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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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The geology of the Fogo seamounts

Ashely de Jonge
Department of Geology, Saint Mary's University, Halifax, NS B3H 3C3

The Fogo seamounts are located approximately 500 km offshore Newfoundland and southwest of the Grand Banks. They are early Cretaceous basalts partially buried under slope deposits that mantle a transform fault zone. It is believed that the seamounts formed one of two ways. They may have formed either from the relative movement of the lithosphere over a mantle hot spot or by magma rising along a linear fault zone. The distribution and age of the Fogo seamounts was studied to decide which of these processes was likely responsible for their origin.

The distribution, size, and geometry of the seamounts was determined using bathymetry, magnetics, and seismic reflection profiles. The distribution of the seamounts shows that there is no clear linear trend; instead a broad zone of volcanism is seen across the transform margin. Flat tops of seamounts indicate marine erosion once volcanic activity stopped, followed by subsidence as the oceanic lithosphere cooled. The flat tops show a complex pattern but are generally deeper to the NW, suggesting greater time for subsidence in that direction. This is supported by biostratigraphic and radiometric data from wells and a dredge sample taken from the area as the seamounts appear to go decrease in age from NW to SE.

These data support the idea that the seamounts originated from magma that was caused by a plume that moved relative to the lithosphere. Reactivated faults then channelled this magma upward, making the Fogo seamounts different from typical seamount chains.

ODP Leg 191 – An account as an undergraduate student trainee in the northwest Pacific Ocean: a summary of radiolarian biostratigraphy

Warna Susanne Downey
Department of Earth Sciences, Dalhousie University, Halifax, NS B5H 4J1

I participated in a deep-sea drilling project as an undergraduate student trainee in the northwest Pacific Ocean off the coast of Japan. The Ocean Drilling Program (ODP) cored Site 1179 on Leg 191. The objective of this leg was to perform a series of engineering tests and to install a seismic observatory on the sea floor. The borehole reached depths of 475 metres in water depths of about 5500 m. Approximately 249 meters of soft sediment were recovered using a hydraulic piston core barrel that reached a total depth of 292.9 meters below sea floor (mbsf). As a micropaleontologist, I examined sediments from the core catcher for radiolaria. The sediments were also examined for palynomorphs, planktonic foraminifera, and calcareous nannofossils, even though few were expected to be found. In this deep-sea environment the sediments examined were expected to contain only siliceous microfossils.

Lithological Unit I is composed of radiolaria- and ash-bearing diatomaceous oozes and zeolitic clays. Radiolaria are common through Unit I and show excellent preservation. Lithological Unit II is composed of diatom- and ash-bearing radiolarian ooze. Radiolaria are abundant through Unit II and show good to excellent preservation. Units I and II make up approximately 100 mbsf and range in age from latest Miocene to Holocene. Lithological Unit III contains red to brown pelagic clays that are barren of microfossils. There are no age date on this unit. The sedimentation rate in this area is very high, with rates of 38-40 meters per million years as indicated by paleomagnetic and biostratigraphic data. Another interesting feature is the presence of sections of the sediment column with high carbonate contents. These areas contain calcareous nannofossil, planktonic foraminifera, and terrestrial pollen. At this time there is no explanation for the carbonate layers that were found at 1000 meters below the carbonate compensation depth. There is also a change in the radiolarian assemblages from mid-latitude to high-latitude species in the carbonate-rich areas. Several techniques using radiolaria are being pursued to explain the anomalous calcium carbonate layers.

Stratigraphy, structure, and mafic sills in a section through the Halifax Group, Black River area, Kings County, Nova Scotia

K. Gladwin
Department of Geology, *Acadia University, Wolfville, NS* B0P 1X0

Field mapping was done in an essentially complete section through the Cambrian-Ordovician Halifax Group in the Black River area to investigate stratigraphy and structure compared to other areas, and the petrochemistry of associated mafic sills. The section is 3.5 km long and oriented NW-SE, approximately perpendicular to regional structural trends. It includes approximately 1 km of continuous outcrop in a recently constructed canal adjacent to Black River. The canal, part of the Black River hydroelectric system, has vertical walls ca. 5 – 10 metres in height.

