to a 45 cm base where the roots are preserved as flattened, coaly impressions in the surrounding dark grey siltstones. The base of this lycopsid tree is infilled by 24 cm of charcoal-rich sediment, the upper few centimetres of which contain robust tetrapod bones, possibly of an anthracosaur or labyrinthodont amphibian. Additional skeletal remains are expected to lie within this mineral charcoal layer. The tree remained hollow long enough for the woody stele to partially collapse within the once hollow tree, having lost the support of surrounding parenchymatous tissues. The burial of the trunk is recorded by almost a metre of grey siltstone overlain abruptly by rooted, laminated siltstone. The upper 60 cm of the trunk is encased by heterolithic, centroclinal cross-strata (vegetation induced sedimentary structure). Together, the tree, and its context, suggests a lycopsid growing in a low-lying interdistributary bayou, inhabited by tetrapods under a seasonal climate that fostered wildfire, and which was eventually buried by prograding distributary channels.

Patterns of geohazards in the Atlantic Ocean: implications of spatial and temporal scales for the study of evolving correlations

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Interactions among processes related to geohazards in the Atlantic Ocean are characterized by space-time variability and complexity. On the one hand, earthquakes can trigger tsunamis and underwater landslides; landslides can produce tsunamis in their turn. On the other hand, earthquake occurrence is characterized by evolving patterns of interaction between successive events. Despite recent progress in geoscience, pattern identification, and dynamic systems theory, the comprehensive and meaningful characterization of such patterns is still challenging. The proposed paper shows that even advanced multiscale pattern analysis methods may lead to results that are time- and orientation-dependent. Consequently, anisotropy and pattern change are approached with the help of a methodology that is able to; 1) identify space-time correlations between events at different scales and for different spatial directions, and 2) distinguish fluctuations from trends as a function of temporal scale. The paper highlights the meanings of the findings for the study of patterns related to interacting geohazards in the Atlantic Ocean. Specific aspects, such as data availability in areas of relatively reduced seismicity, catalogue completeness, and catalogue accuracy are discussed in this context. Special emphasis is laid on the effects of scale scanning in space and in time and on their practical methodological implications.

Oikocrysts in the gold districts of the Meguma Group, central Nova Scotia

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Oikocrysts are one of the most enigmatic features of the Meguma Gold districts. They are ovoid aggregates of quartz, carbonate, and sheet silicates, locally associated with sulphide, that commonly define a prominent down-dip lineation on the limbs of gold-bearing anticlines in the central part of the Meguma Group. Regional mapping of the Oldham and Montague gold districts, and sampling at Mooseland and Caribou, has shown that oikocrysts are confined to the gold districts. A detailed mineralogical and textural investigation of oikocrysts from these areas has been undertaken in an attempt to determine their origin and their link to the gold districts.

Oikocrysts occur mainly in slate horizons interlayered with quartzo-feldspathic metasiltstones and metasandstones of the Goldenville Formation. Field observations confirm that the long axes of the elongated oikocrysts define down-dip lineations on cleavage planes perpendicular to anticlinal fold hinges. Although in hand sample they resemble deformed porphyroblasts, internal mineralogy and texture are not consistent with this interpretation. Instead, their internal features resemble the mineralogy and texture of interlayered metasiltstones. In some cases, an apparent progression from cusps of deformed metasiltstone layers at slate boundaries to isolated oikocrysts in the adjacent slate can be observed. The oikocrysts are generally rimmed by biotite-chlorite intergrowths, which are coarser grained and less deformed than sheet silicates defining cleavage in the surrounding slate. Similar biotite-chlorite intergrowths are present within some metasiltstone layers. These features point to the possibility that oikocrysts are isolated fragments of highly deformed metasiltstone layers. Oikocryst aspect ratios (4:1 to 12:1) reflect the amount of strain in the slate, which is interpreted to reflect folding.

The relative age of oikocryst formation can be constrained by cross-cutting relationships. The quartz-rich aggregates pre-date or are synchronous with at least one stage of cleavage formation, although it is likely that the biotite-chlorite rims formed later. The oikocrysts and their rims pre-date at least one generation of quartz veins and in the Mooseland district they appear to pre-date contact metamorphism. Although these observations suggest that oikocrysts formed relatively early in the structural and metamorphic history, our data so far do not provide an explanation for their association with gold districts.

