Atlantic Geology

1985 Symposium: Tectonic Models for the Evolution of the Appalachian Region

Atlantic Geoscience Society

Volume 21, numéro 1-2-3, april 1985

URI : https://id.erudit.org/iderudit/ageo21_1_2_3abs01

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Éditeur(s)

Maritime Sediments Editorial Board

ISSN

0843-5561 (imprimé)
1718-7885 (numérique)

Découvrir la revue

ATLANTIC GEOSCIENCE SOCIETY

ABSTRACTS

Tectonic Models for the Evolution of the Appalachian Region

1985 Symposium

MARITIME SEDIMENTS AND ATLANTIC GEOLOGY
21, 25-46 (1985)

0711-1150/85/020025-22$4.30/0

The 1985 Atlantic Geoscience Society Symposium was held in the Old Orchard Inn, Wolfville, Nova Scotia on January 18-19, 1985. The theme of the symposium was 'Tectonic Models for the Evolution of the Appalachian Region' and twenty-five oral and eighteen poster sessions were delivered by a variety of delegates from government institutions, industry and academia. As usual the meeting was extremely well attended by over one hundred participants and the quality of the posters and oral presentations was exceedingly high. The annual Rupert MacNeil award for the best student paper was awarded to D.C. Carter, University of New Brunswick, for his presentation on the Late Devonian -Early Carboniferous lithostratigraphy of the Horton Group, Moncton Subbasin, southern New Brunswick. The organizing committee consisted of Convenor - Nancy van Wagoner; Program Committee - Phil Hill, Nancy van Wagoner, Rob Raeside; Publicity - Aubrey Fricker, Paul Batson; Technical Services - Jack Colwell. To all these people may be extend our thanks on behalf of the Atlantic Geoscience Society for a successful and exceptionally well organized symposium. The following list of abstracts are those included at the meeting and, as the reader will recognize, are a summary of much of the current research presently being undertaken in the notheastern Appalachians.

- The Editors

Geocoded database investigations utilizing remote sensing techniques: Guysborough Area, Nova Scotia

M.S. Akhavi, Senior Instructor, Remote Sensing Program
Nova Scotia Land Survey Institute

Multispectral scanner (MSS) images of Guysborough County were investigated to extract spectral reflectance signatures pertinent to the classification of granitic bodies. Existing geologic boundaries were digitized; the geographic information system (GSI) residing on the PRIME 550 computer at NSLSI was used in this step. The digitized data were converted into a raster form conforming to the UTM coordinate system. The data were then transferred to the ARIES II system. Landsat imagery, resampled to a UTM coordinate system in the form of the Digital Image Correction System (DICS) at the Canada Centre for Remote Sensing (CCRS), were enhanced and registered with the transferred information.

Visual examination of the geologic map and Landsat data overlays indicated that spectral and textural characteristics may serve to discriminate plutonic rocks from adjacent metasedimentary rocks. A number of linear structures were also mapped.

An airborne Gamma-ray spectrometric contour map, showing ppm equivalent uranium, was digitized and registered over the Landsat DICS tape. Sangster Lake Pluton, located to the south of the Halfway Cove Pluton, revealed a higher radioactive content, although its spectral characteristics remain similar to other granitic bodies.

An immediate application of the GIS geocoded data base system is to direct field and airborne crews for more precise examination and sampling of exploration targets and suitable associations for mineral deposits.

In order to more fully elucidate the geologic relationships in the study area, additional analyses of data parameters (geologic, geophysical, geobotanical, and spectra) are required and will be the subject of our next year's research program.

An ophiolitic copper-zinc sulphide deposit in northern New Brunswick

K.R. Kettles, Department of Geology
University of New Brunswick, Fredericton, N.B. E3B 5A3

The Turgeon copper-zinc deposit occurs in basalts which form the upper units of an Ordovician ophiolite complex outcropping in the Elmtree Inlier of northern New Brunswick. This relationship would suggest the deposit is similar to the Cyprus-type deposit.

The Fournier Group consists of a lower unit of foliated gabbros, amphibolites, peridotites and trondhjemitic dykes representing oceanic crust. These rocks are overlain by a unit of massive and pillow basalts and at the top of the sequence interbedded basalts and greywackes occur. The upper two units outcrop in the northwestern part of the Elmtree Inlier, where the deposit is located.

