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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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Reproducibility of probe-scan analyses of fine-grained media: a case study using modern bone china

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Modern bone chinas are a hybrid ware that was initially developed by Spode around 1800. They were derived from recipes containing elements of 18th Century bone ash (phosphatic) porcelain and true (hard paste) porcelain. Like their early phosphatic counterparts, they are difficult to produce due to the fact that they have near eutectic compositions; consequently their successful firing requires a degree of temperature control generally beyond the capabilities of early bottle kilns. Consequently, small differences in the compositions of these wares strongly influence their behavior in the kiln. It is therefore important that the composition of fine porcelains be accurately determined so that this aspect of their production can be assessed. Furthermore these types of data, when gathered for archaeological ceramics, can also be used for attribution purposes as well as to address causes of kiln wastage problems that plagued the manufacturers of these wares. Many XRF and other labs are geared toward analyzing rock samples, which have very different compositions compared with most porcelains, so there is a small demand in the marketplace for these types of analyses. However, the electron microprobe can be quickly and easily calibrated to perform raster-type (scan) analyses, which when averaged provide an indication of the bulk composition of fine-grained media, including ceramics. Despite the popularity of this method, there are no criteria available to direct those interested in determining the compositions of porcelains per se. In this regard, beam diameter is potentially an important variable that may influence the minimum number of spot analyses required to provide a reliable (for desired precision and accuracy) indication of the bulk composition of a porcelain sample of given grain size. To evaluate this variable, three thin-sections were made from sherds of a modern, English, bone china gravy boat. The grain size of the sherds ranges from one-twentieth to less than one-fiftieth of a millimeter. This particular ware consists of silica polymorphs, a tricalcium phosphate (C_3P) phase, probably whitlockite, anorthite and an inferred melt phase. Two sets of raster-type analyses were undertaken on each of the three thin-sections: one at a beam diameter of 20 μm and another at 40 μm. Provided that beam diameter is on par with the size of the largest grains in an otherwise very fine-grained sample, preliminary statistical analysis of the data indicate that, for data sets exceeding several hundred analyses, this parameter is not an important variable in governing the data's precision.

A petrographical and geochemical analysis of the Fountain Lake Group, Cobequid Highlands, Nova Scotia

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The Diamond Brook and Byers Brook formations of the Fountain Lake Group outcrop in the eastern portion of the Cobequid Highlands. The Diamond Brook Formation consists of aphyric and porphyritic basalt, and conformably overlies the Byers Brook Formation, which consists of rhyolite flows, minor hypabyssal intrusive rhyolite, and thick pyroclastic deposits.

The basalt is exposed in two major regions, the Scotsburn Anticline and the Earltown-Byers Lake belt. The Scotsburn Anticline basalt is among the most primitive basalt in the Cobequid Highlands. In contrast, the titanium-rich basalt of the Earltown-Byers Lake belt has been modified during petrogenesis. The distribution of feldspar megacrysts as well as chemical evidence (Pearce Element Ratios) suggest fractional crystallization of plagioclase as one process. Higher values for Ga/Al, Th/Sr, and high-field-strength elements indicate some crustal contamination or felsic magma assimilation. The geochemical evolution of the succession has been studied in a section across strike in the Earltown-Byers Lake belt. Passing stratigraphically upward, there is an increase in some major components such as TiO_2, Fe_2O_3, CaO, and P_2O_5, as well as trace elements such as Zr, Y, Ni, Cr, and V.

The Byers Brook Formation is a within plate, felsic volcanic unit, geochemically similar to the Wentworth Pluton (Hart Lake-Byers Lake granite). Since the felsic unit is older than the mafic unit in the region, two or more magma chambers are required to produce the Fountain Lake Group, rather than the extensive fractionation of one magma chamber. The presence of two magma chambers provides means for assimilation and modification of the magmas.