Architecture and origin of the Upper Miocene ignimbrites, island of Kos, Greece

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Kos is one of several localities (Samos, Patmos, Bodrum) in the southeast Aegean Sea with Upper Miocene volcanic rocks. The stratigraphic succession of flows, ignimbrites, and interbedded sediments were studied in the field in order to better understand the age, distribution, source, and tectonic setting of Upper Miocene volcanic rocks of Kos. Previous radiometric dating shows that the age of the volcanism is about 10 Ma.

In northern Kos, thin andesite flows and dacite domes are overlain by thin pyroclastic rocks near Profitis Ilias and at Tripa; north of Ag. Fokas, a thin pyroclastic succession includes lahars. In southern Kos, pyroclastic successions totalling 80 m in thickness are interbedded with Miocene clastic sediments and marls at Ag. Fokas and Ag. Stefanos.

At Ag. Stefanos, the lowest volcanic rocks are volcaniclastic conglomerates deposited from channelized hyperconcentrated flows, overlain by an ignimbrite rich in limestone clasts. This is overlain by 50–60 m of marls and clastic sediments, a 10–20 m thick ignimbrite succession, a further 80 m of marls and clastic sedimentary rocks, and finally 60 m of ignimbrite, possibly in three major eruptive cycles with upward increase in abundance and size of lithic clasts. At Ag. Fokas, 80 m of ignimbrites overlie thin airfall tuff over marls and are interrupted by two thin intervals of sediment, one marl and the other sandstone. In both localities, interbedded sediments appear to be of fluvial or lacustrine origin.

Paleocurrent indicators in ignimbrites suggest that the Ag. Stefanos section was derived from a southeasterly source, most probably from a Miocene precursor of the modern volcanic centre of Nisyros - Yali. Studies are underway to compare lithic clasts from different ignimbrites to examine possible correlations between Ag. Stefanos and Ag. Fokas and to evaluate whether the Ag. Fokas ignimbrites might have been sourced from Bodrum. Minor andesite-dacite volcanism at Profitis Ilias and Tripa may be related to the faulted northern margin of a southern Kos basin within which the thick ignimbrites accumulated.

Upper Miocene volcanism was synchronous with emplacement of the Dikeos monzonite during E-W strike-slip faulting. This faulting created local transtensional or transpressional deformation, leading to uplift and unroofing of the monzonite, the overthrusting emplacement of alpine basement onto the monzonite, and creation of the Late Miocene basins in which thick successions of ignimbrite were deposited subaerially or in shallow lakes. The thickest ignimbrites were derived from a stratovolcano located near the present island of Nisyros.

Contamination of groundwater by geogenic barium

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Groundwaters of the Winnipeg Formation, an important freshwater aquifer in southeastern Manitoba, have barium concentrations in excess of drinking groundwater guidelines over an area of several hundred square kilometres. Water samples throughout this aquifer are at or near barite saturation but sulphate concentrations are exceedingly low, allowing for high barium concentrations. The inequality of barium and sulphate concentrations suggests that either the barium is from a source other than barite or that sulphate is being lost from the groundwater, allowing for a buildup of barium in solution. A lack of alternate sources of barium indicates that sulphate is likely being reduced and converted to sulphide. This concept is also supported by low dissolved oxygen concentrations in areas of high barium concentrations.

First results of the Guitard Brook gold occurrence study, Elmtree Inlier, northeastern New Brunswick

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Late orogenic shear zone-hosted epigenetic gold mineralization at Guitard Brook occurs within Ordovician (~465 Ma) ophiolitic rocks of the Fournier Group in the Elmtree Inlier (EI). These rocks were obducted in an accretionary prism that formed during closure of the Iapetus II ocean basin (~435–440 Ma). Mineralization at Guitard Brook has been traced for 400 m along a NW-SE strike, over a maximum width of 200 m, and to a vertical depth of 300 m. The best intersection reported is 15.5 m grading 1.2 g/t Au; with, mineralization open at depth. Mineralization consists of auriferous arsenopyrite-pyrrhotite ± pyrite veins with minor galena and sphalerite occurring within a hydrothermally altered zone that is localized in and overprints a high strain zone within a sequence of allochthonous, altered mafic volcanic flows or gabbroic intrusions of the Black Point Gabbro.

