ATLANTIC GEOSCIENCE SOCIETY

ABSTRACTS

1990 SYMPOSIUM

"NEW AGE DETERMINATIONS IN THE ATLANTIC PROVINCES"

1990 COLLOQUIUM

"CURRENT RESEARCH IN THE ATLANTIC PROVINCES"

WOLFVILLE, NOVA SCOTIA

The 1990 Symposium and Colloquium of the Atlantic Geoscience Society were held at the Old Orchard Inn, Wolfville, Nova Scotia on February 9-10, 1990. On behalf of the Society we thank Robert Raeside of Acadia University and all others involved in the organization of this excellent meeting.

In the following pages we publish the abstracts of talks and poster sessions given at the Symposium and Colloquium.

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An overview of case studies demonstrating the utility of remote sensing technology for geoscience research in Nova Scotia

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Students and faculty of the College of Geographic Sciences (COGS) have completed over thirty projects to demonstrate the utility of spaceborne imagery and digital image processing for geologic investigation of various localities in Nova Scotia. The high resolution of recent satellite sensors (up to 10 m) has been found very useful for geological and structural mapping. Also, the integration of remotely sensed and Geographic Information Systems (GIS) data has proven viable for resource exploration and targeting for mineral deposits. Other geoscience topics were addressed also. The purpose and scope of these projects were often defined in cooperation with outside agencies. Sponsors from private, government, and academic agencies are invited to participate in this cooperative project program. The list of previously completed cooperative projects and publications list are available from the library at COGS.

Proton microbeam analysis of fluid inclusions from rare-element and miarolitic pegmatites

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Proton-induced gamma-ray emission (PIGE) analysis is very sensitive (typically 100-1000 ppm) to light elements (specifically, Li, B, F and Na) which often show enrichment in highly fractionated silicic melts. However, the minimum detection limit for subsurface targets, such as fluid inclusions, is sample specific.

In order to determine the limits of sensitivity for boron at various depths in spodumene, a calibration curve was derived by measuring the gamma-ray yield from separate spots across a standard glass target underlying a thin wedge of gem-quality spodumene (kunzite). In agreement with theoretical calculations, the results indicate that boron may be detected at levels as low as 0.5 wt. % in a suitably large and homogeneous target lying 20 μm below the polished surface in a spodumene matrix.

A survey of 25 multiphase fluid inclusions in spodumene from the Tanco pegmatite, Manitoba, and the Kamativi pegmatite, Zimbabwe, failed to detect boron. However, Li and Al were readily identified in crystal-rich inclusions in quartz. Proton-induced X-ray emissions (PIXE) revealed S, Ca, and As in several inclusions in spodumene and Cl, Ca, Br, Rb and Cs in two solid-liquid-vapor inclusions in quartz. Fe was detected in an inclusion in topaz from the Volynia pegmatite, U.S.S.R., but the PIGE spectra were complicated by fluorine in the matrix.

The geology of the continental margin of eastern Canada

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"The Geology of the Continental Margin of Eastern Canada" will be the second volume in the Geology of Canada Series and one of the 28 volumes in the Decade of North American Geology (DNAG) Project Series. The volume contains 15 chapters under the section headers: Introduction, Regional Geology, Margin Evolution, Quaternary, Resources, Postscript.

Accompanying the text are 17 pocket figures, including 1:5,000,000 maps of: Bathymetry, Gravity, Magnetics, Geology, Tectonics, Depth to Basement, Quaternary, Crustal Thickness, Seismicity, Stress Orientations. The book will be published in 1990; the 1:5,000,000 maps have been published.

Current coal geoscience research at the Nova Scotia Department of Mines and Energy

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Nova Scotia's coal resources are situated on Cape Breton Island and the northern mainland. Economic coal deposits occur in the Pennsylvanian (Late Carboniferous) Riversdale, Cumberland and Pictou groups, all of continental origin, which were deposited in basins which formed mainly in response to strike-slip movement along major fault systems.

The Nova Scotia Department of Mines and Energy Coal Section conducts study of the province's coalfields in order to obtain a better understanding of their geology and resource potential. The work carried out is multidisciplinary and is often done in conjunction with other government agencies and industry with the results prepared as reports on various aspects of the province's coalfields and as coalfield maps. This work aids the province by promoting exploration and development of the resource and by ensuring its proper management and it provides the information base needed by industry in coal exploration.

Recent and current geoscience research at the Nova Scotia Department of Mines and Energy Coal Section includes: coalfield mapping, sedimentology and stratigraphy projects, seismic surveys, coal, peat, and oil shale resource evaluation projects, computerization of Nova Scotia coal geology data, studies on coal formation in relation to basin development, and studies on coalfield paleogeography and its effects on coal quality and mineability.

Non-marine fossils of the Late Triassic-Early Jurassic Fundy Group of the Annapolis Valley, Nova Scotia

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The Fundy Group of the Annapolis Valley contains four non-marine formations which are, in ascending order, the Wolfville, Blomidon, North Mountain Basalt and Scots Bay formations. Although fossils are most common in the lacustrine carbonate facies of the Scots Bay Formation, they are rare in the other three sedimentary units.

In the Wolfville Formation, we have found the following trace fossils: *Skolithos*(?), *Scoyenia*(?), *Cochlea*, *Tambia*, *Dendrophycus*, (?inorganic), *Atreipus acadianus* (dinosaur footprints), *Rhynchosauroides* cf. *R. brunswicki* (lizard-like footprints), and several other unidentified vertebrate tracks.

From the Blomidon Formation, we have identified the fern *Cladophlebis*, possible lycopod megaspores, a possible cycadophyte, *Dendrophycus*, *Darwinula*-like ostracodes, *Cyzicus*-like and *Estheriella*-like conchostracans, unidentified fish remains, and the trace fossils *Skolithos* and *Scoyenia*.

From the Scots Bay Formation, we have identified conifer logs, the conifer *Pagiophyllum*, the fern *Clathropteris*, stromatolites, charophytic algae, the ostracodes *Darwinula* and *Metacyprus*, the gastropods *Gyraulus*, *Valvata*, and *Hydrobia*, dinosaur footprints, and fish remains.

The plant, invertebrate, vertebrate and trace fossils found by us and other workers indicate that the upper Wolfville Formation is Carno-Norian (Late Triassic) in age, that the Triassic-Jurassic boundary may be within the upper Blomidon Formation, and that the Scots Bay Formation is Early Jurassic in age.

New $^{40}Ar/^{39}Ar$ ages of gneissic, greenschist and contact metamorphisms in the eastern Creignish Hills, Cape Breton Island, Nova Scotia

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The eastern Creignish Hills contain portions of the two types of metamorphic rock that are typical of the Bras d'Or Terrane: low-grade dominantly clastic metawackes and low-pressure gneiss. The low-grade metamorphic rocks are part of the Blues

Brook Formation, and are composed mainly of phyllites and impure metawackes although small amounts of greenstone, quartzite and marble also occur. The majority of the unit is in the chlorite grade of regional metamorphism and detrital textures are preserved. $^{40}Ar/^{39}Ar$ dating of detrital muscovite in two samples from the lowest grade areas has yielded plateau ages of 625 ± 5 Ma, older than all other dated units in the Bras d'Or Terrane. Authigenic muscovite in the Blues Brook Formation has yielded a preliminary age of 524 ± 5 Ma, equivalent to an inferred metamorphic age from the Kathy Road Dioritic Suite in the northern part of the terrane.

Metamorphic grade increases to the southwest, toward the contact with the Creignish Hills Pluton, a compound pluton of presumed late Hadrynian diorite and Early Ordovician granite. Biotite from near the contact yielded a preliminary age of 475 ± 5 Ma, which may reflect thermal resetting by the granitic phase.

The low-pressure gneiss has been termed the Skye Mountain Gneiss and is similar compositionally and in metamorphic grade to other gneissic components of the Bras d'Or metamorphic suite, with cordierite-andalusite ± sillimanite assemblages in pelitic rocks. Two plateau ages were obtained from metamorphic muscovite at 485 and 461 ± 5 Ma. The former is close to ages obtained from the Kellys Mountain Gneiss, and corroborates the widespread effects of Early Ordovician thermal resetting in much of the terrane.

Geology and mineralization associated with the Tobeatic Lake Shear Zone; southwestern Nova Scotia

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The Tobeatic Lake Shear Zone (TLSZ) is situated approximately 45 km NE of Shelburne along the southern South Mountain Batholith (SMB)/ Meguma Group contact. The TLSZ is a NE (060°)-trending, brittle-ductile shear zone that is exposed intermittently for approximately 8 km. The TLSZ is similar in orientation and style of deformation to the Rushmere Lake shear zone (RLSZ) situated approximately 25 km to the southwest. Both shear zones are considered part of the regional Tobeatic Fault Zone.

Intense brittle deformation within the TLSZ is reflected by a ≤100 m wide quartz-breccia zone. The breccia zone is composed of altered (hematized, kaolinized, silicified) leucomonzogranite, metasediment, ultramylonite and microbreccia clasts. These clasts probably represent previously deformed (brittle, ductile) rock refragmented by intense hydrothermal activity associated with extensive multi-stage quartz veining. Shear-related effects (quartz veining, C-S fabrics) are observed in the leucomonzogranite wall rock up to 1 km away from the quartz-breccia zone.

Mineralization associated with the quartz-breccia zone includes: fine- to coarse-disseminations of galena-sphalerite-barite and/or chalcopyrite-arsenopyrite-pyrite within quartz-veins and vuggy quartz-breccia boulders. Petrographic observations indicate that there were several stages of mineral deposition. Analysis of grab samples of mineralized quartz-breccia boulders from along the TLSZ returned up to 10% combined Pb-Zn and 2% Ba. While this type of mineralization is unique to the SMB, similar mineralization (excluding barite) occurs within the Musquodoboit Batholith at the Dunbrack prospect. A compilation of mineral exploration assessment reports and the results of recent geological mapping in the Tobeatic Lake area indicates that approximately 6 km of the TLSZ has potential for hosting significant Pb-Zn-Ba mineralization. Heavy mineral concentrate samples obtained during mineral exploration indicate that the TLSZ may also be a good target for Sn-W mineralization. The presence of Pb-Zn heavy mineral concentrate anomalies and mineralized quartz-breccia boulders up-ice of the TLSZ suggests that other areas of mineralization exist, possibly within associated shear zones. In addition, many mineralized samples contain significant amounts of Au, with concentrations ranging from 100-2000 ppb.

