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ABSTRACTS

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Again this year, abstracts from the annual Atlantic Universities Geological Conference (AUGC) are published in **Atlantic Geology**. This provides a permanent record of the abstracts, and also focuses attention on the excellent quality of these presentations and the interesting and varied geoscience that they cover.

The Editors

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A new method of simultaneous analysis of isotopic composition and abundance

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A sedimentary core extracted from the Humber Arm of the Bay of Islands was used to develop a new analyzing method at the Department of Earth Science of Memorial University of Newfoundland. This method allows the concentration and isotopic composition to be analyzed simultaneously with a Carlo Erba elemental analyzer coupled to a Finnigan Mat 252 mass spectrometer by a ConFlo II interface. The method was used to interpret the ~11,000 year-old sediments in the upper 25 meters of the core. The analyses suggest the sediments of Humber Arm were deposited in an estuary environment that was influenced by different reservoirs of carbon and sulphur. The concentrations and isotopic compositions of carbon and sulphur are related by bacterial reduction of sulphate.

A Late Cretaceous polar forest from NW Ellesmere Island: implications for climate, past and future

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During the Mesozoic greenhouse climate phase forests grew well within the polar circle. These unique polar forest ecosystems flourished in a warm, high-latitude environment where trees were subjected to months of unbroken winter darkness followed by continuous daylight in the summer. Analysis of these polar forests is important because they provide a long-term context for the response of modern boreal forest ecosystems to future global climate change; as one scientist succinctly put it, "the past is the key to the future".

In this paper a Late Cretaceous polar forest (palaeolatitude of ~80°N) is described from Emma Fjord, NW Ellesmere Island. The fossil forest occurs in the Campanian/Maastrichtian Hansen Point Formation of the Sverdrup basin and is associated with volcanic ash fall and pyroclastic flow sediments. Palynological analysis of these units by MacRae (unpublished B.Sc. thesis, Dalhousie University, 1989) indicates that taxodiaceous conifers dominated this region. In this paper, I describe for the first time, five specimens of silicified and calcified tree trunks from the Emma Fjord fossil forest (collected by MacRae and Muecke, Dalhousie University, 1987). Thin section analysis of anatomical features enabled the wood specimens to be assigned to three conifer families, the Cupressaceae, Taxodiaceae and Pinaceae.

Future studies of tree rings preserved in the fossil woods, and the taxonomy of associated fossil leaf remains will further augment our knowledge of the palaeoecology and palaeoclimate of this extraordinary polar forest ecosystem.

Stratigraphy and structure of mélange in the Humber Arm allochthon at Bear Cove, western Newfoundland

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The Humber Arm allochthon comprises westerly transported thrust slices of lower Palaeozoic rocks which are divided into upper, intermediate and lower slices. The upper slice consists of volcanic rocks of the Little Port complex, with the intermediate and lower slices consisting of sedimentary rocks. A sedimentary mélange separates the upper and intermediate thrust slices. Previously mapped as mélange, the rocks at Bear Cove can be divided into three distinct lithological assemblages which are assigned to the intermediate slice. Strata are partially exposed in an eyelid window implying the thrust slices define a duplex structure. Two generations of folding are present in this window. Southwesterly verging F_2 folds define the fault geometry; older F_1 structures represent an initial west directed fault transport that isolated the lithological assemblages. The repetition of assemblages in this window suggest that F_2 is a re-imbrication of a pre-existing F_1 related structure.

Volcanic rocks in the White Rock Formation in the Torbrook area, Nova Scotia: petrology and tectonic setting

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Previous mapping and stratigraphic work have shown that volcanic rocks are a significant component of the White Rock Formation in the Torbrook area in the southwestern part of the Meguma terrane of Nova Scotia. The volcanic rocks include both mafic and felsic units, and a U-Pb (zircon) age of 442 ± 4 Ma has been reported for felsic volcanic rocks at the base of the section. However, no detailed study of the petrology of the volcanic rocks has been done. The purpose of this project is to map and sample the volcanic rocks, describe their petrochemical features, and compare them to volcanic units of similar age in the Yarmouth area that are also assigned to the White Rock Formation. The petrochemical features of the volcanic rocks will also be used to interpret the tectonic setting in which they were formed. The chemical compositions of the mafic volcanic rocks will be compared to the compositions of mafic sills and dykes that are abundant in the underlying Halifax Formation in the Torbrook area, as well as in the Wolfville area, in order to determine whether or not the mafic intrusive rocks are likely to be co-genetic with the Silurian volcanic rocks, or with younger volcanic episodes such as that in the late Silurian New Canaan Formation.