The Guitard Brook samples show, in the Zr-Nb-Y diagram, a more calc-alkalic signature with transitional back-arc basin/plate-marginal to ocean basin setting like the Ordovician Bathurst Subzone rocks. Compared to those, the Guitard Brook rocks have a more N-MORB profile with low Zr/Y and low K and Nb values (Zr-Nb-Y diagram) and an affinity to ocean floor/mid ocean ridge basalts (Zr-Ti-Y and Zr-Ti-Sr diagrams). The REE demonstrate a similar flat pattern like the Ordovician rocks with Sr and Nb depletion, whereas the Silurian rocks show Nb, Nd, and Ta enrichment.

The silicification (early proximal and late distal) is followed by sericitization and saussuritization of the feldspars, which is generally overprinted by chloritization. The sulphide veins are surrounded by later carbonate alteration, which masks the primary gabbroic textures, resulting in fine-grained massive homogeneous, pale-coloured rocks and cross-cutting veins. Elevated granophile element contents, i.e. Sn, W, Mo, Pb etc., suggest a granitic affinity. The Antinouri Lake Granite (372 ± 2 Ma) crops out 9 km west of Guitard Brook and is the closest felsic intrusion to the study area. Although contoured gravity data suggests that the intrusion may occur at depth in the vicinity of Guitard Brook there is no direct evidence of felsic intrusion or contact metamorphism.

Lithogeochemical analysis of altered host rocks show that the majority of basalt samples fall within the subalkaline andesite/basalt field, whereas the majority of the gabbros fall within the subalkaline basalt field on the Zr/TiO_2 vs. Nb/Y diagram. On the Ti-Zr-Sr diagram most samples fall close to the Ti-Zr tie line with atypically low Sr contents, which is interpreted to be a function of feldspar destructive hydrothermal alteration related to As-Au mineralization, which is more likely related to or derived from felsic magmatic fluids rather than from the host mafic sequence. Firstly, the mafic rocks lose Na_2O and gain K_2O, whereas the later alterations show a loss in K_2O and a gain FeO and MgO.

Bulk sulphide and sulphide separate samples from the Guitard Brook mineralization have $\delta^{34}S$ values that range between 2.6 and 10.3‰ (median $\delta^{34}S$ = 4.27 and mean = 4.59 ± 1.5‰). The narrow range in $\delta^{34}S$ is similar to the nearby West Gabbro Zone gold deposit (located 5 km west of Guitard Brook), that has $\delta^{34}S$ values ranging between 1.1–9.8‰ (mean 4.75 ± 2.8‰). The similarity in $\delta^{34}S$ from these two Au occurrences suggests the possibility of a single source for the sulphide-Au mineralization in the Elmtree Inlier.

Sand in the Iapetus and Rheic Oceans: new detrital zircon data from terranes in the Appalachian/ Caledonide Orogen

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Detrital zircon U-Pb geochronologic studies can potentially provide important new information on the links between terranes in orogens; we report on new data from two terranes in the Appalachian-Caledonide system. The Southern Uplands terrane is a belt dominated by Ordovician-Silurian metasedimentary rocks in the British Caledonides, and is equivalent to the Exploits subzone of the Dunnage Terrane in the Newfoundland Appalachians, from which preliminary detrital zircon data were previously reported. Between Laurentian rocks of the Scottish Highlands, and Ganderian and Avalonian rocks of England and Wales, the terrane is interpreted as representing deposition in the closing Iapetus Ocean. Suggested depositional settings include an accretionary fore-arc, and a back-arc environment attached to Laurentia. Deformation in the terrane records convergence, with significant sinistral transpression. Zircons were extracted from quartzose wackes from three tracts in the northern part of the terrane, deposited in the late Ordovician. Zircons from a sample deposited early in the depositional history display a range of U-Pb ages from Paleoarchean to late Ordovician, including the oldest such grain yet recorded from the British Isles. Neoarchean, Paleoproterozoic, and Mesoproterozoic age populations suggest sources in Laurentia, including the Grenville and Trans-Hudson orogens. The overall age distribution is comparable to that in metasedimentary rocks in the Taconian orogen of W. Newfoundland. Several analyses from a younger sample plot on a discordia line suggesting overprinting of Archean zircon in the Early Paleozoic, consistent with Cambrian tectonothermal reworking of Laurentian detritus in the Grampian orogen, which then acted as the proximal source for detritus.