The Halifax Group in the section is bounded on the southeast by metawacke of the underlying Goldenville Group, and on the northwest by quartzite of the overlying White Rock Group. At least two lithological units were recognised in the

Halifax Group. The contacts between units appear to be conformable and gradational. The lower unit consists of parallel laminated interlayered dark grey silty slate and light grey metasiltstone, and minor beds of massive, impure quartzite (metawacke), 0.5 to 2 m thick. Abundant sedimentary structures, including ripples and graded bedding, consistently indicate younging to the north. The upper unit consists of dark grey silty slate with light grey and locally light brown metasiltstone lenses. Only two quartzite beds, both less than 20 cm thick, were observed, and sedimentary structures are poorly developed. Quartz and quartz-carbonate veins and lenses are abundant in both units, and mainly occur in proximity to mafic sills. Below the lower unit and close to the contact with the Goldenville Group, a single outcrop of finer grained, massive, black slate suggests that a third lithologic unit may be present. Similarly, slate outcrops above the upper unit but beneath the White Rock quartzite may represent a fourth unit. Outcrop is insufficient in the study corridor to confirm the presence of the latter units.

Throughout the section, cleavage dips steeply to the south, and bedding dips steeply to the north, consistent with the presence of an unfolded stratigraphic section. Minor strike-slip and oblique-slip faults cut the section, but lack of brecciation or apparent repetition of rare marker units suggest limited movement. A disjunctive shear foliation observed in both hand specimen and thin section is interpreted to represent Carboniferous reactivation of folds in the Meguma Supergroup, as has been reported elsewhere in the Meguma terrane.

The section contains at least 15 metamorphosed and moderately to highly altered mafic sills that vary in width from less than 1 m to 6 m, although one sill exposed in Black River is 65 m wide. Like their host rocks, the sills show evidence for greenschist facies metamorphism, as indicated by the mineral assemblage chlorite, actinolite, epidote, and albitic plagioclase. Interpretation of geochemical data from the sills, emphasizing least mobile elements, indicates that they are alkalic and formed in a within-plate tectonic setting. They have compositions similar to those reported for "type 1" sills in the Meguma Supergroup elsewhere in western Nova Scotia that have been interpreted to be penecontemporaneous with the Halifax Group. However, they are also chemically similar to volcanic rocks of the overlying Silurian New Canaan Formation. Hence their age and tectonic implications remain uncertain.

The petrogenesis of amazonite-bearing pegmatites in the Georgeville area, Nova Scotia

Shannon Hay
Department of Geology, St. Francis Xavier University, Antigonish, NS B2G 2W5

A series of pegmatite pods and subvertical dykes occur within, and proximal to, the (580 ± 2.2 Ma) Georgeville pluton, along the exposed coastline in the northern Antigonish Highlands, Nova Scotia. Dykes have variable orientation and sizes, ranging from 0.5 m to 10 m in length. Dykes range in composition from simple quartz-feldspar types to mineralogically complex pegmatites that contain amazonite, topaz, zinwaldite, and Sn, Ta, and Nb oxides. One of the most complex pegmatites in the region was selected for study in order to investigate the genetic relationship of the dyke to the nearby alkali feldspar granite, to determine the internal evolution of the pegmatite, and to estimate the physical and chemical properties of the pegmatite-forming fluid.