Previous work in the Torbrook area has suggested that the volcanic units occur on both limbs of the Torbrook syncline, and can be traced over a strike length of about 35 km. The relationship with the underlying Halifax Formation appears conformable; however, based on the presence of fossils no younger than Tremadocian in the Halifax Formation, and the ca. 442 Ma age (latest Ordovician to early Silurian) from the felsic volcanic rocks at the base of the White Rock formation, the contact is more likely to be a disconformity representing an age gap of as much as 40 million years. The volcanic rocks occur interbedded with the slate and are overlain by the quartzite units that are characteristic of the White Rock Formation. Pillow basalts have been reported in Fales River, overlying the felsic volcanic rocks. The felsic volcanic rocks are mainly welded tuffs, with well-preserved igneous textures in spite of a strong regional and local contact metamorphic overprint.

Decompressional reaction textures in the southeast Long Range inlier, Newfoundland: products of thermal metamorphism adjacent to the Taylor Brook gabbro complex?

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High-grade metamorphic terranes typically record aspects of their tectonic history subsequent to regional metamorphism. The rocks in many such terranes commonly preserve arrested mineral reaction features, such as corona structures, indicating that high-grade metamorphism was superceded either by near-isobaric cooling or near-isothermal decompression. However, in the Proterozoic Long Range inlier of western Newfoundland, these corona structures are spatially associated with a mafic intrusion, the Silurian Taylor Brook gabbro complex (TBGC).

Reaction textures and corona structures, which include pressure-sensitive assemblages (e.g., coronal pyroxene on garnet in metabasite), have been identified in gneissic rocks near (within a few km) the TBGC. These types of coronal assemblages are generally interpreted to indicate near-isothermal decompression following regional metamorphism, which in the inlier occurred at ca. 1.03-1.10 Ga. However, since they appear to be absent elsewhere in the inlier, there is reason to believe that they are products of contact metamorphism within the thermal aureole of the intrusion. Furthermore, one-dimensional thermal modeling calculations yield results consistent with palaeotemperatures determined for the coronal assemblages in samples collected at various distances from the TBGC. We therefore conclude that the coronas formed during cooling of the TBGC, so that there is a ca. 0.7 Ga difference (i.e., mid-Proterozoic *versus* Silurian) between the age of the regional metamorphic mineral assemblages, as represented by the mineral cores of the corona structures, and the coronas themselves. Investigation of coronal structures within the aureole of the TBGC therefore adds an additional point to the P-T-t curve for the Long Range inlier.

How are rocks stuck together in waterless environments?

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The mechanisms of lithification on the earth are generally well understood. Most of these processes involve water and fluid alterations. However, in the bulk of the solar system there is no liquid H_2O present to aid in the lithification of fragments. When astronauts first landed on the moon they found it to be very solid with many boulders and a very fine dust coating most surfaces. How were these boulders formed? They contained fragments of many different rock types bonded together with in a coherent way.

Through the examination of eight lunar breccias composed of varying lithologies and comparing them to four meteorite samples and eight laboratory synthesized lunar breccias, a mechanism of lithification is proposed. It involves small amounts of melting around grain boundaries (sintering). The intergranular melt forms delicate "bridges" between grains. The temperatures and pressures required to cause the edges of a grain to melt are produced by shock from an impacting body. The amount of melt and therefore the cohesiveness of the sample is directly related to the amount of melt in the matrix of the rock. In addition there is a correlation between the porosity of the sample and the cohesiveness of the rock. The composition of the melt was found to vary locally as the composition of the grains varied. However, when plagioclase grains of anorthite composition were present along with clinopyroxene or olivine, the anorthite selectively melted to form bridges. It is concluded that rocks (breccias) composed of fragmented minerals and rocks are rendered coherent and solid due to grain-grain bonding via localized melting. Shock-related processes are responsible for this lithification.