The Turgeon deposit consists of two main sulphide occurrences outcropping on the Heron prospect. Extensive drilling and surface mapping has indicated that the ore occurs in podiform masses, long lens- to pipe-shaped bodies, and areas of disseminated and veinlet mineralization. The massive ore lenses are commonly bounded by vertical to subvertical faults, which are probably "synmineralization. The main sulphides present are pyrite, chalcopyrite, and sphalerite, with occasional occurrences of pyrrhotite, magnetite, and chalcocite. No zoning pattern is evident in the sulphides and banding of ore is minor. Associated alteration of the host rocks near mineralized areas is mainly chloritization and silicification.

Geological highway map of New Brunswick and Prince Edward Island

L. Ferguson, Department of Geology, Mount Allison University
Sackville, N.B. E0A 3C0
L.R. Fyffe, Department of Natural Resources
Mineral Resources Branch, Fredericton, N.B. E3B 5H1

The Atlantic Geoscience Society's "Special Publication No. 2", (a Geological Highway Map) has been expanded in scope to include the Province of Prince Edward Island in addition to New Brunswick.

The Geological map was compiled by L. R. Fyffe and the map side, including details of 125 sites of geological interest in New Brunswick and a further 11 in Prince Edward Island is in an advanced stage of preparation. The first Colour Proof of the map side will be on display at the Wolfville Symposium of the Society.

The reverse side of the map is almost complete and includes 20 assorted panels dealing with localities of interest throughout the two Provinces as well as a section dealing with its geological history, The Geological Time Scale and a brief glossary.

The English version of the map is on schedule and should be available for purchase at the GAC/MAC Meetings in Fredericton in May. It is hope that the French version may also be ready then.

A Carboniferous meander belt deposit at New Waterford, Nova Scotia

M.R. Gibling, Department of Geology
Dalhousie University, Halifax, N.S. B3H 3J5

The three-dimensional form of fluvial sandstone bodies is an important aspect of their stratigraphy and sedimentology, especially because the bodies may act as reservoirs for hydrocarbons or rest upon economic coal seams. In the Mississippi alluvial plain, meander-belt ridges composed mainly of sand are formed by lateral migration of the river channels. The ridges of abandoned Mississippi River meander belts are 16-32 km wide and rise 3-7 m above the flood-basins; those of the Arkansas and Red Rivers, tributary to the Mississippi, are underlain by at least 30m of sand.

A few cases in the stratigraphic record are well enough exposed to reveal the structure of ancient meander-belt deposits. At New Waterford in the Sydney Basin, excellent cliff exposures of the Pennsylvanian Morien Group show a sheet-like sandstone unit 15m thick and at least 750m wide normal to the mean paleoflow direction. The application of well-established hydraulic equations suggests that the sandstone unit was formed by a large river which formed meander belts averaging more than 4 km in width.

Major erosional surfaces within the unit bound complexes of strata 5-10m thick and 100-300m in apparent extent, in which lateral accretion sets are prominent. The complexes tend to show upward fining and an upward change from large-scale trough cross-beds to small-scale cross-beds and horizontal stratification. Paleocurrent vector means for the complexes vary by up to 90°, with flow generally parallel to the strike of the lateral accretion sets. The complexes are interpreted as accretionary lenses from one point bar overlapped by that of the next that migrated across the area. Overlap would occur from both sides, hence we see lateral accretion sets dipping in approximately opposed directions within adjacent wedges. No abandonment fills were noted.

The unit rests upon a coal seam 20cm thick and is overlain by red mudstones and thin-bedded sandstones of overbank type. The change from grey, coal-bearing strata below the unit to redbeds above may reflect slight topographic elevation of the meander belt after abandonment, when the river changed its course to a distant, topographically lower location. By comparison with the Mississippi system, the sandstone unit probably represents about 1000 years of deposition during which time the river occupied a laterally mobile but stable meander belt on an extensive low-gradient alluvial plain.

Tectonic evolution of Devono-Carboniferous oilshales in the Maritimes

L.C. Daigle, Department of Geology, Mount Allison University Sackville, N.B. E0A 3C0

Middle to early Upper Devonian time in the Maritimes is characterized by uplift and erosion during the Acadian Orogeny. Upper Devonian through Carboniferous and Permian has tectonic activity resulting in the deposition of thick sequences of terristrial sediments.

This tectonism affected basin development and sedimentation. Combined with environmental conditions existing the deposition of oil shales was promoted.

In this study the Albert Mines deposit of New Brunswick was first examined and a model for the origin of the oil shale and for the deposition of the deposit was developed. This was based on lithology, facies relationships and fauna.