Twelve samples were taken at 1 m intervals along the strike of the dyke and prepared for polished thin sections. Petrographic and mineralogical analyses were done by transmitted and reflected light microscopy. Albite crystallized primarily in the wall zone but is also present in the intermediate zones and has an An content of 0. Quartz also crystallized in the wall zone and forms a mosaic along the contact of the greywacke host and the pegmatite. Columbite-tantalite, zircon, and k-feldspar were analyzed with the electron microprobe. Columbite-tantalite compositions vary systematically from ferrocolumbite with Mn/(Mn+Fe)=0.15 and Ta/(Ta+Nb)=0.33 to manganocolumbite with a Mn/(Mn+Fe)=0.62 and Ta/(Ta+Nb)=0.22. X-ray diffraction data verified the presences of beryl and topaz. Optical spindle stage measurements indicate a fluorine content of 19.1 wt% in topaz. Pale green muscovite is found mainly as a secondary mineral. Accessory zircons range from 5% Hf (wt. %) with a Zr/Hf ratio of 21, to 20% Hf (wt%), with a Zr/Hf ratio of 4. Two dark micas were identified in the dyke, annite and zinwaldite. Annite was found in the wall zone, and zinwaldite was found in the intermediate zones. Both were identified by electron microprobe analysis, and were compared to previous work from other similar pegmatites. Whole-rock analyses using XRF were completed, and the data were used to compare with the granites of the Georgeville Pluton. Trace element concentrations were determined using ICP-MS and was also compared to the nearby granite. F, Nb, Th, Cs, and Sn were found to be enriched in the pegmatite relative to the granite. Elevated concentrations of Ba and Co are believed to be due to contamination by host sediments.

The rare-element pegmatite dyke can be classified as a Nb-Y-F pegmatite on the basis of geological affiliation and geochemical features. The pegmatite crystallized from a F-rich fluid that segregated from the Georgeville granite. High concentrations of F and high field strength elements such as Zr, Y, Nb, and Sn may be the result of extreme fractionation of the granitic melt, or due to the strong partitioning of these elements into an immiscible hydrous silicate fluid that segregated from the Georgeville pluton during the later stages of crystallization. Experiments are being conducted to test these models.

The style of Late Paleozoic deformation in the Antigonish Basin: an example from the Monks Head section, Antigonish, Nova Scotia

Jason Johnson
Department of Geology, St. Francis Xavier University, Antigonish, NS B2G 2W5

A shoreland section at Monks Head in northern mainland Nova Scotia exposes a structurally complex package of interbedded limestone, gypsum, and siltstone of the Visean Windsor Group. These rocks are in faulted contact to the east with red sandstone of the Westphalian Port Hood Formation. The Windsor Group rocks are part of the upper basin fill sequence of the Antibonish-Mabou Subbasin that formed in the latest Devonian. Windsor Group rocks are of special interest in this are because the limestone has a high porosity and is petroliferous, implying a potential for petroleum reservoirs in the Antigonish-Mabou Subbasin.

The Monks Head rocks display a complex history of folding, faulting, and vein emplacement involving interplay of extensional and compressional tectonics. Field relationships indicate that these structural features are essentially coeval. Gypsum veins cross cut and are rotated locally by bedding parallel faults. This indicates that vein emplacement occurred throughout the deformational history and thus permits their use as structural markers. Late-stage, large-scale, northeast-trending faults are thought to have been generated in a regional dextral shear regime associated with the Alleghanian orogeny and formation of Pangea. Regional folding in the Monks Head section is associated with these faults, whereas smaller scale faults and folds are the result of the response of the rock layers to shortening. The orientation of gypsum veins, vergence of axial planes, C-S fabrics, and fold axes are related to motion along the Monks Head fault, which led to basin inversion in the Late Carboniferous.

Laboratory models of partial melting

Tammy Perry and Allison Leitch
Department of Earth Sciences, Memorial University of Newfoundland, St. John's, NF A1B 3X5

This presentation described the development and use of partial melting experiments that were started in the summer of 2000 at Memorial University. These experiments aim to help people understand the processes involved when crustal rocks are melted by hot magma coming from deeper within the earth, as well as how crystals in a boundary layer influence melt rates of the wall rock and nature of mixing of the melt with the warm environment. The experiments have encountered some challenges but have been successful in most respects. Although work is continuing the analysis reported in this presentation should be of use to those people with interest in partial melting and to those who may be planning to carry out similar experiments.