Groundwater nitrate contamination by agri-chemicals: refining the conceptual model

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Groundwater is the principle source of potable water for about 40% of the Canadian population. In rural areas, including most agricultural regions, it accounts for more than 90%. Non-point source contamination of groundwater by widespread use of nitrogen fertilizer in the agricultural sector is currently one of the focal issues in hydrogeology. Although nitrate is the most common chemical contaminant in groundwater, it remains one of the most poorly understood and least regu-

lated sources of groundwater contamination. Before this issue can be adequately addressed, however, a useful conceptual model of groundwater contamination by agricultural nitrate must be refined.

Until recently, the conceptual model for non-point source contamination assumed nitrate reached the groundwater table in a laterally homogeneous manner, and resulting groundwater nitrate concentrations were presumed to be horizontally constant. Based on this conceptual model, one-time sampling of a single, multi-level groundwater sampler would characterize groundwater nitrate under any given farm field.

There is, however, a mounting body of evidence indicating this conceptual model is inadequate. Field studies conducted in Strathroy, Ontario are generating a detailed picture of nitrate in the subsurface under three different agricultural management practices over time. A high degree of spatial and temporal variability in non-point source groundwater nitrate has been observed, contrary to the predictions of the earlier conceptual model.

Further insight into nitrate variability has been attained through the application and subsequent observation of a non-point source tracer. Potassium Bromide (KBr) was used because background concentrations are not detectable, which permits excellent resolution of recharging water (as opposed to nitrate, where high background concentrations can obscure recently infiltrated water). The results of the tracer test indicate an unprecedented degree of variability in subsurface transport, again discordant with the homogeneous conceptual model.

The amount of nitrate leaching under these fields is significant and apparently varies considerably under differing farm management strategies. Estimates indicate that up to 50% of fertilizer nitrogen applied to the fields is leached to the groundwater. Both the economic and groundwater implications are obvious.

Nitrate contamination of groundwater is a very real and growing problem, however, until the development of a clear conceptual understanding is completed, it is impossible to evaluate which particular farming practices will minimize contamination or to postulate a long term prognosis for the issue.

Regional overview of the middle to upper Jurassic, Scotian shelf

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The Scotian shelf has been subject to hydrocarbon exploration by several oil companies from the late sixties to the present, with the bulk of exploration done in the seventies. Despite this exploration effort, no significant hydrocarbons have been discovered from the middle to upper Jurassic Abenaki Formation. Most of the hydrocarbons recovered from the Scotian shelf are found within the Cretaceous fluvial-deltaics of the Mic-Mac, Mississauga, and Logan Canyon formations. This presentation re-examines the hydrocarbon potential of the middle to upper Jurassic Scotian shelf, with emphasis on the Abenaki Formation carbonates.

The Abenaki Formation contains four members in ascending order: (1) Scatarie Member, (2) Misaine Member, (3) Baccaro Member, and (4) Artimon Member. The lower Callovian Scatarie Member is a deepening upward, cyclic carbonate ramp that was transgressed by the upper Callovian Misaine Member shales. The Baccaro Member consists of two southwest-northeast trending carbonate platforms separated, near Sable Island, by the prograding fluvial-deltaics of the coeval Mic-Mac Formation. The Baccaro Member is the thickest member of the Abenaki Formation, with a maximum thickness exceeding 1300 m. It is also overlain by several different units, depending on the distance from the Sable Island delta. Approximately 150 km southwest of Sable Island, the Baccaro Member is covered by shallow water reefal sponges of the local Artimon Member. About 200 km further southwest, the informal Roseway Canyon Member carbonate platform carbonates overlies the Baccaro Member. Typically it is overlain in the southwest by the Verrill Canyon Formation shales and to the northeast by the Mic-Mac Formation deltaics.