The Big Marsh oil shales of Nova Scotia were then compared to the Albert shales. The Big Marsh area is of similar age and also has very similar lithology, facies relationships, and fauna. The model developed earlier for the Albert shales applies well to the Big Marsh shales. This indicates that the model is valid and could be used to predict the location of similar deposits in the Maritimes.

Lithostratigraphy of the Late Devonian-Early Carboniferous Horton Group of the Moncton Subbasin, southern New Brunswick

D.C. Carter and R.K. Pickerill, Department of Geology University of New Brunswick, Fredericton, N.B. E3B 5A3

The Horton Group in the Maritimes Basin of eastern Canada represents the basal unit in a succession of molasse-type sediments which accumulated in an essentially non-marine, post-orogenic, successor-type basin. Present distribution of the Horton Group represents the erosional remnants of a complex series of basin and arch structures which controlled sediment distribution and character.

The Moncton subbasin is a northeasterly trending, southwesterly narrowing basin, bounded on the south by the Caledonia Uplift, the north by the Kingston - Indian Mountain Uplift and the east by the Westmorland Uplift. The Caledonia Uplift provided a continuous supply of detrital material; the others were passive features during most of Horton Group deposition. Horton Group strata which accumulated in the Moncton subbasin are characterized by a complex series of alluvial fan, fluvial-deltaic and lacustrine sediments.

The Horton Group, in this area, is subdivided into the basal Memramcook Formation, the medial Albert Formation and the upper Moncton Formation. The Albert Formation can be divided into a series of five members; the Dawson Settlement, Frederick Brook, Hiram Brook, Gautreau and Round Hill members. The Moncton Formation can be divided into a basal Weldon and upper Hillsborough member.

Complex temporal and spatial development of Horton Group lithofacies make basin wide correlation of formations and members difficult and sometimes speculative. Stratigraphic designations made with any certainty must be based on the occurrences of certain key units.

For example, it is difficult or impossible to differentiate between the Memramcook and Moncton formations without the presence of the medial Albert Formation, and within the Albert Formation the distinction between the Hiram Brook and the Dawson Settlement members is difficult without the medial Frederick Brook or overlying Gautreau members. Within the Moncton Formation, distinction of the Weldon and Hillsborough members is dependent on the recognition of the unconformable contact.

The study of the Horton Group in the Moncton Subbasin has pointed out the unsatisfactory nature of the previous stratigraphic nomenclature, the modification of which has indicated areas which will be classified and expanded by future work.

Organic maturity on the northern Grand Banks

M.P. Avery and J.S. Bell, Atlantic Geoscience Centre
Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2

The depth below which oil generation can occur has been estimated from vitrinite reflectance measurements made on ditch cutting samples from 16 exploration wells drilled on the northern Grand Banks. Along the axis of the Jeanne d'Arc Basin, sediments become marginally mature for oil generation at burial depths of approximately 2000m. On the flanks of the basin this diagenetic change occurs at deeper levels ranging down to 3500 - 4000m in the Hibernia-Rankin area.

This thermal paleotopography can be accounted for in terms of the distribution of the highly conductive Argo Salt and the basement structure of the region.

Precambrian rocks of the Avalon Terrane in the Cobequid Highlands, Nova Scotia

H.V. Donohoe, Jr. Nova Scotia Department of Mines and Energy
Halifax, N.S. B3J 2X1

The Cobequid Highlands expose two sequences of Precambrian strata. The older of the two, approximately 800 to 1000 Ma, forms the granitic basement to this part of the Avalon Terrane. It consists of two metamorphic complexes separated by the dextral slip Rockland Brook Fault. The Mt. Thom Complex is exposed north and east of the fault and consists of para- and ortho-gneisses which have been deformed and metamorphosed three times. A whole rock Rb/Sr isochron yielded an age of 934±82 Ma from a granitoid gneiss. The other unit, the Bass River Complex, is located south of the Rockland Brook Fault. Detailed mapping has shown that the complex comprises an amphibolite, granitoid gneiss, and ortho- and para-gneiss unit (Great Village River Gneiss), a quartzitic unit (Gamble Brook Schist), and a dominantly mafic volcanic unit (Folly River Schist). The Great Village River Gneiss is interpreted to be "basement" to the other two, based on a more complex structural, metamorphic, and intrusive history. The quartzitic rocks and volcanic rocks were deposited on the older gneiss, intruded by granite stocks and then the entire complex was deformed by two deformations, with garnet grade of regional metamorphism accompanying the first of these deformations. Garnet-biotite gneisses crop out south of the Cobequid Fault in the Clarke Head Fault Zone 15 km southeast of Parsboro. This occurrence of probable Precambrian rock is interpreted as the southern edge of the Avalon Terrane adjacent to the Minas Geofracture.