Earliest Silurian age for the bimodal Kingston dike complex in southern New Brunswick, Canada

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The Kingston dike complex forms a linear 5 km x 125 km NE-trending belt of sheeted bimodal dikes in the Avalon Composite Terrane of southern New Brunswick. The complex is bordered by major mylonite zones. In the absence of evidence for large-scale rotation, the orientation of dikes relative to the complex suggests their injection accompanied sinistral motion. The complex has previously been attributed to the transform termination of subduction within a late Precambrian magmatic arc. However, rhyolite dikes of the sheeted complex yield a U-Pb (zircon) age of 435.5 ± 1.5 Ma, confining emplacement of the bimodal dike swarm to the earliest Silurian. Ductile shear zones affecting the margins of the complex are therefore Silurian or younger in age although the recognition of mylonite zones that predate the complex demonstrates a history of polyphase ductile shear. The Kingston dike complex is therefore a component of the Lower Silurian Coastal Volcanic belt and provides new evidence in support of Early Silurian sinistral displacement in the northern Appalachians. Such movement is suggested by paleomagnetic data and has been proposed to record the accretion of the Avalon Composite Terrane to cratonic North America.

U-Pb geochronology of Precambrian rocks, eastern Cobequid Highlands, Avalon Terrane, Nova Scotia

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Precambrian rocks in the eastern Cobequid Highlands consist of gneiss and amphibolite (Great Village River Gneiss and Mount Thom Complex) structurally overlain by platformal clastic rocks (Gamble Brook Formation) that are unconformably overlain by interlayered arc-related volcanic and sedimentary rocks. This entire succession is polydeformed and intruded by arc-related gabbroic to granitic plutons. Recent U-Pb geochronological data have constrained the ages of these late Precambrian lithologies and tectonothermal events. Concordant igneous zircons from the Great Village River orthogneiss yield ca. 734 ± 2 Ma ages. Zircons from Great Village River paragneisses yield ages ranging from 610-590 Ma. The depositional age for the Gamble Brook Formation is not well constrained. The depositional age of the late Precambrian volcanic and sedimentary is constrained between D2 and D3 structural events. The age of D2 deformation is given by the ca. 605 ± 5 Ma intrusion of syntectonic granitic gneiss. The sequence is intruded by the 612 ± 4 Ma Debert River Pluton which post-dates D3 deformation. Thus, although there are some geochronological problems, it is clear that late Precambrian volcano-sedimentary successions in the eastern Cobequid Highlands were deposited, deformed and intruded between ca. 620 and 600 Ma.

Evolution and classification of dinoflagellates

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Dinoflagellates are single celled organisms which form a coherent phyletic entity recognizable by the presence of a unique type of nucleus, the dinokaryon, during part or all of its life cycle, and a combination of other distinctive features. Living dinoflagellates include parasites, symbionts and free living photosynthetic and phagotrophic forms which are found in most aqueous environments. Many species have a complex life-cycle, which may involve a fossilizable cyst stage. Such cysts have been found widely in Triassic to Recent marine and nonmarine sediments.

In an endeavour to produce a phyletic classification which includes all known dinoflagellate genera, we with several other workers have employed an informal cladistic approach to augment traditional methods. Previous classifications emphasized either fossil or living dinoflagellates and largely ignored an integral treatment of the two groups.

The proposed classification can be presented as an evolutionary scenario which postulates that dinoflagellates with a dinokaryon during part of the life cycle ("part-time") formed a link between other eukaryotic single-celled organisms and dinoflagellates with a "full-time" dinokaryon, the latter group diversifying primarily in an adaptive radiation during the Late Triassic and Early Jurassic.

Heteromorphic strobili and polyphylly of *Sphenophyllum oblongofolium* (Germar et Kaulfuss, 1831) Unger, 1950

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Many branches of *Sphenophyllum oblongifolium* and some with attached strobili have been retrieved from the roof shale of the Lloyd Cove Seam, the Upper Carboniferous of Sydney Coalfield, Nova Scotia, Canada. The polyphyllous nature of the species is reconfirmed as regular leaves grow on the thinner axis and the linear and more deeply dissected leaves on the thicker axis. The gradual change has been demonstrated with the intermediate forms. The strobili are laterally attached to the branches with different types of leaves. There are six sporophylls at each node of axis and two anatropous sporangia per sporangiophore in each sporophyll. The *in situ* spores recovered from the strobili are monolete and assigned to *Laevigatorspotites ninimus* (Wilson et Coe) Scopf, Wilson and Bentall, 1944. The taxonomy of the species is discussed with the polymorphy of the strobili and the foliage. The growth habit of the plant in conjunction with the taphonomy and the relation between the calamites and sphenophytes are reinterpreted. The previous plant biostratigraphic correlation based on form species is challenged.

Strike-slip motion along the Baie Verte Line, Newfoundland

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The Baie Verte Line, which separates the Humber and Dunnage zones in northern Newfoundland, was a tectonically active boundary from the Ordovician to at least the Carboniferous. Earlier workers noted a variation in the trend of structures (the Baie Verte Flexure) from north-northeast in the southern part of the Baie Verte Peninsula to east further north and suggested that the Baie Verte Line changes trend around the Flexure.

Steep foliations within and adjacent to the Baie Verte Line are the most prominent of the structures that record the Line's long deformational history. Initial field and petrographic studies indicate that these foliations developed through westward-directed thrusting followed, or accompanied by, motion with a strong strike-slip component. A transect across the Baie Verte Line shows a subhorizontal lineation in the more deformed centre of the Line, and a moderately to steeply plunging lineation away from the Line; deformation is commonly associated with the development of phyllonites and a shear band foliation. Macroscopic and microscopic sense-of shear indicators record both dextral and sinistral motions, with both thrusting and normal components. The oldest foliations containing sense-of-shear indicators suggest dextral movement while the youngest motions identified are sinistral.

Our work emphasizes the importance of strike slip motion in determining the present distribution of lithologic units and structural domains within the Appalachian orogen. Many faults studied in Newfoundland and elsewhere show features similar to those described above. We suggest that strike-slip motion should be accommodated in any model of terrane accretion in the northern Appalachians.

Geology and lithological correlation of Cape Porcupine, Aulds Cove, Guysborough County, Nova Scotia

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The Porcupine Quarry of Construction Aggregates Limited, is atop a small crystalline massif that makes up the elongated hill of Cape Porcupine which is approximately 3.2 km long in the southeast-northwest direction by 1.1 km wide in a southwest-northeast direction. Initial mining to build the Canso Causeway has resulted in the highwall that forms the face which now is the steep back-drop to the plant at tide-water of Construction Aggregates Limited. Present mining is used for a wide variety of products for both local use and export.

The hill is composed of intermediate to mafic volcanic rocks intruded by granite. The dominant andesitic volcanic rock comes in two varieties: one with less than 30% amphibole and a second with greater than 70% amphibole and commonly more. The granitoid rock of the quarry is distinctive in its small-scale shattered cataclastic fabric, its moderate-reddish-orange colour, and its lack of mafic minerals. The volcanic rocks are severely hornfelsed. The high calcium content of the volcanics has resulted in patches and lenses of skarn-like rock with epidote as the most common mineral. Veining is ubiquitous and commonly divides cataclasts. Vein mineralogy is usually epidote or quartz. A broken fragment of highly-veined rock is typically bounded on all sides by vein material. The epidote replacement as well as the epidote and quartz veins preserve the original hardness of the rock and increase its angularity both improving its qualities as aggregate.

These rocks are brittly deformed ranging from shattered rock at a 10 cm spacing to phyllitic mylonites. Boundaries between lithologies are usually tectonic and the prominent cataclastic fabric is seen at the millimetre scale as well as at the scale of the outcrop.

The massif is surrounded by overlying clastic sedimentary rocks probably of the Lower Carboniferous Horton Group containing clasts of lithologies of the hill. The rocks of the hill are cut by jointed, ophitic basaltic dikes of probable Triassic age.

The rocks of Porcupine Quarry are juxtaposed against Cape Breton Island across the Strait of Canso. It has previously been proposed that the Strait marks a fault that divides the Avalon exposed in northern mainland Nova Scotia from the non-Avalon rocks in northern Cape Breton Island. This interpretation seems to be confirmed in that intense faulting is indicated by vertical phyllitic mylonites found along the Strait to the northeast of the quarry, and in that lithologic correlation of the Cape Porcupine granite is possible only with a pluton 40 km to the east on Petit-de-Grat Island which intrudes probably Fourchu Group rocks of the Avalon Composite Terrane.

Provenance and thermal history of detrital sandstones of the Scotian Basin, offshore Nova Scotia, using apatite fission track and $^{40}Ar/^{39}Ar$ methods

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Apatite fission track analysis and $^{40}Ar/^{39}Ar$ age spectrum analysis have been carried out on mineral separates obtained from sandstone drillcores taken at depths of between 2 and 5 km from 9 wells in the Scotian Basin. K-feldspar argon spectra (which are unaffected by present-day basinal heating at depths of less than 4 km) from the Early Cretaceous Missisauga and Logan Canyon formations give mainly Precambrian ages (800-1000 Ma), and are similar to spectra from the Grenville Province of the Canadian Shield. Muscovite argon spectra give Acadian ages (Cambrian-Carboniferous, average 387 Ma), indicating that the sources of the K-feldspar and muscovite had very different thermal histories. K-feldspar and muscovite argon spectra from the Jurassic Mohican Formation give mainly Late Paleozoic ages (250-350 Ma) and are similar to spectra from plutons from the Nova Scotian mainland. Provenance data are used to constrain depositional models for the Mohican and Missisauga formations. At depths of greater than 4 km argon diffusion is evident from the K-feldspar spectra, and estimates of argon loss range from 2 to 16 per cent.

Apatite fission track ages are generally much younger than stratigraphic ages, and tend to zero at a depth of 4 km (corresponding to formation temperatures of approximately 125°C). Thus, apatite fission tracks provide a valuable maturation index over the range of temperatures normally associated with the generation of liquid hydrocarbons. Fission tracks in samples from the Mic Mac J-77 and Erie D-26 wells are more annealed than present formation temperatures would predict, and are interpreted to have been affected by a heat source (warm fluids?) subsequent to deposition.