From the examination of Canstrat logs, well history reports' well logs, production tests, core and ditch cutting descriptions from over 20 wells, the Baccaro Member shows the most potential for hydrocarbons. For the most part, the Baccaro Member contains tight oolitic mudstone and grainstones cemented with micrite and/or sparry calcite. However, porosity streaks of 5 to 15 m with a mean visual porosity range of 6 to 10% can be found in most wells. Maximum porosities of 15 to 20+% were found in dolomites and dolomitic oolitic packstone and grainstones of the Demascota G-32 well. Paleogeographic facies reconstructions based on lithology and biostratigraphy (i.e., palynology and micropaleontology) interpret the majority of the porous zones to be associated with the edge of the carbonate platform.

Oil staining in core samples, gas cut mud (i.e., presence of gas bubbles within the drilling mud after a drill stem test) and gas to surface from well history report drill stem tests and repeat formation tests found in a few wells indicate the presence of hydrocarbons within the Jurassic. Most of the hydrocarbon potential is not found in the Baccaro Member carbonate platform, but rather in the Mic-Mac sandstones within the Baccaro Member. These sandstones are informally referred to as intra Mic-Mac units and are found in overpressurized gas traps to the Uniacke G-72 (i.e., 20.5 MMCF gas to surface daily) and Arcadia J-16 wells, southeast of Sable Island. Other possible traps are along the carbonate platform edge and talus slope of the platform edge where transgressive Verrill Canyon Formation shales provides a seal and source. According to the paleogeography, no hydrocarbons were found in these traps because no well was drilled close enough to the platform edge. Hydrocarbon potential within the middle to upper Jurassic Scotian shelf is therefore restricted to the intra Mic-Mac units and Baccaro Member carbonate platform facies.

The Brunswick No. 6 Cu Zone: petrology, geochemical composition, and petrogenesis

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Located along the eastern margin of the Bathurst Mining Camp, the Brunswick No. 6 deposit is approximately 27 km southwest of Bathurst, New Brunswick. In 1907, the deposit was intersected during an investigation of the iron formation that was similar to the Austin Brook Fe deposit located 900 m south. In 1952, the deposit was rediscovered after drilling vertical loop electromagnetic anomalies, which led to the subsequent staking rush that identified most of the known deposits in the Camp. Production at Brunswick No. 6 began in 1966 from an open pit producing 12,125,000 tonnes of ore grading 5.43% Zn, 2.16% Pb, 0.39% Cu, and 66.5 g/t Ag before production ended in 1983. The massive sulphides can be divided into three zones: (1) massive pyrite zone(s) containing minor to significant amounts of chalcopyrite, magnetite, and pyrite with minor sphalerite and galena; (2) a massive to banded, pyrite-sphalerite-galena zone with minor chalcopyrite and pyrrhotite; and (3) massive pyrite with minor sphalerite, galena, and chalcopyrite. (Is the Cu zone another part of these zones or another zone?) The massive sulphides and associated exhalative iron formation (Brunswick Horizon) are hosted at the top of an altered felsic sedimentary-volcanoclastic sequence (Nepisiguit Falls Formation) and beneath rhyolitic flows and related fragmental rocks (Flat Landing Brook Formation) within the Lower Ordovician Tetagouche Group. The main deposit occurs in an asymmetrical F_2 fold with a variable plunge (F_1) with a north-south axial plane dipping approximately 50°W.