The younger Precambrian sequence is dominated by mafic volcanic rocks in two formations: Warwick Mountain Formation in the east and Jeffers Formation in the west. The age of the units is considered to be approximately 600 to 700 Ma. An upper age limit for the Jeffers Formation north of Parsboro is given by the age of the Jeffers Brook Pluton (diorite) which yielded an average of K/Ar mineral dates on biotite and hornblends and a Rb/Sr biotite mineral isochron of approximately 600 Ma. The pluton truncates the recumbent F_1 and upright F_2 deformation events. In the east the Warwick Mountain Formation has the same structural history and probably the same age.

South of the Rockland Brook Fault the McCallum Settlement Pluton (granite) yielded a whole rock Rb/Sr age of 575±22 Ma and intruded the mafic volcanic rocks of the Bass River Complex. West of this pluton is the Debert River Pluton (granite) which has yielded a whole rock Rb/Sr isochron of 596±70Ma. This pluton intruded the mafic volcanic rocks of the Bass River Complex, the Frog Lake Pluton (diorite), and a relatively undeformed sedimentary rock succession that had previously been assigned to the Early Carboniferous Nuttby Formation. The two dated plutons are undeformed and the sedimentary succession is probably Late Precambrian.

The older Precambrian rocks of the Bass River Complex are correlatives of the Greenhead Group in Saint John, N.B. and the George River Group in Cape Breton.

Petrochemistry and tectonic setting of some Carboniferous volcanic rocks in New Brunswick

S.M. Barr, Department of Geology
Acadia University, Wolfville, N.S. B0P 1X0

L.R. Fyffe, Department of Natural Resources
Mineral Resources Branch, Fredericton, N.B. E3B 5H1

Samples of volcanic rocks from the Carboniferous New Brunswick Platform and from two isolated basins farther to the northwest were selected for a preliminary petrochemical investigation. The samples are representative of three age groups: (1) Tournaisian volcanics of the Platform are predominantly felsic with minor interbedded mafic volcanic rocks; felsic volcanics are lacking in the two outliers; (2) Namurian volcanics, which are present over a wide area of the Platform, are dominantly mafic with minor felsic tuff; (3) Late Westphalian to Stephanian volcanics consist of riebeckite-bearing felsic volcanic rocks. Whole rock and trace element abundances together with chemical compositions of clinopyroxenes demonstrate that the oldest group comprises rift-related rhyolite, tholeiitic basalt and andesite; the middle group comprises alkali basalt and trachyandesite; and the youngest group comprises trachyte and peralkaline rhyolite. This change of chemical composition with time coincided with the evolution of the Carboniferous tectonic regime from a rifting environment, apparently associated with intracontinental wrench faulting, to one of regional basin subsidence.

Geodynamic models of convergent margin tectonics: Implications for the development and structure of the Appalachians

G. Stockmal, C. Beaumont, Department of Oceanography
Dalhousie University, Halifax, N.S. B3H 4J1
R. Boutilier, Department of Geology
University of Toronto, Toronto 5, Ont. M5S 1A5

The Appalachian orogen, along with virtually all Phanerozoic and Proterozoic orogens, is now recognized as a "collage" of so-called suspect or exotic terranes. Those terranes which collided with the ancient eastern margin of North America were in many cases overthrust onto the flank of the continental craton (e.g. the Taconic allochton). This process of partial subduction of continental lithosphere, sometimes called A-subduction, appears to be the norm during continental collision. Therefore, a geodynamic model designed to investigate the geologic consequences of A-subduction is applicable to any orogen in general.

Our quantitative geodynamic model for continental margin evolution follows geologic development from rifting, through the cooling passive margin phase, to eventual overthrusting of an exotic or suspect terrane and the creation of a foreland basin. The models are two-dimensional and use finite-differences and finite-element techniques to compute thermal evolution and lithospheric flexural response, respectively.

Geological and geophysical studies have identified to inferred a number of large-scale features common to most orogens. These include: (1) the foreland basin adjacent to the thrust belt, (2) a strong negative-positive couple in the observed Bouguer gravity anomaly, (3) a crustal scale structural ramp spatially coinciding with the gravity couple, and (4) very thick crystalline overthrusts (20 km thick) with relatively little associated topography lying outboard of the crustal ramp. The last two features have been inferred from seismic reflection studies.