The Davis Lake Pluton: results from recent mapping

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The southwestern portion of the 370 Ma peraluminous South Mountain Batholith (SMB) is composed of several rock types collectively termed the Davis Lake Pluton (DLP - previously referred to as the Davis Lake Complex). One of these rock types, the East Kemptville topaz muscovite leucogranite, hosts the East Kemptville Sn-Zn-Cu-Ag deposit (56 million tons, 0.165% Sn), North America's only primary producer of tin. The DLP is considered a temporal equivalent of other plutons within the SMB.

Limited outcrop exposure of the DLP necessitated the use of drill core information and till clast lithology to construct a geological map of the area. Consequently, contact relationships are seldom observed between rock types of the DLP and not observed between the DLP and other adjoining plutons of the SMB.

The DLP, a circular intrusive complex with a western extension, consists of five rock types and is dominated by a medium- to coarse-grained, megacrystic leucomonzogranite (Davis Lake leucomonzogranite) with bluish-grey alkali feldspar megacrysts. The remaining four rock types flank the Davis Lake leucomonzogranite along its northwestern and southern margins and are as follows: (1) Solomon Lake muscovite biotite monzogranite with three variants distinguished by grain size and texture; (2) Sabeans Lake leucomonzogranite characterized by a slightly porphyritic matrix; (3) Dog Lake leucomonzogranite characterized by a porphyritic texture; and (4) the East Kemptville leucogranite, a variably greisenized, medium-grained, equigranular topaz-muscovite leucogranite. Deformational fabrics are pervasively developed throughout all rocks types of the DLP, with the most intense deformation occurring in the extension and lower half of the circular part of the DLP (e.g., the Dog Lake leucomonzogranite porphyry is considered to be a texturally modified version of the Davis Lake leucomonzogranite).

Compared with the plutons in the eastern half of the batholith, the major oxide and trace element chemistry of the DLP indicates elevated A/CNK values, Si, F, Rb, P, Li and depleted Mg, Ti, Mn.

Several radiometric features currently remain unexplained in terms of bedrock or till source. Possible explanations include late or post-magmatic alteration and unexposed porphyry bodies.

Cooling and uplift history of the Long Range Inlier, Newfoundland, using fission track thermochronometry

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Apatite fission-track (FT) ages and track-length data were obtained for three samples on a NNW to SSW profile across the Long Range Inlier (LRI). Two came from near sea level on the northwestern (A) and southeastern (C) flanks of the inlier respectively, whereas sample B was collected on the plateau of the LRI. Lower samples A and C give FT ages of 196 Ma and 187 Ma respectively. The higher sample (B) has a 100 Ma older FT age, about 295 Ma. Assuming a normal geothermal gradient (20°C/km), this indicates that the flank samples have not been buried at depths >5 km since early to mid-Jurassic, while the central Long Range has not been buried >5 km since Late Carboniferous. It appears that the LRI cooled below the closure temperature of apatite during the Jurassic. Cooling histories obtained from preliminary track-length data indicate slow cooling of all three samples since they passed through the 100°C closure temperature. This suggests that cooling and exposure of the LRI was controlled by slow uplift related to erosion. $^{40}Ar/^{39}Ar$ in biotite and hornblende on these same samples indicate that the western LRI has not been reheated above 300°C since 880 Ma and in the central LRI above 500°C since 981 Ma. New samples from the Cat Arm Dam road and Western Brook Pond produce apatite apparent age profiles that give linear cooling and uplift rates from the Late Carboniferous to Early Jurassic consistent with cooling rates obtained from track-length data. An anomalous early Cretaceous apatite FT age from the Daniel's Harbour area may record a thermal event that requires further investigation.

Implications of isotopic data from granitoid plutons in the Canso area, eastern Meguma Terrane, Nova Scotia

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Devonian peraluminous granitoid plutons in the Canso area can be divided into two suites, based on differences in age, composition and areal extent. The older suite consists of a few small, widely scattered bodies of biotite ± hornblende tonalite (378.5 ± 2 Ma, U-Pb, zircon). The younger suite is composed of numerous biotite-muscovite granite and minor granodiorite plutons (371-373 Ma, U-Pb, monazite), each of which is relatively homogeneous in lithology compared to the total range of rock types observed. At least seven episodes of intrusion of granitoid magma that varied irregularly in composition with time are required to satisfy contact relationships at the current level of exposure.

The tonalite and granitic suites must have evolved along different paths, based on their age and compositional differences and the fact that zircons in the latter show obvious inheritance whereas zircons in the tonalite plutons are uniformly clear and unzoned. Initial $^{87}Sr/^{86}Sr$ ratios, calculated using the U-Pb dates, range from 0.7030 to 0.7093 for the granitic plutons. Although the causes of this variation are still somewhat ambiguous, the wide range suggests that the granitic plutons formed from two or more parent magmas, generated at about the same time in heterogeneous, quartzofeldspathic lower crust.

Emplacement of the South Mountain Batholith: structural and intrusive considerations

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The ca. 370 Ma South Mountain Batholith (SMB) is a polyintrusive complex emplaced into Meguma Group metasediments during widespread Acadian magmatism in the Meguma Terrane. The duration of intrusion was short (i.e., 1-3 Ma) with batholith emplacement representing a single event. Emplacement was advanced by two principal processes, diapirism and stoping.

Little is known of the emplacement mechanism below the present level of exposure; however, it is probable that diapirism was the dominant process at deeper levels with stoping becoming more important in the final stages of emplacement. Diapiric ascent occurred along a major, long-lived crustal scale structure now represented by a series of regional NE-trending faults which transect the SMB and country rocks; the Tobeatic and East Kemptville-East Dalhousie Fault zones. Late-stage intrusions localized along these faults indicates activation of these structures at the time of emplacement.

Evidence of stoping at contacts, an abundance of xenoliths and a general lack of deformation of regional Acadian structures in the country rocks implies stoping was the dominant mode of emplacement at the present level of exposure. Linear NE- and NW-trending granite/country rock and granite/granite contacts demonstrate stoping was influenced by coincident structures in the country rocks (pre-granite structures) and early phases of the batholiths (syn-granite structures). These structures are represented by the dominant regional joint trends and faults in the SMB and by joints and faults in the country rocks, which together constitute the dominant structural pattern in the Meguma Zone.

The SMB is polyintrusive, consisting of numerous discrete intrusions which are petrographically and geochemically distinct from one another. This complex intrusive character is interpreted to reflect intrusion of numerous independent intrusions rather than differentiation of a single, large magma chamber.

New radiometric data from basement rocks offshore Nova Scotia

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and

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About 20 hydrocarbon exploration wells on the Scotian Shelf have encountered basement rocks beneath the Mesozoic sedimentary basins. Most basement lithologies are either granite or low grade metamorphic rocks. We have made new radiometric determinations on granites from two wells on the La Have Platform and on Meguma Group rocks from the Montagnais I-94 impact structure and compare these data with radiometric data from on land.

K-Ar dating of biotite from Ojibwa *-** gave an age of 359 ± 12 Ma; from Mohawk *-** 329 ± 14 Ma. $^{40}Ar/^{39}Ar$ dating of Meguma metapelites at Montagnais I-94 gave an age of 359.3 ± 1.1 Ma. We have also dated pseudotachylite from Sandy Point, Shelburne Company by whole rock K/Ar at 281 ± 10 Ma.

The similarity of the metamorphic age from Meguma rocks at Montagnais and the biotite from Ojibwa suggests that this records a phase of plutonism, approximately coeval with the South Mountain Batholith. Although simple K/Ar dates are difficult to interpret with confidence, the date from Mohawk is similar to the mid-Carboniferous "Hercynian-Alleghanian" reheating event recognised by several workers in the satellite plutons of southern Nova Scotia. There is no evidence for igneous activity corresponding to the mid-Permian plutonism off southwestern Nova Scotia. Since the pseudotachylite sample was somewhat altered, it is unclear whether the relatively young age results from some argon loss or whether it records a mid-Carboniferous thermal or shearing event.

New Sm/Nd isotopic data have been recently obtained from the Montagnais I-94 as part of a study into the relationship of the Montagnais impact to known tectite fields. This Sm/Nd chronology yield T_{CHUR} of 1127, 1190 and 1390 Ma for Meguma Group metasediments and 1330 Ma for the overlying Tertiary sediments. This T_{CHUR} estimate compares favourably with 1358 ± 104 determined by previous workers for Meguma metasediments. Rb/Sr data suggest a significant enrichment in Rb at about 400 Ma, which may correspond to either metamorphism of the Meguma Group or intrusion of the major batholiths.

Lithoprobe east marine deep seismic reflection data, Bay of Fundy and the Gulf of Maine: pre-preliminary interpretation

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Approximately 210 km of marine deep seismic reflection data were gathered in the Gulf of Maine and across the Bay of Fundy in 1988. These data were collected to 20-24 s two-way time, equal to 50-60 km depth at a seismic velocity of 5 km/s. The lines were positioned to cross-cut and parallel the regional structural grain in the Meguma zone and thus compliment the 1986 and 1984 data sets gathered in the Gulf of St. Lawrence and north of Newfoundland.

A number of features are clearly imaged, including: the Fundy graben bounding fault, which may flatten abruptly at mid crustal depth; a strongly layered lower crust, which is divisible into two discrete packages SE of Passamaquoddy Bay; and a

shallowly dipping set of reflectors which appear to cross-cut the Moho SW of Yarmouth.

The interpretation of this data set is in a preliminary stage only. Therefore, we are not offering a complete story. Rather, we are displaying the data set as well as line drawings made from the seismic records to prompt feedback from the general AGS membership.