The highest Cu concentrations are associated with: (1) the uppermost part of the pyrite-pyrrhotite-rich stockwork and remobilized veins hosted in the intensively chloritized, felsic volcaniclastic sequence that forms the stratigraphic footwall to the deposit; and (2) the potentially economic, basal massive-sulphide body located beneath a relatively barren, pyritic zone near the base of the deposit. Relative to the main orebody, the Cu-rich zone under consideration is located near surface at the north end of the deposit, although Cu-rich massive sulphides are known to envelop the north end and base of the Pb-Zn massive-sulphide lens. Preliminary, ore reserve calculations indicate a tonnage of 1.7 Mt grading 0.9% Cu (William Luff, personal communication). Mineralogically, the principle minerals are pyrite, pyrrhotite, chalcopyrite, and trace sphalerite, galena, and arsenopyrite. Generally, chalcopyrite and pyrite are fine grained, although cataclastically deformed pyrite porphyroblasts (porphyroclasts) and clasts are hosted in a recrystallized pyrrhotite-rich matrix. The weighted average composition of the Cu Zone using all the analyses (n = 344) from 24 drill holes into the resource are: 0.60% Cu, 1.10% Zn, 0.51% Pb, and 48.3 g/t Ag, which is similar to the original resource calculations. In this study, 12 sample intervals, 5 feet long, from 10 drill holes were re-assayed yielding an average of 0.90% Cu, 1.28% Zn, 0.42% Pb, 28.6 g/t Ag, 0.046% Bi, and 0.225 g/t Au, as well as 0.131% As, 0.030% Sb and Sn values below the detection limit of 0.005%.

Overall, the Cu-rich basal sulphide zone at Brunswick No. 6 is very similar to the Cu-rich basal massive-sulphide zone at the Brunswick No. 12 deposit, which is estimated to contain 25 Mt grading 1.1% Cu. The high Cu and low base-metals within the basal massive-sulphide zone compared to the Zn-Pb-Ag exhalative massive sulphides in both deposits is common in proximal VMS deposits. It is usually interpreted as a hydrothermal zone-refining feature, which is consistent with (1) the relatively high pyrrhotite to pyrite abundance and higher abundance of chalcopyrite, arsenopyrite, bismuthunite, and cassiterite, which have higher temperature sensitive solubilities; (2) lower sphalerite, galena, tetrahedrite/tennantite, and argentite, which have lower temperature dependant solubilities; and (3) occurrence above the stockwork feeder zone that formed the deposit.

The nature of the Columbia River Fault Zone at Revelstoke, British Columbia

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Revelstoke, British Columbia, is located at the intersection of three major lineaments, the Columbia River, Illecillewaet River, and Tonkawatla Creek Valleys.

The Columbia River Valley geomorphology is controlled by the Columbia River Fault Zone which extends approximately 250 km along the valley, trending 340 to 350° accept at the Revelstoke dam where its trend changes to 030°. The fault is a normal fault, which dips easterly to southeasterly at Revelstoke and juxtaposes footwall rocks of the Monashee Complex against Clachnacudainn hanging wall rocks of the Selkirk Allochthon. Easterly movement of the Selkirks over the Monashee Complex occurred by ductile and brittle processes, however, there is little control on displacement resulting from brittle deformation alone.

The lineaments followed by the Trans Canada Highway along the Illecillewaet River Valley on the eastern side of Revelstoke, and Tonkawotla Creek Valley on the western side, trend approximately 075°. Lithologies across the valleys have little to no displacement, however, structural evidence shows fractures parallel to the trend of the valley suggesting a major joint or a fault with minor displacement. This indicates that large lineaments can be related to geologically minor features. It is argued by comparison that the Columbia River Fault Zone need not be a major brittle structure and could, in fact, be the result of a number of small anastomosing faults. This would explain its sinuous nature at Revelstoke.

Seismic velocities of crustal samples from the Torngat Peninsula and Nain: ECSOOT'96

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The subsurface geology of central and northern Labrador, as well as the Labrador Shelf, is presently being interpreted through the use of various seismic techniques. In the fall of 1996, LITHOPROBE funded a wide-angle seismic refraction experiment (ECSOOT'96) off the coast of Labrador to determine the subsurface geology of *in situ* mid-lower crust to Moho depth. Forty representative samples were taken from two areas of Labrador, namely the Torngat Peninsula and southern Nain Province. Laboratory measurements of compressional and shear wave velocities to confining pressures of 600 Mpa were performed on the sample set, the results of which will be used for comparison with offshore seismic data to determine the lithologic nature of the mid-lower crust.