Our geodynamic model either reproduces or offers explanations for all of these features. (1) Foreland basins are now well known to be the flexural consequence of thrust loads upon the lithosphere; the model correctly accounts for flexure of a lithosphere whose strength is thermally control-

led. (2) The location of the Moho throughout margin development is predicted because the model explicitly accounts for the initial rifting history of the margin. Computed gravity anomalies across the model demonstrate that the commonly observed negative-positive couple is probably caused by the shift in Moho position across the ancient rifted margin. The position and wavelength of gravity anomalies in the southern Appalachians suggest that the ancient stretched margin was approximately 200 km across and presently underlies the Blue Ridge. (3) the "hinge line", which marks the boundary between unstretched and stretched continental lithosphere, is shown to spatially coincide with the position of the crustal scale ramp inferred in the COCORP northern Appalachian line as well as in the Swiss Geotraverse of the Alps. (4) Very thick overthrusts without high topography are reproduced in our model because they are emplaced in a pre-existing ocean basin or passive continental margin with significant water depths. Thus the thick crystalline overthrusts in the Appalachians inferred by COCORP reflection seismology are not incompatible with the present low topographic expression.

Controls on tin mineralization in chlorite sulfide - hematite zinnwaldite lodes at True Hill, N.B.

D. Lentz, Department of Geology
University of New Brunswick, Fredericton, N.B. E3B 5A3

The True Hill intrusion is a subvolcanic granite porphyry related to the Beechill granite series in SW New Brunswick. Two styles of mineralization and alteration are present, W, Mo greisen and the chlorite sulfide-hematite zinnwaldite lodes (CSL, HZL). Both styles of mineralization are present at the Mount Pleasant mine.

The lodes crosscut the epizonal granite porphyry and the surrounding Siluro-Devonian metasediments as the Cornish lodes do. They invariably contain tourmaline and rutile when hosted in metasediment but don't contain tourmaline when hosted in the granite porphyry. This suggests that boron from the metasediments has formed the tourmaline; hence no meteoric water necessarily contributed to the development of the lodes.

The epizonal granite porphyry shows a decreasing intensity of alteration away from the contact also indicating that the mineralization is of magmatic affinity.

The lodes contain a hematite-zinnwaldite mineralization which overprints the early chlorite sulfide mineralization. The early chlorite sulfide mineralization formed from very low pO_2, low-moderate temperature, low-moderate total sulfur fluid.

The lodes show excellent zoning at Mount Pleasant but zoning is less well-developed at True Hill.

The second style of metallization is hematite-zinnwaldite cassiterite indicative of a fluid with high pO_2 and temperature and low total sulfur and pH. The reaction margin between the two types of mineralization controls the deposition of the cassiterite. The two fluid types may directly reflect changes in the character of the exsolved magmatic volatile phase which were due to enhanced vapour phase separation.

Logan Canyon Formation lithofacies: Scotian Shelf

D.R. Langdon, J.S. Bell, A. Fricker, Atlantic Geoscience Centre
Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2

A series of maps have been prepared from the Atlantic Geoscience Centre's LITHFILE data base to portray lithological variation within the Logan Canyon Formation on the Scotian Shelf.

The unit accreted as a lithotope with positive topography suggesting partly progradational accumulation. Maps of sand content, silt content, and net porosity thickness suggest dispersal in a series of lobes. The distribution of coarse sands and contained carbonaceous material suggests that the Logan Canyon Formation may have been sourced by three south-flowing distributary systems whose clastic contributions were amalgamated by southwestward longshore drift.

The Continental Margin of eastern Canada geological framework and petroleum potential

A.C. Grant, K.D. McAlpine, J.A. Wade, Atlantic Geoscience Centre
Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2

The Atlantic-type continental margin of eastern Canada is underlain by a series of Mesozoic-Cenozoic sedimentary basins separated by basement highs or areas of thinner sediments. Regional and salt tectonics have structured the Mesozoic sequence, which is masked by a less-deformed wedge of prograding uppermost Cretaceous and Cenozoic sediments. The basins have been targets of active hydrocarbon exploration for over two decades. Data from 162 exploratory wells and about 600,000 km (372,830 mi) of multichannel seismic coverage have delineated three major geological/geochemical regions.