Geochemistry of basalts from deep sea drilling sites in the North and South Atlantic and the Indian Ocean correlates with initial elevation at ridge crests

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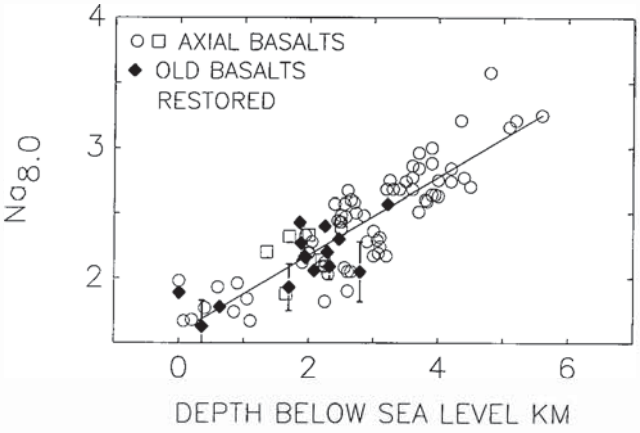
Klein and Langmuir have shown that major element geochemistry of modern axial basalts from mid-ocean ridges correlates with present water depth. Examples are: FeO and Na_2O after correction for low-pressure fractionation, and CaO/Al_2O_3. Studies I am doing with Emily Klein of Duke and Bill Melson of the Smithsonian show that the geochemistry of numerous older basalts from mid-ocean ridges in the North and South Atlantic and the Indian Ocean ranging in age from 2.5 to 140 Ma behaves in a similar way when plots are made against the initial elevation at the time of crustal formation. Klein and Langmuir also suggested that ocean crustal thickness correlates with Na_2O corrected for low-pressure fractionation, and I will try to show how well crustal thickness correlates with initial elevation.

These results may have interesting implications for establishing the secular variation of ocean crustal chemistry, and for the stability of ocean topographic features.



Getting scientists into the Dartmouth schools

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The Canadian Geological Foundation and the Royal Society of Canada have funded a pilot project which aims to bring scientists, technologists and mathematicians from the numerous scientifically based institutions in the Halifax-Dartmouth region into the local schools. I will describe this fledgling program, focused at present on the schools of the Dartmouth School Board.

Implications of $^{40}Ar/^{39}Ar$ hornblende ages from late Proterozoic-Cambrian plutons in the Avalon Composite Terrane of Nova Scotia

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The Avalon Composite Terrane in Nova Scotia mainly represents a late Proterozoic, rifted, cratonic, magmatic arc complex. The geochemistry of the volcanic rocks indicates that most of southeastern Cape Breton Island is underlain by a volcanic arc, whereas the Antigonish and Cobequid Highlands expose intra-arc rift sequences. These units are unconformably

overlain by subaerial to shallow marine Cambrian-Ordovician sedimentary sequences containing an Atlantic fauna that are interbedded with Early to Middle Cambrian, within-plate, continental rift volcanic rocks. $^{40}Ar/^{39}Ar$ plateau ages recorded by hornblende from plutons spatially associated with these volcanic rocks correspond to three groupings: (1) ca. 600-635 Ma in Cape Breton Island south of the Macintosh Brook Fault (traversing the Boisdale Hills); (2) ca. 525-555 Ma in Cape Breton Island north of the Macintosh Brook Fault (Boisdale Hills, North Mountain and Creignish Hills); (3) ca. 600-625 Ma in the Antigonish and Cobequid highlands. Based upon the low metamorphic grade of the late Proterozoic and Early Paleozoic rocks, and the low pressures recorded in contact aureoles and plutons, it is inferred that these plutons were emplaced at relatively shallow crustal levels, and therefore the $^{40}Ar/^{39}Ar$ plateau ages probably closely date their emplacement. Interpretation of the age data suggests that plutonism in Nova Scotia associated with the rifted magmatic arc lasted from ca. 635-600 Ma. Igneous activity continued between ca. 555-525 Ma and may have been related to the Cambrian, within-plate, rift volcanism.

Tectonic map of Pre-Mesozoic terranes in Circum-Atlantic Phanerozoic orogens: a 1:5,000,000 compilation

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This map depicts the terranes on a Transverse Mercator Projection palinspastically reconstructed for Permian times, i.e., a closed Atlantic Ocean. The map shows terranes categorized by their age (ranging from ca. 700-250 Ma) and tectonic setting: autochthonous and imbricated basement/miogeocline, continental rise, oceanic lithosphere, oceanic sedimentary/volcanic sequence, magmatic arc complex, intra-arc basin, periarc basin, trench complex, and units of uncertain affinity (metamorphic rocks, continental rift rocks and continental crust). Correlations across Mesozoic/Tertiary orogens requires the depiction of Precambrian and Paleozoic terranes in these orogens. Also shown are post-accretionary stitching plutons, overstep sequences and accretionary diagrams for various sections of the orogens.

The major cratonic terranes and their miogeoclines are structurally separated from the magmatic arc and oceanic terranes, which occur in the internal and uppermost structural parts of the orogens. The Late Precambrian terranes are limited to the southeastern part of the map and their accretionary activity overlapped the time span for the opening of Iapetus. Most of the identified Paleozoic, magmatic arc and oceanic terranes appear to have formed during the Cambro-Ordovician, with relatively few terranes formed during the Silurian-Carboniferous times. Most oceanic terranes appear to represent small ocean basins rather than fragments of the main oceans.

$^{40}Ar/^{39}Ar$ chronological study of the Liscomb Complex, Meguma Terrane, southern Nova Scotia

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The Liscomb Complex (LC) of southern Nova Scotia consists of high-grade metavolcanic and metasedimentary gneisses (age unknown), granitic intrusions and gabbroic intrusions that are collectively enveloped by Lower Paleozoic Meguma Group lithologies. Field relationships indicate that (1) gneisses of the LC truncate Acadian-age structures in the Meguma Group, (2) xenoliths of gneisses occur within both the gabbroic and granitic intrusions, and (3) leucocratic dykes cut gabbroic rocks. Hence, the inferred chronology of emplacement is (1) diapiric emplacement of the gneisses, (2) gabbroic intrusion, and (3) granite intrusion; all phases are post-Acadian in age (i.e., ≤ ca. 400 Ma). In order to establish an absolute time frame of events and study the thermal history of the region, $^{40}Ar/^{39}Ar$ analyses of mineral phases from all units was attempted and preliminary results obtained on 2 amphiboles (amph), 7 biotite (bt) and 5 muscovites (ms) are reported.

Granitic intrusions: 5 concordant bt and ms age spectra indicate apparent ages of ca. 370 Ma; this includes a bt-ms pair

from one granite sample.

Gabbroic intrusions: 2 amph gave internally concordant age spectra with plateau ages of ca. 370 Ma, while 3 bt analyzed gave either older plateau ages (ca. 376 Ma) or internally discordant age spectra (integrated ages of 377 Ma to 385 Ma).

Gneisses: bt in gneiss immediately adjacent to granite gave a plateau age of ca. 375 Ma, while samples (2 bt, 1 ms) removed from the granite-gneiss contact gave plateau ages of ca. 375 Ma.

The $^{40}Ar/^{39}Ar$ data corroborate the field relationships and, furthermore, indicate that the gneisses may have been emplaced and cooled below the blocking temperatures of the mica phases (300-350°C) at 375 Ma, some 5 Ma prior to the intrusion of felsic and mafic rocks. The concordant amph, bt and ms ages for the intrusions indicate rapid post-crystallization cooling. The anomalously old ages for bt from the gabbroic samples may reflect an excess Ar contaminant.

Rb/Sr and $^{40}Ar/^{39}Ar$ geochronological studies of the tin-bearing East Kemptville leucogranite, southwest Meguma Terrane, Nova Scotia: evidence for multiple episodes of tectono-thermal perturbations

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The East Kemptville tin deposit is hosted by a topaz-muscovite leucogranite which intrudes Cambro-Ordovician metasedimentary rocks of the Goldenville Formation. The presence of penetrative deformation within the leucogranite (S surfaces, C-S fabrics, mylonites) suggests that post-crystallization modification of both whole rock Rb/Sr (337 Ma) and $^{40}Ar/^{39}Ar$ (295 Ma) isotopic systems occurred; thus, neither age reflects the time of intrusion or tin mineralization as suggested by the respective authors. We report here results of a geochronological study designed to define the age of crystallization of the leucogranite and timing of the overprinting tectonic events.

Rb-Sr analyses of the least deformed and chemically pristine samples of leucogranite gave the following results: (1) 11 whole rock (WR) samples define an age of 353 ± 6 Ma (MSWD = 1.78, F-value = 2.72), Sr(i) = 0.7269; (2) 9 WR samples minus their muscovite (WRMMS) define an age of 368 ± 13 Ma (MSWD = 9.66, F-value = 2.83), Sr(i) = 0.7208; (3) 7 muscovite (MS) separates define an age of 334 ± 2 Ma (MSWD = 2.41; F-value = 3.03), Sr(i) = 0.7462; (4) WR-WRMMS-MS ages for 7 samples define ages from 372 Ma to 324 Ma with a spread of Sr(i); and (5) WRMMS-K-feldspar-plagioclase(-quartz) ages for 7 samples define ages from 270 Ma to 249 Ma. A $^{40}Ar/^{39}Ar$ age spectrum for the most pristine muscovite available is discordant with the low temperature gas defining an apparent age of ca. 280 Ma. In contrast, a plateau age of ca. 338 Ma is defined by the high temperature gas fraction which includes 66% of the gas released.

The isotopic data are interpreted to indicate initial closure of the Rb/Sr whole rock system at ca. 353 Ma with subsequent resetting of the muscovite and feldspar mineral systems at ca. 334 Ma and ca. 260 Ma. The 334 Ma event completely outgassed the muscovite analyzed in this study, while an event of post 300 Ma age caused partial outgassing. The heterogeneous nature of the tectono-thermal events is reflected by the variable WR-WRMMS-MS and WRMMS-KF-QP Rb/Sr isochrons and variable $^{40}Ar/^{39}Ar$ muscovite age spectra thus far obtained at East Kemptville.

Absolute dating of Meguma gold mineralization in the eastern Meguma Terrane using $^{40}Ar/^{39}Ar$ technique: chronological evidence for convergent metallotectonic processes in the Meguma Terrane at ca. 370 Ma

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Gold mineralization in the Meguma Terrane is hosted by Lower Paleozoic metaturbidites of the Meguma Group. The deposits are preferentially localized in steep, frequently overturned limbs of antiformal structures and more rarely hinge zones; other structures (e.g., kink zones) may also be important. Gold is confined to white, crystalline quartz which is generally

late in the paragenesis and is associated with Cu, Pb, Zn sulphides and Bi-Ag tellurides. Fluid inclusion and isotopic (C, O) data indicate remarkable uniformity among gold districts. Petrofabric studies of vein material indicate vein formation post-dated regional metamorphism, and deformation as a shear cleavage axial planar to the folded quartz veins overprints the regional (i.e., Acadian age) fabrics.