The Meguma Terrane of Nova Scotia lies on the opposite margin of Iapetus, and has been interpreted to represent a fragment rifted from Gondwana. The terrane is dominated by a thick package of turbidites assigned to the Meguma Group (or Supergroup). Two samples were investigated. A sample from the stratigraphically lowest part of the succession in SW Nova Scotia yielded a remarkably uniform population of grains with ages in a single broad cluster in the late Neoproterozoic, plus rare older Proterozoic grains. A sample with a Middle Cambrian depositional age, collected from a rare shelly fossil locality higher in the succession at Tancook Island, yielded a much more diverse population of zircons with peaks in the late Neoproterozoic (~600 Ma), and mid Paleoproterozoic (~2 Ga).

Gypsum at Cheverie, just some boring white rock?

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Along the coast of the Bay of Fundy there are several locations where gypsum outcrops. The ones at Cheverie reveal two important points to the careful observer. The first one is the rate of weathering. Visiting the outcrop after a timelag shows that those rocks lying on the beach have visibly been eroded during a period of only a few months, due to the abrasion of the waves, but also to solution by the water. There are several types of gypsum crystals visible and they appear to have a slightly varying solubility. If these rocks erode so fast, why are they still

forming cliffs? From another point of view, the erosion caused by the ice during the last ice age left very visible striations on the very hard Meguma Group migmatitic rocks and levelled them. Why then are there substantial hills in this area, underlain by gypsum that can be scratched by finger nails? The explanation is that the gypsum is still moving up, and a roughly calculated rate is on the order of millimetres to a centimetre per year. This is similar to rates found at diapirs on Axel Heiberg Island.

The second point is that there are calcareous layers within the gypsum. These have a strong algal appearance, and vary in density and colour. This is not remarkable. In brine that is precipitating gypsum, algae and bacteria are about the only life forms that can flourish there in the absence of the normal predators. The algae can form "sheaths" when there is still enough calcium available. Further in the precipitation process there may not be enough calcium and no sheaths are formed. Algae are the precursors of Type I, or oil-prone, source rock. Even very light scratching of the calcareous layers at Cheverie produces a strong hydrocarbon smell, like diesel oil. Measurements with Rock Eval were not successful, likely because the volatile material escaped prior to entry into the instrument due to the required grinding of the rock. The calcareous sheaths are visible; the ones formed farther in the cycle not. Thus, the potential of these evaporites to form a source rock should not be overlooked, even though there are few visible clues. As an example, in the world class petroleum system of the Gulf of Mexico oils with an algal source signature that do not conform to the established source rocks have been found.

The Meguma Supergroup of southern Nova Scotia: new insights on the stratigraphy, tectonic setting, and provenance

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The Meguma Group of southern Nova Scotia has traditionally been subdivided into a lower sand-dominated Goldenville Formation and an upper slate-dominated Halifax Formation interpreted to be deposited on a passive margin. Recent mapping in the Meguma Group, combined with petrography and petrochemistry, has resulted in re-evaluation of its stratigraphy, tectonic setting, and provenance. As previously proposed, the Goldenville and Halifax formations should be formally elevated to "group" status because both units can be subdivided into several formations and members. Thus, the Meguma Group is elevated to "supergroup". The lower part of the Goldenville Group is a metasandstone-dominated unit termed the Church Point formation in the Digby-Yarmouth area and Green Harbour formation in the Pubnico-Chester area. The equivalent units to the northeast (Halifax-Canso area) are subdivided into the Taylors Head and Tangier formations. Several metasiltstone/slate-dominated units are recognized in the lower part of the metasandstone package and include the High Head and Moses Lake members in southwestern Nova Scotia and the Moose River formation in the Halifax-Canso area. The middle part of the Goldenville Group consists of metasandstone/slate termed the Government Point formation (equivalent to the Tancook member) in southwestern Nova Scotia. No equivalent unit is recognized in the Digby-Yarmouth or Halifax-Canso areas. The upper part of the group consists of metasiltstone of the Bloomfield (Digby-Yarmouth area), Moshers Island (Pubnico-Chester area), and Beaverbank (Halifax-Canso area) formations. Units in the overlying slate-rich Halifax Group include the Acacia Brook and Bear River formations in the Digby-Yarmouth area, Cunard and Feltzen formations in the Pubnico-Chester area, and Cunard and Glen Brook formations in the Halifax-Canso area.