On the Scotian Shelf, 15 significant (predominantly gas/condensate) discoveries have been made out of 75 wildcats drilled since 1967. Five of the discoveries, including the Venture field, are in an overpressured zone that has been explored extensively only since 1979. No commercial hydrocarbon accumulations have been found in the southern Grand Banks where 29 wildcats were drilled between 1966 and 1975. The northeastern Grand Banks region has been actively explored by drilling since 1971. The 28 wildcat wells drilled through late 1984 have yielded nine significant (predominantly light oil) discoveries, including the giant Hibernia oil field. Labrador-southeast Baffin Shelf exploration has yielded six gas/condensate discoveries in 28 wildcat wells drilled since 1971.

The Geological Survey of Canada has developed hydrocarbon generation concepts to explain the regional variation in oil and gas occurrence and to assess future potential in terms of the thermal maturity of the source rocks, type of organic material, and time of trap formation. These factors are related to the geologic history of the margin, which is characterized regionally by diachronism in major basin inception and in the resultant stratigraphic record.

(from A.A.P.G. Bulletin, 1984, v. 68, p.1203)

Precambrian geology of the western Cobequid Hills, Nova Scotia

*G. Pe-Piper, A. Macdonald, F. Boner, M. Blank and D.J.W. Piper**
Department of Geology, St. Mary's University,
Halifax, N.S. B3H 3L3
**Atlantic Geoscience Centre,*
Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2

Late Precambrian volcanic, sedimentary and plutonic rocks outcrop over some 100 square kilometres north of the Cobequid Fault in the western Cobequid Hills. The Jeffers Brook Formation of volcanic, pyroclastic and deep-water siliciclastic rocks has recumbent folds and a flat lying penetrative cleavage that were formed prior to the intrusion of the Late Hadrynian Jeffers Diorite. Hornblende gabbro intrusions east of the Jeffers Diorite thermally metamorphosed part of the Jeffers Brook Formation prior to the main deformation. The oldest rocks in the area are marbles, shales and quartzites, possibly correlative with the Green Head Group. These rocks were also thermally metamorphosed prior to acquiring a flat lying penetrative cleavage. The margin of the Jeffers Diorite and parts of the Jeffers Brook Formation are cut by large complex dykes and sills of basalt and pink porphyritic rhyolite. These do not cut nearby Silurian rocks. Metamorphic biotite is widespread in both mafic volcanics and siliciclastic rocks of the Jeffers Brook Formation and in the complex sills and dykes. Texturally the biotite appears both syn- and post-tectonic; a radiometric age of 303 Ma is probably an unroofing age.

Origin of the Stellarton Subbasin

G. Yeo, Geological Survey of Canada
601 Booth St., Ottawa, Ont. K1A 0E8
K. Gillis, Nova Scotia Department of Mines and Energy
P.O. Box 999, Stellarton, N.S. B0K 1S0

The Stellarton Sub-basin is a small (6x21 km), elongate, easterly-trending, fault-bounded basin connecting the two principal fault systems north of the "Minas Geofracture", the Cobequid and Hollow Faults. Late Carboniferous (Westhalian B to D) grey shales, hosting numerous coal and oil-shale seams, with minor grey-tan and red sandstones, red mudstones, and conglomerates, fill the basin. These sediments, interpreted to be of lacustrine or fluvio-lacustrine origin, were derived from source areas to the north and south. North of the Stellarton Sub-basin, in fault-contact with or separated from it by a narrow body of older strata, lie partly time-correlative, grey-tan sandstones and red mudstones of the Pictou Group. These fluviatile deposits were derived from source areas to the west and south.

There is little doubt that the Stellarton Sub-basin developed as a consequence of early Hercynian, strike-slip movement on the Cobequid-Hollow Fault system. The mechanism of basin development is less certain, however. One suggested interpretation is that the Stellarton Sub-basin is a pull-apart basin resulting from secondary faulting at the termination of the Hollow Fault. Alternative models are that subsidence resulted from strike-slip along braided, curved faults, or formation of a rhomb-graben due to side-stepping transfer of strain from the Hollow to the Cobequid Fault. The model must account for the structural juxtaposition of contemporaneous, but quite different sedimentary sequences in the Stellarton and Eastern Cumberland Sub-basins. During the Middle and Late Carboniferous, these sub-basins must have been separated by a highland which acted as a clastic source for both.

If left-lateral displacement predominated on the Hollow-Cobequid Fault system, then the Antigonish-Cobequid Highlands may have formed a continuous high between the Stellarton Sub-basin and the Eastern Cumberland Basin. If, as seems likely from consideration of the available geological evidence, right-lateral slip predominated, then the Stellarton and Cumberland basins would have been separated by a relatively broad Lower Carboniferous high.