The age of vein formation at five districts (Beaver Dam, Caribou, Moose River, Upper Seal Harbour, Fifteen Mile Stream) has been obtained via $^{40}Ar/^{39}Ar$ analyses of vein-hosted biotite, muscovite and amphibole. The data are generally similar with plateau ages of ca. 370 ± 5 Ma defined for most samples. There is no evidence for partial resetting of any sample and in all cases ages close to the time of mineral, and hence vein formation are indicated. Consideration of resetting of mineral ages via granitic intrusions is unlikely given the variable distances of deposits from such bodies, the lack of evidence for convective cooling of Meguma Terrane granites, and the large range in blocking temperatures for the dated minerals (i.e., ≥500°C to ≤300°C).

The formation of Meguma gold deposits at ca. 370 Ma is considered to be sensibly coincident with intrusion of large volumes of granitic (± mafic) magma and shear zone development throughout the Meguma Terrane. The convergence of these processes which together created structural anisotropies for thermally generated metamorphic fluids is considered to be an important part of gold metallogeny in the Meguma Terrane.

Radon measurements in exploration, ground water surveys, and disaster prevention in coal mines

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Radon gas, a radioactive daughter isotope formed by the decay of U and Th, was discovered in 1900. ^{222}Rn gas has a half-life of 3.825 d and itself decays to solid radioactive isotopes, which makes it an environmental hazard if it enters the lungs. However, its radioactivity makes radon gas easily detectable along its pathway to the atmosphere as far as hundreds of metres from its source. Radon methods can be categorized into two groups: (a) conventional methods (based on air pumping); and (b) accumulated methods (based on detection of Rn daughters). The latter methods are more commonly used, because they are easier and can give good results.

Radon migrates through permeable pathways and can be easily detected as far as hundreds of metres from its uranium source. Rn measurements are useful as follows:

(1) Exploration of U deposits. This is a traditional use of Rn. However, it can be used as well in petroleum exploration and geological mapping.

(2) Ground water surveys. Radon travels faster through faults, especially through active ones. Therefore using Rn detection techniques we can locate ground water and thermal waters related to permeable structures.

(3) Preventing water disasters in coal mines. Many coal mines suffer the problem of water eruptions, which cause much loss of lives and property. Rn methods, especially accumulated methods, are useful tools in predicting and preventing these disasters. Abandoned workings and leaky pipes can be located in a variety of mining environments.

(4) Environmental monitoring. Concern has been raised for high Rn concentration in homes and working places because of its association with lung cancer; prevention is simple and economical by Rn monitoring.

Neutron calibration for fission track dating

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Fission track dating, as other radiometric dating methods, requires that some of the assumptions be met. Some of the parameters to be checked and calibrated are neutron energy, neutron flux, and the composition of standard glasses. An essential part of the calculation of a fission track age is the induction of ^{235}U fission tracks in a well thermalized neutron flux. The fission cross-sections of ^{238}U and ^{232}Th will increase at higher flux energies, which may contribute significantly to reduced track density. In order to determine the thermalization of our irradiation site at McMaster reactor, we have irradiated (a) several standard glasses of different U and Th contents, and (b) a Th standard glass (CN3, 40 ppm Th), with the following results.

(1) The greater the U content of the glass, the higher the induced track density (independently variations in Th content).

(2) The track density as high as 6.50×10^4 track/cm^2 was induced from glass CN3, though it is reported to be essentially free of U. This track density corresponds to about 1 ppm U. Because Th has little or no effect on the glass when well thermalized (see (1)), we conclude that there must be at least 0.5 ppm U in glass CN3.

(3) The track density from glasses in one irradiation package was obviously lower than those of the other packages, though the

same irradiation conditions were specified, including that either the actual irradiation time (900 sec), or actual flux (5×10^{15} n/cm^2) were lower for this package.

We are confident that our internal calibration using the zeta factor in fission-track dating compensates for these minor deviations from the ideal conditions, but we conclude that watchful calibration and standardization are essential because no externally obtained data can be taken at face value.

A preliminary report on the Eastern Highlands shear zone, Cape Breton Island, Nova Scotia

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The Eastern Highlands shear zone (E.H.S.Z.) is the boundary between the Aspy Terrane and the Bras d'Or Terrane in Cape Breton Island. It extends mainly in a NE direction but turns to an EW direction to the north of Warren Lake.

The rocks around the E.H.S.Z. are strongly deformed. At least three generations of ductile deformation have been recognized on the basis of overprinting relationships or fold styles. Regional folds (F1) are tight to isoclinal with axial planar cleavage. They are overprinted by the E.H.S.Z. with associated F2 folds. F2 folds are also tight to isoclinal, but no associated axial planar cleavage is developed. F2 folds are in turn overprinted by F3 folds, which are open and fold the mylonitic foliation associated with the E.H.S.Z. Brittle faults, probably as the reactivation results of the E.H.S.Z., are also developed.

Mylonitic rocks, including mylonite, ultramylonite and phyllonite, are widespread in the shear zone. Mylonitic foliation has a constant orientation with respect to the shear zone boundary, except in the area around the east Clyburn Brook, where mylonitic foliation forms a girdle, probably reflecting the later deformation (F3). Stretching lineation mainly trends W-SW, with a plunge between 40° and 70°. All available kinematic indicators (S-C relationships, drag folds, mica fish, oblique shape fabrics and shear bands) show an oblique movement with a dextral horizontal component and a NW or N side up vertical component, not influenced by the curving of the shear zone.

Some small scale sinistral shear zones have also been found.

Geochemical discrimination of provenance and tectonic setting of siliciclastic rocks in the Antigonish Highlands, Nova Scotia

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The Antigonish Highlands, Nova Scotia, is suitable for testing the reliability of geochemical discriminants in sedimentary rocks because the tectonic setting has been evaluated using penecontemporaneous volcanic rocks, and since sediments derived from the same source area are deposited in variable tectonic environments.

Volcanic sequences ranging from Precambrian to Late Paleozoic in age are each interlayered with clastic sedimentary rocks. Geochemistry of these volcanic rocks indicates that the Precambrian turbidites were probably associated with an ensialic volcanic arc, whereas the Paleozoic fluviatile arkosic sequences of various ages were deposited in an intra-continental rift environment.

Generally, standard discrimination plots for sedimentary rocks are consistent with provenance type and tectonic setting determined from analysis of the volcanic rocks. Some discrimination diagrams cannot distinguish immature intra-continental sediments from volcanic arc turbidites.

In general, variation diagrams yield smooth trends showing progressive increases in SiO_2, and decreases in Al_2O_3, Ti, Rb, $MgO + Fe_2O_3$, Ga, V, and Ni from older to younger sequences. These trends indicated a single provenance area for these sequences, and increasing maturity of the younger sediments. Rb/Sr isotopes show a limited range of $^{87}Sr/^{86}Sr$ initial ratios within individual units, which lie within the range of $^{87}Sr/^{86}Sr$ initial ratios for volcanic rocks of the same age. This implies that the main sediment source for each sedimentary unit was the penecontemporaneous volcanic sequences.

Recent advances in the geology of the South Mountain Batholith: anatomy and origin of a batholith

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Recent detailed geological mapping of the South Mountain Batholith (SMB) of southwestern Nova Scotia has delineated 260 granitoid bodies which have been assigned to 49 map units. Map units have been grouped into eight rock types that, in order of decreasing mafic mineral content (biotite, cordierite, garnet), include: biotite granodiorite (9.6% of the SMB); mafic porphyry (0.04%); biotite monzogranite (52.2%); muscovite-biotite monzogranite (8.9%); coarse grained leucomonzogranite (21.1%); polyphase intrusive suite (0.7%); fine grained leucomonzogranite (6.8%); muscovite leucogranite (0.7%). Muscovite is present in all rocks and increases from trace in granodiorite to >20% in some leucogranites. Biotite, with accessory zircon, monazite, apatite, ilmenite ± rutile ± xenotime ± allanite, decreases from >25% in some granodiorites to 0% in most leucogranites. Cordierite is present in trace amounts in most rocks and may constitute up to 5% of the mode.

The mapping has delineated at least 13 plutons within the SMB. These plutons can be divided into biotite-bearing (granodiorite-monzogranite) and muscovite-biotite-bearing (monzogranite-leucomonzogranite-leucogranite ± granodiorite) compositional types. Plutons may be lithologically composite, consisting of several rock types or uniform, comprising a single rock type. Recent geochronological data ($^{40}Ar/^{39}Ar$, Pb-Pb) on mica and whole rock suites, representing the entire compositional range, indicate that the plutons were emplaced ca. 370 Ma.

Geochemical analysis of the eastern SMB indicate that all rocks are peraluminous (A/CNK 1.13-1.29) with low Ca (0.41-2.87%) and high SiO_2 (67.10-73.90%) contents. Most major and trace elements display smooth variation trends attributable to the removal of biotite and included accessories, plagioclase and alkali feldspar by fractional crystallization. Most plutons display compositional zoning (normal and/or reverse) defined by systematic variations in mineralogy and geochemistry. These variations result from pluton-scale fractional crystallization. Each pluton represents one or more magmas that rose, coalesced with adjacent plutons and fractionated *in situ*.

Oxygen isotope data (9-12 °/oo) and $^{87}Sr/^{86}Sr$ (0.7080-0.7100 except >0.720 for the Davis Lake Pluton) are consistent with derivation of the SMB magma via partial melting of metasedimentary and altered volcanic rocks. The aluminous and mafic granulite xenoliths from Tangier are probably a suitable source material for the SMB magma. This requires that the SMB magma was generated during the collision of the Meguma Zone.

Ichnology of the Triassic Lepreau Formation, southern New Brunswick, Canada

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Continental redbeds underlying most of the Point Lepreau Peninsula have historically been assigned to the Triassic Lepreau Formation. The Triassic age of the Lepreau Formation is based on the reported presence of Pennsylvanian-derived lithoclasts and on palaeomagnetic data.

The formation is subdivided into three members; the basal Fishing Point Member (350 m), the Duck Cove Member (1200 m), and the uppermost Maces Bay Member (1175 m). The basal member reflects deposition in an alluvial fan environment. The middle member reflects braided fluvial conditions. The uppermost member is interpreted as representing progradation of an alluvial fan into the braided fluvial environment.