Monitoring oil spill bioremediation using marsh foraminifera as indicators

J. Sabean
Department of Earth Sciences, Dalhousie University, Halifax, NS B5H 4J1

A controlled experiment is in progress to identify the impacts of an oil spill on a coastal salt marsh and to evaluate *in situ* biological remediation techniques to help restore the environment. Marsh microfossils known as foraminifera (forams), a group of Testate Rhizopods, are highly susceptible to such types of environmental pollution, and are being used to monitor the effects of the oil spill and the treatments.

The project, run by the Department of Fisheries and Oceans (DFO) and funded by the United States Environmental Protection Agency (EPA), is situated near Petpeswick Inlet on Conrods Beach, along the Eastern Shore of Nova Scotia. Plots were laid out and weathered crude oil was applied to the surface of the designated plots in early June at low tide. Six different treatments are being used in triplicate for a total 18 plots, including a control plot (no treatment), an oiled plot (natural attenuation), and plots with the enrichment of nutrients, cut plants and/or agricultural disking. Each plot is divided into a grid. Based on a statistical design, one centimeter thick samples are taken from the field with a metal 10 cc core, so that no one square within the grid is sampled twice. This was done bi-weekly for the first two months and monthly for the last three months until the end of October. The samples are then sieved, processed and analyzed under a stereomicroscope in a lab to determine the types of species, the number of living vs. dead, and normal vs. deformed populations. The forams observed are one-celled micro-organisms that secrete a siliceous test of mico- to meio-fauna size (between 63 – 500 mm), that remains in the surface sediment record in a large abundance (400–4000 species per sample).

Results suggest that the oil has had an impact on at least one particular species, *Miliamina fusca*. A very high percentage is deformed in comparison to non-oiled specimens. The treated plots should reverse this type of effect, and show recovery in the spring. A recovery of this manner would imply the effectiveness of the bioremediation treatments, and provide counter-measure strategies suitable for oil-contaminated coastal salt marsh environments.

The Benton LL6 chondrite: formation and evolution of a brecciated and shocked meteorite

Erin L. Walton
Department of Geology, University of New Brunswick, Fredericton, NB E3B 5A3

The Benton LL6 chondrite is a relatively unweathered, brecciated meteorite that was witnessed as a fall at Benton, New Brunswick, on 16 January 1949. Two stones were recovered (1.5 kg and 1.34 kg) showing good fusion crusts. Internally, the meteorite comprises light-coloured, subangular to subrounded clasts embedded in a dark grey matrix. The matrix consists predominantly of olivine, subordinate orthopyroxene and plagioclase, and accessory apatite and clinopyroxene. Opaque phases include troilite, taenite, tetrataenite, kamacite, chromite and ilmenite. The mean matrix grain size is 23 microns. Clasts comprise the same mineral phases as the matrix, as well as chondrules and larger (50-100 micron) single mineral grains (mainly olivine and orthopyroxene). Composite (polyphase) clasts can be several millimetres in length. Following brecciation, the whole sample was thermally metamorphosed (annealed), with the matrix and clasts yielding subrounded grains with 120° triple point junctions.

Numerous examples of post-brecciation and post-annealing shearing and displacement at the micron to millimetre scale can be discerned in the form of shock veins. Most of these veins are defined by remobilized opaque minerals. Shock effects are also present throughout the sample in the form of undulose extinction, irregular and planar fractures, slight mosaic patterns, and planar deformation features in orthopyroxene.

Benton reveals a sequence of events that reflect a complex history: (1) chondrule formation and initial assembly; (2) brecciation; (3) thermal metamorphism and (4) shock veining. Events (2) and (4) can be equated with distinct impact events; the former representing bombardment of target material that remained in-situ, the latter probably with release from the source body to yield a meteorite. Thermal metamorphism was probably due to a combination of the following heat sources; the decay of short-lived radionuclides, electromagnetic induction during an early T-Tauri stage of the sun, or possibly the brecciated in situ target material being in proximity to an impact-generated melt sheet. Comparisons with terrestrial impact-related lithologies allow analogies to be made regarding the geological history of Benton, with implications for chondritic meteorite evolution.