Investigations which would help resolve the problem of the origin of the Stellarton Sub-basin include study of regional fault systems, particularly to determine the timing, sense and extent of displacement on them; detailed study of facies and thickness variations within the basin; study of the provenance and dispersal patterns of the Stellarton and Pictou groups, and paleomagnetic studies of Lower Carboniferous redbed units to test for post-depositional displacement.

Scotian Shelf in-situ stress regime interpreted from oil well data

A.J. Podrouzek and J.S. Bell, Atlantic Geoscience Centre
Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2

Analysis of mud weights, mud circulation records and overburden loads suggests that the Mesozoic and Cenozic sediments on the Scotian Shelf are anisotropically compressed in a stress regime where $S_V > S_{H\,max} > S_{H\,min}$.

Borehole breakout azimuths portray a consistent configuration with $S_{H\,max}$ oriented in a northeast-southwest direction across the shelf. This principal stress azimuth is found in the Mesozoic sedimentary section, both above the Argo salt and in areas where it is absent.

These stress trajectories agree with principal stress axes determined from earthquake first motions on adjacent land areas in the Maritimes and Eastern Canada. They show that the Scotian Shelf area forms part of the Mid-America Stress Province.

Carbonate-hosted Pb-Zn-Ba-F deposits, and the evolution of Carboniferous Basins in Nova Scotia: a progress report

C. Ravenhurst, Department of Geology
Dalhousie University, Halifax, N.S. B3H 4J1

The purpose of my thesis project is to investigate how the thermal and structural history of Carboniferous basins in Nova Scotia, is related to the formation of the mineral deposits around their margins. The deposits probably formed as a normal consequence of the evolution of the sedimentary basins. Genetic hypotheses ranging from exhalative syngenetic and early diagenetic, to epigenetic related to basinal brine expulsion or igneous intrusions, have been proposed in the literature for the Nova Scotia deposits. Consequently, the age of the main mineralizing event has been proposed to be Early Carboniferous, Permo-Carboniferous, and even Jurassic. Genetic models for similar carbonate-hosted deposits (Mississippi Valley type and Irish type) throughout the world, range from early hydrothermal fluid circulation, to diagenetic compaction-driven fluid flow, to very late gravity-driven fluid flow. Each model poses constraints on timing, on the isotopic composition of the ores and host rocks, and on the thermal evolution of the basin/deposit system.

(1) The timing of the mineralizing event, and the thermal and structural history of the basins, can be determined by K-Ar dating of hypogene clays, 40Ar/39Ar on microcline, and by fission-track dating of (detrital) apatite and zircon in the host rocks. Vitrinite reflectance, which is essentially an integration of temperature over time, can be used as a check.

(2) The paths of the mineralizing fluids, which show the link between the basins and the deposits, can be mapped by C and O isotopic alteration in the carbonates, and by thermal anomalies recorded in vitrinite, apatite and feldspars in the clastics.

(3) The source of the water, gangue minerals and metals can be determined by D/H analyses of fluid inclusions, Sr isotopes, and Pb isotopes, respectively.

A number of interesting conclusions can be drawn from our preliminary data on some of the Nova Scotia deposits.

Pyrrhotite mineralization and associated Precambrian (Y) schists of the Green Mountain Anticlinorium, Cuttingsville, Vermont

B. Rudnick, Department of Geology
University of New Brunsick, Fredericton, N.B. E3B 5A3

Pyrrhotite mineralization is present in a sequence of Precambrian marble and schists near Cuttingsville, Rutland County, in central Vermont. Surface working of the pyrrhotite was done during the last century. Recent exploration includes core drilling, geophysical and soil geochemical surveys, and geologic mapping.

Soil geochemical analysis for Cu, Pb, Zn, Au and Ag defined an anomaly two to three times larger than the pyrrhotite exposure. Significant anomalous values include: Au (14.4 ppm), Cu (750 ppm), Pb (258 ppm). Magnetic, VLF-EM, and SP surveys outlined five anomalous zones on the grid surveyed including an extension of the exposed sulphides.

Petrographic description from outcrop and core define the following lithologies: (1) marble (calcite ± phlogopite, ± talc, ± chlorite, etc.; ankerite and siderite are locally present); (2) mica quartz schist and mica K-feldspar - plagioclase-quartz schist (both ± biotite, ± amphibole, ± chlorite, ± garnet, ± tourmaline, ± epidote group minerals); (3) biotite-chlorite-plagioclase-quartz schist (± clinozoisite, ± phengite, ± amphibole); and (4) amphibolite. The pyrrhotite present is most commonly within the marble or at contacts of marble and schistose units. Metamorphic grade is middle greenschist facies. Evidence of at least two deformational and metamorphic events is present.