Ichnofossils occur commonly in sandstones and, to a lesser degree, in siltstones and shales, and are of essentially simple morphology. The Duck Cove Member contains the most diverse assemblage (ten ichnogenera). Preservation is poor due to the generally unimodal, coarse grain size of the host strata. The ichnofaunal assemblage belongs to the *Scoyenia* ichnofacies of Seilacher and was probably produced by opportunistic organisms able of withstanding rapid environmental changes under semi-arid conditions. The presence of ichnofossils more common in marine deposits (*Rusophycus* ichnosp. and *Cruziana* ichnosp.) reinforces the danger of using isolated occurrences of ichnofossils as palaeoenvironmental indicators.

Two U-Pb ages from the Upsalquitch Forks area, northern New Brunswick: economic and tectonic implications

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The penetratively deformed Silurian Chaleur Group and Lower Devonian Dalhousie and Tobique groups are cut by abundant syn- to post-tectonic dykes and plugs. The Mulligan Gulch porphyry, a hypabyssal felsic intrusion (dome) that cuts and in part is interlayered with Late Silurian sedimentary rocks, yields a U-Pb zircon age of 419 ± 1 Ma; whereas the Jerry Ferguson porphyry, a felsic intrusion that cuts Early Devonian volcanic rocks, yields a U-Pb zircon age of 401 ± 1 Ma.

These precise U-Pb ages demonstrate that (1) intrusions in the Upsalquitch Forks area are more or less coeval with volcanic rocks of the Chaleur, Dalhousie and Tobique groups; (2) most gold occurrences in the area, which are genetically related to mafic intrusions that are co-magmatic with the felsic rocks, formed in Late Silurian to Early Devonian time; (3) Acadian deformation was predominantly a Silurian rather than a Devonian process; and (4) Late Silurian to Early Devonian igneous activity occurred in a compressive, rather than a tensional, tectonic setting.

Metallogenesis of antimony-gold in Canadian Appalachian orogen compared with Hercynian-Mautitanide orogenic belt of western Europe and Morocco

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Forty-three Sb ± Au occurrences are documented in the Canadian Appalachian orogen (CAO). Most occur in the Central Mobile Belt and are linked to late Acadian felsic intrusions. Deposits include stratabound, vein type, and those in felsic volcanic rocks related to post-Acadian volcanism. The deposits are related to their tectonic setting during and immediately prior to mineralization, hence no pre-existing geochemical province in the crust or upper mantle is required.

In France the spatial framework for over 250 Sb ± Au deposits was strongly controlled by structures, especially faulting. A distinct separation of Sb ± Au ± As deposits from Sb ± Au deposits exists in terms of discrete fault systems and metallogenic episodes during the Hercynian orogeny.

In western Europe intersecting late Hercynian faults exercised an important control over the emplacement of igneous rocks and related Sb ± Au (± As) mineralization. The same is true of Morocco except that gold is sparse. In western Europe a mineral zoning exists outwards with respect to granites, of Sn, Sn-W, Sb-W, Sb-Au, and Sb-Pb-Zn. Comparable zoning is not so clearly evident in the CAO.

Significant Sb ± Au mineralization occurred in western Europe throughout geologic time, culminating in the Carboniferous. A comparable age range of deposits in the CAO is biased by numerous cases of post-Acadian remobilization of Sb and Au. This latter aspect, together with the difference in age between the Acadian and Hercynian-Mauritanide orogenies, complicates the case for establishing a Pan-Atlantic continuity in Sb ± Au metallogeny.

Hydrocarbon generation and migration of oil shale, coal, and sandstone sequence from the Westphalian B-D (carboniferous) sediments of Stellarton Basin, Nova Scotia

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Closely-spaced samples of oil-stained light sandstone, organic-rich shale, and two coals (different origin) of Carboniferous age (Westphalian B-D) from borehole P59A of the Stellarton Basin, Nova Scotia were analyzed by organic petrography (organic facies and maturation) and organic geochemistry (Rock-Eval pyrolysis, pyrolysis-gc, extraction-liquid chromatography-gas chromatography, stable carbon isotope of the saturate and aromatic fraction, and biomarker analysis by GC-MS). Organic-rich shales and coal show variable organic facies and hydrocarbon generation within a maturation range of 0.8 to 1.0% Ro having various proportions of telalginite, lamalginite, and amorphous liptinite I and IIA forming kerogen type IIA, IIA-IIB, IIB-III, and III source rocks. Molecular parameters reveal possible oil-source rock correlation between sandstone and organic-rich shales. Fluorescence data and molecular parameters revealed primary migration, redistribution, and fractionation of hydrocarbons within the network of organic-rich shales, coal, and sandstones.

Source-rock potential and maturation of Jurassic-Cretaceous sediments and their relation to hydrocarbon occurrence and overpressuring

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Organic facies and maturation of Jurassic-Cretaceous sediments from the various boreholes (Cohasset A-52, Cohasset D-42, Evangeline H-98, Louisbourg J-47, Sable Island E-48, Sable Island O-47, South Venture O-59, and Venture B-43) revealed various assemblages of macerals related to oxic, dysoxic, and partially anoxic organic association. These variations in organic facies resulted in source-rocks of Kerogen Type IIA-IIB, IIB, IIB-III, III, and III-IV. Liquid chromatography, isotope, gas chromatography of both low and high molecular weight hydrocarbons on the source-rock extract and condensate and crude oil show various types of organic input classifying them into different families. Fluorescence data indicate a possible extension of the oil/wet gas floor in the overmature (>1.4% Ro) zone, below 5400 m because of overpressuring. Relation between gas generation, vitrinite reflectance, and overpressuring was re evaluated.

Proterozoic tectonostratigraphy of the Avalonian-Cadomian belt: an example of orogenic activity at the extremity of a Late Proterozoic supercontinent

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The Late Proterozoic Avalonian-Cadomian belt may represent orogenic activity between the amalgamation and break-up of supercontinents. This activity is characterized by synorogenic sedimentation and bimodal arc-related volcanism that unconformably overlies a passive margin sequence, and by locally intense strike-slip related deformation that is penecontemporaneous with deposition. Angular unconformities are largely restricted to areas affected by strike-slip deformation. The belt is also characterized by the lack of evidence for widespread deformation, crustal thickening or delamination suggesting that the termination of the orogeny was not due to continent-continent collision. The passive margin succession probably represents the trailing edge of a continent prior to supercontinent amalgamation. The inception of the Avalonian-Cadomian orogenic cycle is attributed to southward-directed subduction along the margin of the supercontinent after its amalgamation. The termination of subduction is attributed to transform activity associated with the breakup of the supercontinent, and initiation of the Iapetus cycle. Transform activity may have resulted in the closure of some late Precambrian arc-related basins, the development of Early Cambrian intra-continental rifts and the end of the Avalonian-Cadomian cycle.

Petrographic and geochemical evidence for a hypogene origin of granite-hosted, vein-type Mn mineralization at the New Ross Mn mines, Lunenburg County, Nova Scotia

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The abandoned New Ross Mn mines are hosted in megacrystic biotite monzogranite of the South Mountain Batholith (SMB) 10 km north of New Ross, Lunenburg County. Past workers disagree as to whether the deposits are of supergene or hypogene origin. Recent deep diamond-drilling at one of the deposits and geological mapping has provided new data on the origin of these deposits. The SMB in this area consists mostly of coarse grained megacrystic biotite monzogranite. A swarm of small, elongate leucomonzogranite plutons both intrude and are in fault contact with the monzogranite to the north and west of the Dean and Chapter mine and at depth below the past mine workings. These plutons occur elongate parallel to a series of persistent, northeast-trending topographic linears which traverse this region of the SMB and, in most cases, represent faults and/or shear zones. This spatial association suggests these structures played a role in the localization of the plutons. Brecciation and hydrothermal alteration of the leucomonzogranites indicates movement and hydrothermal activity continued on the faults after final crystallization of the plutons.

Several types of hydrothermal alteration are well-developed in the mineralized zones at the mines and along other northeast-trending structures in this region of the SMB. Diamond drilling at the Dean and Chapter mine shows that, although the Mn mineralization is absent at depth, the shear zone and hydrothermal alteration persists to at least 452 m (1482 ft) below the mine workings. Low temperature, postmagmatic hematization and kaolinization is best developed within the main ore-bearing zones from surface to a depth of about 150 m (492 ft). With increasing depth, the amount of kaolinization decreases but hematization remains important. Desilicification accompanies hematization at several locales both in the megacrystic monzogranite and the leucomonzogranite intrusions. The desilicification is developed to the point that no free quartz remains in the rock. Higher temperature alterations such as silicification, greisenization and K-feldspathization occur associated with emplacement of the leucomonzogranite. The silicification occurs as total replacement of the rock and grades through greisenized selvages into fresh leucomonzogranite or monzogranite.

The activity of phosphate during the alteration sequences is of particular importance. At depth below the Dean and Chapter mine, P_2O_5 enrichment occurs in the higher temperature silicified, greisenized and K-feldspathized rocks (up to 5.20 wt. % P_2O_5). The importance of phosphate in the system continued into the lower temperature alterations and also crystallized as apatite intergrown with the Mn- and Fe-oxides on the mineralized zones (up to 9.95 wt. % P_2O_5). The textural relations and geochemical signatures indicate the entire alteration sequence and the mineralization comprise an evolving hydrothermal system developed from upward migrating hydrothermal fluids. These processes operated over much of this region of the SMB and suggest a high potential for as yet undiscovered deposits.

Role of volatiles in the petrogenesis of the Carboniferous North River and West Moose River plutons, Cobequid Highlands

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The West Moose River Pluton is a Carboniferous high level granite pluton; the North River Pluton is similar but developed at a deeper structural level. Both plutons have small marginal gabbro bodies that predate the main granite. The plutons were deformed (in a predominantly brittle manner) shortly after intrusion and are cut by mafic sheets, some of which are deformed along with the granite. Deformation patterns are consistent with dextral shear on the Cobequid Fault Zone. Geochemically, the granites are A-type, with high Zr, Y, Nb and Ga/Al, and are similar to Fountain Lake rhyolites, which are interpreted as co-genetic.