Seismic velocities from both sample sets fall within two lithological fields, felsic and mafic. Felsic samples from the Torngat Peninsula have compressional wave velocities (Vp) ranging from 6.2 to 6.6 km/s and shear wave velocities (Vs) from 3.6 to 4.0 km/s, while mafic samples have Vp between 6.5 and 7.2 km/s, and Vs between 3.8 and 4.2 km/s. Felsic samples from the southern Nain Province have Vp between 6.2 and 6.7 km/s, and Vs between 3.5 and 3.7 km/s, while mafic samples have Vp between 6.7 and 7.0 km/s and Vs between 3.7 and 4.0 km/s.

Anisotropic samples were found in both regions of Labrador, as determined by both compressional and shear wave velocity data. Anisotropic samples were typically mafic and/or displayed a definite foliation and/or lineation defined by the orientation of anisotropic minerals.

Based on this data it can be concluded that strong reflections would most likely be produced by contrasts between mafic and felsic rocks. Based on seismic refraction data from the Torngat Peninsula, the predominantly felsic rocks that occur onshore in outcrop continue at depth and become increasingly majfic within the lower crust.

A re-evaluation of the shoreface, channel, and regional sand facies within the Colony and McLaren formations, upper Mannville Group, east central Alberta: implications for reservoir potential

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The Cretaceous Mannville Group in east-central Alberta has proven to be a prolific heavy oil and gas reservoir. The Colony and McLaren formations (upper Mannville Group) contain mud-dominated regional sands, with progradational shoreface shoreface deposits aligned in a northeast-southwest lineation. Sand filled channels are common as well and, in the past, have been considered as the primary exploration target. Most previous estimations of reservoir potential have relied heavily on the combined Colony and McLaren channel sands. This study is an attempt to re-evaluate reservoir potential by considering channel, shoreface, and regional sand facies within the Colony and McLaren formations as separate and unique exploration targets.

Channel, shoreface, and regional sand facies were identified within the Colony and McLaren formations through the evaluation of 360 Gamma/Neuton-density and Specific Potential/Resistivity logs from the study area. Interpretations were verified through correlation with core samples. Seven distinct depositional successions were identified. These interpretations were used to construct separate isopachs for the Colony and McLaren formations in which the channel, shoreface, and regional sand facies were all delineated. It was found that the majority of gas is located within these channel facies. However, significant gas was also delineated within the shoreface facies, and to a lesser extent, within the regional sand facies. The size and shape of shoreface and regional sand facies, in conjunction with structural maps, can be used to accurately assess pool volumes and potential for interconnection. With this data it is now possible to estimate remaining gas volumes in individual pools, a valuable aid in acquiring land for future exploration and development.

The uranium-organic bearing section of the Sunday Run Formation, northern Labrador

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The purpose of this study was to identify the nature of the uranium bearing section and to contribute in answering major geological questions concerning the early Earth's atmosphere and ore-forming models. The Paleoproterozoic Sunday Run Formation (ca. 2.0 Ga) consists of several lithologies that include the uranium mineral called brannerite. Brannerite was detected through the use of a microprobe during element mapping: a spectrum calculated for the "dense" mineral defined precise uranium peaks. During the petrographical analyses of the area's thin sections, indigenous organic material and sulphide horizons were also discovered.

The discovery of the organic material created a new segment of this study to include its classification and origin. Bituminous-rich lithologies contain *in situ* sparopelic cannel-type coal that represents an accumulation of cyanobacterial material or authochthonous bitumen. During more detailed

observations of this organic material, Paleoproterozoic fossils that resemble remnant filaments were discovered. It is conceivable that these microfossils are the oldest recorded fossils found in eastern North America.

Massive and disseminated sulphides are preferential indicators for economic potential. Examination of the sulphide horizons revealed very fine-grained pyrite and chalcopyrite scattered throughout the lithologies in minor pyritic colonies. As a result of low abundances, it is suggested that this section of the Sunday Run Formation has little economic potential for exploration at this time. This is also evident for the economic potential of brannerite.