The High Head member contains a distinctive metasiltstone unit with abundant trace fossils including the early Cambrian ichnofossil *Oldhamia*, suggesting that the Goldenville Group below this member may extend into the Neoproterozoic. The upper part of the Tancook member has yielded an early Middle Cambrian shelf-lithofacies trilobite faunule of Acado-Baltic affinity. The upper part of the Bear River formation locally contains the graptolite *Rhabdinopora flabelliformis* and acritarch species that are Early Ordovician, suggesting that the underlying Acacia Brook, Cunard, Bloomfield, Moshers Island, and Beaverbank formations are Middle to Late Cambrian, and that a significant unconformity exists between the Halifax Group and the overlying late Ordovician - Early Silurian White Rock Formation. A revised minimum thickness for the Meguma Supergroup is 10 km.

Protoliths of the metasandstone units were predominantly immature feldspathic wacke and arenite. Preliminary whole-rock geochemical data suggest that most of the clastic material in the Meguma Supergroup was deposited near an active or recently active continental margin, not an Atlantic-style passive continental margin as previously assumed. These new chemical data, combined with detrital muscovite and zircon studies in progress, provide additional constraints on the position of the Meguma terrane in lower Paleozoic continental reconstructions.

Thermal effects of salt and brines in sedimentary basins

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The thermal conductivity of salt is up to four times greater than other sedimentary rocks; thus salt diapirs funnel geothermal heat and cause a high-temperature anomaly in the basinal sediments above. Depending on the shape of the salt body and its depth, the surface heat flow over the salt can be 2 to 3 times greater than away from the salt, and thus have drastic effects on hydrocarbon maturation; deeply rooted diapirs cause the

greatest thermal disturbance. In addition to heat conduction, advection of warm fluids (brines, oil, and gas) produces highly localized heat anomalies on top of diapirs. Long distance fluid movement in the basin may be driven by hydraulic gradients due to overpressures under the relatively impermeable salt, particularly during times of high sedimentation, dehydration of gypsum to anhydrite, or in zones of tectonic compression; mineralized veins and brecciated systems may form, aided by hydrofracturing. Later on in the basin history, large scale circulation of heavy brines (with salt dissolved from evaporites) may be driven to the surface by hydrostatic forces from surrounding highlands. Localized heat such as that provided by salt diapirs can drive convective flow and contribute to the formation of salt springs and pools. The above processes have the potential of contaminating freshwater resources, yet diaper- related geothermal anomalies may provide renewable energy through the use of heat exchangers.

In the Maritimes Basin, a large number of (100°–200°C hydrothermal) metallic mineral deposits were formed in subevaporite environments by maximum burial at ca. 300 Ma. Salt is being mined underground at Mines Seleine, Magdalen Islands, Quebec, where Lower Carboniferous salt of the Windsor Group has diapirically risen to the surface from a depth of ca. 8 km. Apatite fission track data indicate that the basin was inverted and rocks now at surface were cooled below ca. 100°C during the Triassic-Jurassic Atlantic margin breakup, whereas apatite within the salt mine yields Cretaceous apparent ages; the temperature-sensitive fission-track lengths have been significantly shortened (equivalent to >3 km depth in a well). Time-temperature modelling of the data requires re-burial of the salt structure in post Early Cretaceous times and heating of the diapir to higher temperatures than the regional background, confirming the focused thermal effects of the salt diapir. Salt springs are common in many diapir areas in Atlantic Canada.

In Axel Heiberg Island, part of the Sverdrup Basin, Nunavut, Upper Carboniferous evaporites have risen to the surface from a depth of ca. 8 km and intrude post-glacial sediments. Mineralized breccias and veins occur in many near-salt structures largely developed during Eocene Eurekan compression (ca. 60–50 Ma). Apatite fission track data on surface samples along a >80 km transect demonstrate that whereas the region was exhumed and cooled to ca. 100°C during the Eocene basin inversion, data from an area with active gypsum-anhydrite diapirs indicate that rocks now at the surface remained warm (to temperatures equivalent to ~5 km depth elsewhere) well into the Neogene. We suggest that the thermal effect of the diapir is also responsible for the existence of perennial salt springs in this permafrost area.