The early gabbros and later sheets show similar geochemistry to the Fountain Lake basalts and are different from later Triassic volcanic rocks. TiO_2 content increases from the gabbros to the least-deformed sheets; other high field strength elements increase along with TiO_2. Ga/Al and Zn are high, probably reflecting the role of halide complexes. Rb/K and Cs/K ratios are also unusually high in the mafic sheets, but not the lavas, reflecting some late stage metasomatic event. The enrichment in TiO_2 and other HFS elements is not the result of partial melting of enriched mantle, since later rocks are more enriched. Neither can fractionation adequately explain the enrichment in rocks with [Mg] of 50-60 and higher Cr and Ni. The relative enrichment of different elements is consistent with partitioning between co-existing mafic and felsic magmas, being greatest for P and Hf.

The mafic rocks are interpreted as the heat source for melting of anhydrous lower crust previously depleted during Hadrynian I-type plutonism. The resulting felsic melts were enriched in halogens, with regional variation in the ratio Cl/F. The plutons developed in an overall transtensional environment associated with the rifting of the Gulf of St. Lawrence Basin, reflected in the intrusion of major gabbro plutons (Folly Lake, Wyvern). Major strike slip faults provided pathways for magma to reach the surface and deformed the plutons, allowing intrusion of mafic sheets.

Lode gold mineralization at Deer Cove, Baie Verte Peninsula, Newfoundland

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The Baie Verte Peninsula has recently become an important target for gold exploration in Newfoundland because of its tectonic and lithological similarities with the Mother Lode Belt of California. The Deer Cove lode gold deposit is located within the Point Rousse ophiolite complex of the Dunnage Zone and is one of the many significant gold occurrences in this area.

The mineralization is hosted by mafic volcanic rocks which occur in an overturned back-thrusted block overlying talc-carbonate altered ultramafic rocks. A genetic model has been suggested in which the gold is thought to be remobilized from the ultramafics during the back-thrusting event and carried through fractures which served both as conduits for the hydrothermal fluids and depositional sites for the gold-bearing quartz-carbonate veins. Detailed petrography, as well as geochemical and stable isotope data from this study, further characterize the deposit and support, to a certain extent, the postulated model.

Gold deposits such as Deer Cove have important implications for Appalachian metallogeny.

A trilobite-bearing horizon in the Meguma Group of Nova Scotia

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The Meguma Group of southern mainland Nova Scotia is a thick succession of mainly turbiditic sandstones and argillites that contain few fossils. Previous fossil finds (mainly graptolites) have been largely confined to the upper Halifax Formation, and have indicated Tremadocian (Early Ordovician) ages.

A single 44 cm bed, rich in bioclastic carbonate material, occurs on Tancook Island in Mahone Bay, within the Tancook Member close to the top of the Goldenville Formation. The bed contains abundant echinoderm and trilobite fragments. Lithological characteristics of the sediment indicated that, although transported, the bioclastic material has not been derived by erosion of significantly buried sediments. It probably represents shelly material swept off an adjacent shelf and carried down slope into deeper water.

The trilobite bioclasts are very poorly preserved, broken, exoskeletal fragments, which have suffered compaction and tectonic distortion. Nevertheless, a number of recognisable fragments of cranidia, pygidia, and hypostomes have been recovered. These suggest that the faunule is older than previously described Meguma fossils; the forms recovered are most consistent with an early Middle Cambrian age. Tentative generic identifications suggest an Acado-Baltic affinity.

The proposed age suggests that the bulk of the Goldenville Formation in the Mahone Bay area is of Cambrian age. The overlying manganiferous argillites of the Mosher's Island Member may be a condensed succession representing much of the Middle and/or Upper Cambrian.

Mining research at Potash Company of America in New Brunswick

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Approximately 2 Mt of potash and 0.5 Mt of rock salt are currently being mined by Potash Company of America (PCA) from a Windsor Group evaporite structure north-east of Sussex, New Brunswick. Local diapirism and large scale recumbent folding of the north-east trending evaporites, together with variously scaled halokenetic features within the structure, have combined to produce an extremely complex potash ore body. A cut-and-fill mining method, using road header continuous miners, was designed to contend with rapid variations in ore width, azimuth and dip, and to maximize extraction from a deposit which is small relative to those in other potash districts.

A number of geotechnical research projects, partially funded by government agencies, have been designed to provide practical benefit to the mining operation. To aid in an understanding of the geomechanical aspects of the evaporite members being mined, a two year rock mechanics research programme has just been completed. This project, which included instrumentation, laboratory testing and computer simulation, provided input for rational mine layout and pillar design. Such data are critically important in mine design which must maintain the integrity of the pillars to preclude the possibility of hydraulic connection with the surrounding water bearing clastic sediments.

Failure horizons often related to thin clay seams above the ore zone together with shear surfaces within the ore are associated with local hanging wall instability. The need to understand and control such deformation, particularly in areas of flat (<30%) ore has led to a research project to study the effectiveness of salt tailings as hanging wall support. The placement of tailings in potash stopes is an integral part of the cut-and-fill mining sequence but the support pressure which they provide to the evaporite back and overlying clastics is not known. This project, partially funded by New Brunswick Department of Commerce and Technology, will answer these questions and lead to improved placement techniques. In a related project, instrumentation is being developed along with CANMET to allow acquisition of high quality consolidation data from tailings within the stopes.

Also, as mining is taking place under the Trans Canada Highway and its associated strip development, an ongoing programme of surface subsidence monitoring is being conducted in association with the Survey Engineering Department of University of New Brunswick. This study involves the use of a network of high quality survey monuments, photogrammetry and GPS. Finite element models are being developed concurrently to provide quantitative subsidence prediction.

The high development cost of a typical potash mine, currently close to $500 million, and the relatively low value of the ore necessitate maximum utilization of a limited reserve. Research projects such as these, which further the understanding of evaporite geomechanics, have become an essential part of efficient resource exploitation.

New palynological age dates, zonations, and stratigraphy in the Permo-Carboniferous strata of the Cumberland Basin, Nova Scotia

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Approximately 400 palynological age dates were determined for strata from the Cumberland Basin of northern Nova Scotia. The continental dominated basin-fill is up to 7 km thick and ranges from Visean to Early Permian in age (Late Devonian to Early Visean strata are present deep within the basin but are not sufficiently documented to be included).

The Cumberland (revised)/Riversdale Group rocks extend from Late Namurian to late Westphalian C - early Westphalian D. Seven distinct informal spore assemblage zones have been recognized in these rocks, strata of zones 1 to 6 (late Namurian to early Westphalian C) occur along the Joggins shoreline, from Downing Cove to Spicers Cove. Zone 7 assemblages (Westphalian C-D) are found in the Malagash Formation throughout most of the basin. The Pictou Group (revised) ranges in age from late Westphalian D to Stephanian in the Balfrom and Tatamagouche formations to Early Permian in the Cape John Formation. Spore samples from the Mabou Group (Canso) Middleborough Formation, and adjacent rock units suggest a Visean to Namurian age. The Middleborough is in part an age equivalent to the upper Windsor Group.

Substantial reworking of spores was found to occur throughout the basin and especially in the Joggins Section. Similar reworking of spores are recognized in the Sydney Basin. Abundant well preserved allochthonous material indicates extensive recycling and therefore extreme caution must be used in interpreting small data sets or individual samples. The recycling appears to be cyclic in nature and may reflect periods of uplift and erosion of Carboniferous strata on adjacent highland/platform areas. The palynological results are extremely valuable in establishing relationships within and between lithostratigraphic units in the basin. Although diachronous units are problematic the sampling density has closely defined the limits of these relationships. The division between the Westphalian A and B boundary based on international assemblage ranges is not clear, even though rocks can be well defined in relative age relationships using the local informal zonations. There does not appear to be any significant break in age between the Riversdale and the Cumberland groups in the basin, and given their lithological similarities, the usefulness of the term Riversdale Group becomes obscure.

Comparison of apatite fission track length spectra and organic maturation indicators in the Maritimes Basin, eastern Canada

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This study attempts to establish the relationship between apatite fission track length spectra and organic maturation indicators in the Late Devonian to Early Permian strata of the Maritimes Basin, in order to derive thermal profiles for the basin.

Fission track length measurements are compared to the Ro values of vitrinite samples from 1 km deep drill holes in the Cumberland and Sydney basins (sub-basins). The drill holes studied show erratic vitrinite reflectance profiles which are typical of many drill holes in the basin. In the literature, these have been explained as resulting from variables such as time, temperature, pressure, and oxygen fugacity. The variability of the Ro values may be related to the presence of faults, recycled organic matter, changes in the type of organic matter, proximity to intrusions, thermal conductivity contrasts related to lithologic boundaries, coalification jumps, and gas-bearing sequences. The presence of marcasite and pyrite in the drill holes suggests that

secondary effects of oxidation and chemical alteration related to low temperature sulphide mineralization, may be significant variables contributing to the erratic Ro profiles. Unlike the organic indicators apatite fission tracks are only affected by temperature. For example, preliminary results from the Cumberland Basin drill hole SA-1+2 reveal that track lengths progressively shorten from a mean of 14.8 microns at 305 m to 12.8 microns near the bottom of the hole at 1030 m. The fission track length spectra do not correlate with the inconsistent ("kinky") downhole distributions in the Ro values which vary from 1.09 to 2.05.

The results from this study indicate that apatite fission track length analyses, when combined with the organic maturation methods can isolate the temperature variable from other controlling factors which affect organic maturation.

New Quaternary age dates in Atlantic Canada

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Dating events older than 50,000 years B.P., the limit of the radiocarbon method, has been a major drawback in assessing the chronology of the Quaternary. Recently several new methods have been applied to the dating of buried forest and sea beds exposed in the province. These methods include U/Th disequilibrium dating of wood, amino acid racemization dating of shells and wood and electron spin resonance dating of shells. These methods are not without problems, and must be assessed together and in concert with geological evidence in establishing a chronology. Using this approach a new chronology has emerged. Deposits of the penultimate interglacial (marine isotopic stage 7) have been found in southern Nova Scotia. The last interglacial has been subdivided into three units corresponding to marine isotope stages 5a, 5c and 5e. Mid-Wisconsinan (60,000 - 30,000 years B.P.) radiocarbon and U/Th dates on some of the forest beds have pushed up the limit of this non-glacial interval but the validity of these dates are suspect.