Ultramafic rocks in a Neoproterozoic arc, Antigonish Highlands, Nova Scotia

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Typical continental arc magmas are calc-alkaline and range from andesitic to felsic compositions. The ca. 610 Ma Neoproterozoic Greendale complex, in the Antigonish Highlands, Nova Scotia is a local example of regional arc-related magmatism that typifies the Avalon terrane. The dominant rocks of the complex exhibit calc-alkaline trends and have continental arc magmatic affinities that range from andesitic to felsic in composition. However, they also contain an important ultramafic component that is atypical of Neoproterozoic Avalonian magmatism. Petrographic examination and microprobe analyses of the ultramafic rocks within the Greendale complex show that they contain tschermakitic hornblende which poikilitically encloses olivine, hypersthene, augite, and chrome spinel, and minor amounts of interstitial phlogopite and plagioclase (<5 %) as well as late magnetite-apatite veins. The mafic minerals have high magnesium numbers (78–80), that are typical of ultramafic rock compositions. The Greendale complex was emplaced during the final stages of coeval dextral motion between the Hollow and Greendale faults associated with subduction along the northeastern margin of Gondwana. Geochemical analyses, phase equilibria and field relationships indicate a two-stage process for emplacement of the ultramafic rocks. Early crystallizing mafic minerals (olivine, augite, and hypersthene) probably formed as cumulus minerals in a basaltic parental magma chamber at depth. Large, poikilitic hornblende crystals are believed to have formed after this magma (with its entrained mafic minerals) was injected into a shallower water-rich environment near the roof of the Greendale complex. This process would account for large poikilitic hornblende crystals that enclose the early mafic minerals.

The origin of magma within the Greendale complex is related to Neoproterozoic intra-arc rifting. The range of rock compositions within the Greendale complex, including the ultramafic component offers insights into Neoproterozoic tectonic processes which contributed to the formation of the Avalon terrane in Atlantic Canada.

Petrology and lithogeochemistry of volcanic rocks hosting seafloor hot springs systems in the Manus basin, southwest Pacific Ocean

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The eastern Manus back arc basin, Bismarck Sea, southwest Pacific Ocean contains at least seven hydrothermally active fields: PACMANUS, DESMOS, Susu, Satanic Mills, Roger's Ruins, Nimab, and E. foot. The volcanic host rocks to these hydrothermal systems (basalt, basaltic andesite, andesite, dacite, rhyodacite, and rhyolite) display many similarities to the host rocks of ancient volcanic hosted massive sulfide (VHMS) deposits located on land. Understanding the characteristics and the genesis of hydrothermal alteration caused by seafloor hot spring systems will improve the ability of geoscientists to identify prospective hosts for VHMS deposits and thus may lead to discovery of new mineral deposits.

Rock samples collected during dredging of these seafloor hot spring systems during the 1990s and the drill core collected during ODP leg 193 (Nov. 2000 to Jan. 2001) were used to examine the petrology and geochemistry of the volcanic host rocks. Detailed petrographic descriptions of thin sections were used to constrain molar element ratio analysis interpretations from the lithogeochemical data, and assist in deciphering the observed compositional variations in the rocks. Using the identified compositional trajectories caused by hydrothermal alteration, the hydrothermal alteration reactions and metasomatic exchanges were identified. These can be used in generic models to assist in exploration for VHMS deposits on land.

Metamict zircons from the Georgeville pluton

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Zircon is a common accessory mineral in many igneous rocks. Zircon is a valuable tool for radiometric age dating of rocks. The zircons from the Georgeville pluton are highly metamictized and hydrated. A Raman microprobe was used to determine the amount of metamictization that has taken place. The Raman microprobe was also used to quantify the amount of water present in the zircon. The chemistry of these zircons is highly variable. Typical electron microprobe analyzes show that the zircons contain high concentrations of hafnium, uranium, thorium, and yttrium in some areas while in other areas they are much lower. The high concentrations of radioactive elements like uranium and thorium are responsible for the metamictization of the zircons. The variable distribution of elements was probably due to hydrothermal activity moving the elements around after the crystal structure had been destroyed by the radioactive elements.