Many new dates have been obtained from the interval 14,000 - 10,000 years B.P. Evidence for change from warmer to cold climate around 11,000 has been established by dating pollen transition zones in lakes and buried organic beds. This fluctuation correlates with the Younger Dryas-Allerod oscillation of Europe. Rapid climate change is indicated by synchronous glacial buildup and advances.

The La Poile Group, the Hope Brook gold mine and geochronology

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Gold mineralization has been known to exist at the Chetwynd prospect in the La Poile Bay-Cinq Cerf Bay area of southwestern Newfoundland since near the beginning of the century. Correspondingly, the geological history of this area and the place of gold mineralization within this history has been of long-term interest to the geological community. Therefore, it has been mapped three times in this century by provincial government geologists at increasingly smaller scales (1:63 250; 1:50 000; and 1:20 000), in part to assist exploration efforts in the area. Each mapping project has elucidated different aspects of the complex geology of the area but a complete understanding of this history has proven to be elusive. Radiometric geochronological techniques have been utilized in the last two mapping projects and clearly attest to the advantages of such techniques, though difficulties and liabilities with certain techniques have also been revealed. Different interpretations by each mapper have resulted in conflicts between the published reports and therefore uncertainty may exist in the public's understanding of the regional geology. This is particularly so for the La Poile Group, which has figured prominently in each regional interpretation. The definition of and the interpreted relationship of the La Poile Group to surrounding rock units are reviewed. La Poile Group felsic volcanic rocks are spatially associated with the gold and copper mineralization at the Chetwynd Prospect and at the Hope Brook

gold mine, about 2 km northeast of the Chetwynd Prospect. However, U-Pb zircon geochronological data from the Hope Brook mine area indicates that the host to gold mineralization is late Precambrian in age (aluminous zone, 576 ± 2 Ma; unaltered quartz-feldspar porphyry, 567 ± 2 Ma) whereas a nearby La Poile Group sample is dated at 429 ± 4 Ma (Silurian). The timing of gold mineralization within the complicated regional framework cannot yet be conclusively delineated. Although the preferred interpretation suggests that silicification (and by association, gold mineralization) is related to late Precambrian felsic magmatism, alteration may also be related to younger (≅500 Ma and/or ≅420 Ma) felsic magmatism, late Precambrian-Silurian mafic magmatism and/or syn-deformational processes. Furthermore, the concentration of gold within the aureole of the post-ductile deformation Chetwynd granite (dated at 390 ± 3 Ma) suggests that this event may have been important in the formation of an economic gold deposit.

$^{40}Ar/^{39}Ar$ dating constraints on gold-quartz breccia mineralization of the south Gordon Lake region, N.W.T.

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A structural, lithologic and metamorphic model is proposed for the localization of stratabound auriferous quartz breccia zones in the hinge region of a vertically-plunging regional fold; known locally as the 'Gordon Lake refold'. The breccias are hosted in black, carbon rich siltstone metaturbidites of the Burwash Formation; part of the Archean Yellowknife Supergroup. Brecciation probably commenced during (and continued after) peak metamorphism, and was accompanied by asymmetrical tightening and migration of the refold hinge. This tightening induced a predominately dextral bedding-parallel slip that: (1) developed a distinctive crenulation cleavage, and (2) focused mineralizing fluids into the refold centre. $^{40}Ar/^{39}Ar$ dating of five mineral separates (three biotites, a muscovite and a hornblende) was done to provide preliminary temporal and thermal constraints on breccia formation and metamorphism (Table 1).

The hornblende spectra display a steep age gradient. However, the age obtained from the last heating step is in reasonable agreement with U-Pb dates for the formation of the nearby Yellowknife Volcanic Belt. All the micas exhibit relatively undisturbed spectras and produce well defined plateau ages. Geological interpretation of these data must take into consideration: (1) the variation in sample grain size and quality, (2) the wide range of biotite ages compared to their close spacing (<1 km), and (3) possible differences in mica mineralogy and chemistry.

A favoured interpretation is that the Gordon Lake region reached a peak metamorphism at approximately 2600 Ma. Later, around 2550 Ma, localized areas within the cooling (but still above the closure temperature of biotite) meta-sedimentary pile, were overprinted by thermal highs. These thermal highs were caused by the intrusion of late granites (i.e., Spud Lake Pluton), and structurally focused hydrothermal systems (such as the Gordon Lake quartz-breccia zones). The whole region then slowly cooled below the closure temperature of biotite (ca. 300-350°C) by around 2500 Ma.

Table 1

Sample	Mineral	Location/Type	Interpreted age (Ma)
TS212/6/4	hornblende	Cameron River Volcanics	2620 ± 48
TS83-04	biotite (C)	Kidney Pond breccia zone	2555 ± 8
TS22/6/8	muscovite (C)	Spud Lake Pluton	2554 ± 11
TS86-94	biotite (F*)	Regional metamorphic	2504 ± 4
TS86-84	biotite (F*)	Crenulated metamorphic	2402 ± 4

(C - coarse 500-1500 μm; F - fine 180-250 μm; * - <5% impurities)

Structure and significance of the Acadian deformation front, western Newfoundland

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Structures formed at the Acadian deformation front are exposed in the western Port au Port Peninsula, Newfoundland, and are also seen in seismic profiles to the north of the peninsula.

Cambro-Ordovician carbonate platform units in cliff exposures show west-facing folds of several hundred metres amplitude, cut by west-vergent thrust faults. Farther north, the poorly exposed Round Head structure has similar geometry. Between these two areas of west-vergent structures is a zone in which strata of the Cape Cormorant and Mainland formations (Taconian syntectonic sediments) contain numerous east-vergent faults. These faults are at low angles to bedding, regardless of the attitude imposed by the later, large-scale, west-vergent folds. We interpret them to represent an early, eastward episode of Acadian thrusting that affected the upper part of the platform succession.

Limestones of the post-Taconian Long Point Group contain deformation zones dipping moderately NW, with local duplication of stratigraphy. West-vergent sub-horizontal discrete faults overprint the earlier east-vergent zones. The critical contact at the base of the Long Point Group was dug out. A very sharp uneven contact separates Long Point Group sandstone from underlying highly sheared green plastic mudstone of the Humber Arm Allochthon with an anastomosing 'scaly fabric' on a millimetre scale. The contact surface is marked by strong slickenside striations plunging steeply northwest. We interpret the contact as a thrust, not an unconformity, marking the upper, east-vergent detachment of an Acadian 'triangle zone', within the Cambro-Ordovician platform succession and Humber Arm Allochthon were transported substantially to the west. The triangle was subsequently over-printed by west-vergent structures. These relationships indicate that carbonate platform units of western Newfoundland must be substantially allochthonous.

Late Precambrian U-Pb ages for the Brookville Gneiss, southern New Brunswick: implications for stratigraphy of the Avalon Terrane

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The Brookville Gneiss (BG) consists of low-pressure cordierite + K-feldspar and cordierite + andalusite paragneiss with minor marble and calc-silicate lenses, and granodioritic to tonalitic orthogneiss. The orthogneiss has a protolith age of 605 ± 3 Ma (U-Pb, zircon). Metamorphic titanite from the orthogneiss has a U-Pb age of 564 ± 6 Ma, indicating the minimum age for upper amphibolite facies metamorphism of the BG. Based on U-Pb analyses of single detrital zircons, two paragneiss samples have maximum sedimentary protolith ages of 943 ± 3 and 641 ± 3 Ma. The latter is considered to represent the maximum age of the protolith for the paragneiss. The ages indicate that the igneous protolith of the orthogneiss is not much younger than the sedimentary rocks that it intruded, and that the BG is younger than the Neohelikian(?) Green Head Group (GHG) to which it was previously considered basement. This is consistent with our mapping which has shown that BG has mylonitic contacts with the GHG. It also has faulted contacts with Avalonian volcanic, sedimentary, and plutonic units. We assign BG and GHG and associated dioritic to granitic plutons to the Brookville Terrane, correlative with the Bras d'Or Terrane of Cape Breton Island (Nova Scotia) and distinct from the adjacent Avalonian units.

We term these Avalonian units the Caledonia Terrane, correlative with the Mira Terrane of Cape Breton Island.

Volcanology of subaqueous felsic volcanic rocks, Mount Carleton area, north-western New Brunswick

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Two main lithologic associations of Lower Devonian felsic volcanic rocks are recognized in the Mount Carleton area: a glassy lava facies and a pyroclastic/epiclastic facies. The glassy-lava facies includes massive to flow-banded, typically porphyritic and often auto-brecciated rhyolites frequently displaying spherulitic and perlitic textures, and interpreted as subaqueous lava domes. A striking feature of many glassy lavas is the development of apparent pyroclastic textures. In thin section, this phenomenon is seen to be due to the effects of perlitic fracture, autoclastic or hyaloclastic brecciation, nodular devitrification, and/or inhomogeneous hydrothermal alteration. The non-fragmental nature of these rocks is evident in porphyritic varieties, in which size and abundance of feldspar phenocrysts is clearly independent of apparent "fragment" and "groundmass" domains. Pyroclastic/epiclastic facies rocks interfinger and intercalate with the glassy-lava facies, as well as with marine sedimentary rocks. Pyroclastic rocks include lithic lapilli tuffs and pumice-lapilli tuffs which are interbedded with submarine lavas and volcaniclastic rocks. A subaqueous depositional environment is supported by petrographic evidence such as random orientation of lapilli, absence of welding, and the presence of lithic fragments of perlitic rhyolite from previous eruptions of glassy lava. Epiclastic volcanic rocks include debris flows and volcaniclastic sediments; like the lithic and pumiceous tuffs, they are products of explosive volcanism. However, epiclastic rocks display prominent flow features and are interpreted as redeposited pyroclastic ejecta which settled from the eruption column, accumulated on the flanks of the vent, and sloughed laterally into deeper water. Epiclastic deposits of this type vary from relatively proximal coarse-grained deposits containing blocks up to 15-20 cm, to distal fine-grained tuffaceous sediments. The spatial and temporal association of pyroclastic rocks and glassy, viscous or "dry" lavas implies a significant variation in the volatile content of the magma sources of these eruptions. Lithic tuffs containing abundant angular rock fragments may be the result of shattering during phreatic explosions following introduction of sea water. Pyroclastic rocks rich in pumice and glass shards, however, resulted from eruptions of rapidly vesiculating magma, perhaps reflecting locally elevated volatile content in a zoned magma chamber.