Heavy metal particulates in the soil surrounding the Tilt Cove smelter, Newfoundland

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Heavy metals are one of the most frequently encountered groups of pollutants, affecting areas located in close proximity to mining and smelting operations. Smelters are the main sources of atmospheric emissions of arsenic, copper, cadmium, chromium, lead, nickel, and zinc. Environmental impacts of this heavy metal pollution include uptake of heavy metals by plants and the potential for transfer of contaminating elements along the food chain.

The Tilt Cove region has a Cyprus type, ophiolite-hosted, volcanogenic copper deposit. This deposit has been successfully mined over several periods for a combined total of approximately 40 years. The Tilt Cove smelter, however, was only in operation for a maximum of four years, between 1888 and 1892. Using X-ray fluorescence analysis, it was possible to determine the concentrations of environmentally hazardous elements in the vicinity of the smelter. The short period of operation of the smelter, over 100 years ago, allows for examination into the long term retention time of heavy metals.

Stratigraphy and structure of the Humber Arm allocthon, southwestern Bay of Islands, western Newfoundland

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The Humber Arm allochthon consists of westerly transported thrust slices of lower Palaeozoic rocks, remnants of the Iapetus Ocean and its Laurentian continental margin. Upper thrust slices represent oceanic mantle and crust of the Bay of Islands Ophiolite, and igneous rocks of the Little Port and Fox Island River complexes of island arc affinity. Intermediate thrust slices consist of sedimentary rocks belonging to the early Cambrian Blow-Me-Down Brook Formation, which may have underlain the passive margin succession in a rift basin. The lower thrust slices are composed of sedimentary deposits of the evolving lower Palaeozoic continental margin, as well as flysch deposited in the foredeep formed during the emplacement of the allochthon in the Taconic orogeny. Mélange zones, characterized by the mixing of rock from different formations, occur at the bases, and within, the intermediate and upper thrust slices.

Little detailed work has been carried out on the stratigraphy and structure of the sedimentary successions within the western frontal part of the Humber Arm allochthon. These successions have tentatively been correlated with lithostratigraphic units of the Humber Arm Supergroup defined in the eastern part of the allochthon, and their structure is generally considered to be chaotic.

The Rope Cove area comprises the westernmost sedimentary rocks of the allochthon. Two sedimentary assemblages have been recognized. The Blow-Me-Down Brook Formation consists of thick-bedded, green arkosic sandstone, and minor red and black shale. It has an early Cambrian age based on the presence of the trace fossil *Oldhamia*. The Bear Cove assemblage is a Tremadocian limestone-shale association divided into three sub-assemblages based on lithological features.

The structure of the study area represents a southwesterly verging imbricate thrust stack, with a complex internal geometry. The thrust slices contain thin lithological sections of very limited chronostratigraphical range and large stratigraphic intervals of the sedimentary succession are not represented in the thrust stack. In addition, thin slices of pillowed basalt, assigned to the Fox Island River volcanics, are interleaved with thrust slices of the Bear Cove assemblage. Also, the early Cambrian Blow-Me-Down Brook Formation is structurally interleaved with the much younger Bear Cove assemblage.

Structures within the imbricated rocks record polyphase deformation with F_1 isoclinal folds overprinted by northwest verging F_2 folds. Locally, folds in the Bear Cove assemblage may include syn-sedimentary slump folds. The architecture of the imbricate stack is related to the F_2 phase, and folded F_1 thrust surfaces are observed locally. Open F_3 folds affect second generation thrust surfaces. The arrangement of the assemblages in the thrust stack indicates that the F2 event led to fine-scale re-imbrication of pre-existing duplexes, which isolated limited stratigraphic sections of the lower Palaeozoic succession. The inclusion of the Fox Island River volcanics in the middle of the thrust stack implies that the floor thrust of the upper igneous structural slices was breached during the F2 event.