The pyrrhotite mineralization is believed concordant with the stratigraphic units. The lithologies appear similar to Precambrian rocks of the Berkshire Massif, Adirondacks, and the Reading Prong. The units are suggested to represent a platformal sequence of carbonate with clastic (greywacke, arkose, sandstone), and possible volcanic components.

Biostratigraphic approach to Holocene marsh development, Plum Island, Massachusetts, USA

J. Hossley, B. Cameron, Department of Geology
Acadia University, Wolfville, N.S. B0P 1X0
J.R. Jones, Department of Geography
University of Texas at Austin, Austin, Texas

Studies of the origin and development of offshore marshes has been overshadowed by the debate over the origin of barrier islands, but knowledge of sequential marsh development should provide data for evaluating various barrier island models. To elaborate on this concept, we report our preliminary results from a 40-core study of the Plum Island marsh located 65 km northeast of Boston. This barrier island began forming about 6,000 years BP and the marsh behind it is typical of many barrier islands. More recent growth appears to be the result of high energy events, dune migration and complex spit development, rather than major sea-level rise.

Core samples were taken every 15 cm down to the contact with the underlying Eastern Coarse-Grained Facies (fine, aeolian and/or spit sands) and analyzed for sediment characteristics and foraminifera. Approximate (and tentative) dates were assigned to the core samples on the basis of depths corresponding to previously determined C-14 curves.

Significant marsh development did not occur in the study area until sometime after about 3,100 BP. The percentage of silt, clay and vegetative mass increased from about 3,400 BP and reached a high at about 2,700 to 2,900 BP when relative stabilization of eustatic sea level began. Since about 2,600 BP the ratio of silt and clay to sand (9:1) and the percentage of vegetative mass (about 25%) have essentially remained constant.

Preliminary analysis of the foraminiferal distribution at the base of 10 cores and throughout one core indicates: (1) Only **Trochammina inflata** occurs at the base, suggesting an early high marsh environment succeeding aeolian and/or spit sands. (2) **Miliammina fusca** only occurs just above the basal sample, suggesting a later low salt marsh in a more open back-barrier environment about 3,000 to 3,300 BP. (3) **T. macrescens** appears next, and with **T. inflata,** which occurs throughout, indicates a transition up into a high salt marsh environment sometime soon after about 2,900 BP.

These preliminary results suggest that the southern Plum Island marsh may have developed over a submerged spit.

"Possible gravity glide structures of the Avalon Basin, Newfoundland"

James P. Hea, Department of Energy, Mines and Resources
601 Booth St., Ottawa, Ontario K1A 0E8

The Avalon basin of the Grand Banks, Newfoundland was formed in two stages, an extensional stage during the Triassic and Jurassic and a post-extensional stage in the Cretaceous and Tertiary. The early basin is a rift-graben whose shape is controlled by faults. The basin axis was the locus for the deposition of thick Jurassic and Lower Cretaceous sediments which thin or were eroded on the basin margins. Episodes of basin block faulting and margin uplifts of the Avalon basin are recorded by the "Top Jurassic", "Pre-Albian" and "Mid-Cretaceous" unconformities. The basin was subsequently buried under Upper Cretaceous and Tertiary shelf deposits.

Extensional structures include titled fault blocks and anticlinal rollovers associated with listric normal faults. There are also indications on seismic sections of possible gravity glide structures. These include single and shingled glide plates formed by rock failure of block crests and slopes as well as mass glide structures involving plastic deformation by folding and rupture by faults which sole in Upper Jurassic shales. Large glide folds involving Upper Jurassic and Lower Cretaceous reservoirs in proximity to Kimmeridgian shale source rocks are expected to be the habitat for oil and gas fields basinward of Hibernia and the eastern flank of the Avalon basin.

Secondary mobility of high field strength elements in metabasalts

J.B. Murphy, Geology Department
St. Francis Xavier University, Antigonish, N.S. B2G 1C0
A.J. Hynes, McGill University
809 Sherbrooke West, Montreal, Que. H3A 2K6

Examples of secondary mobility of petrogenetic-indicating elements such as Ti, P, Zr and Y in metabasalts are presented from the Arbuckle Brook Formation (ABF) of the Antigonish Highlands and the Ascot Formation (AF) of southeast Quebec. The mobility is attributed to the presence of CO_2 in the fluid phase during metamorphism (now indicated by the presence of calcite).

The style of mobility exhibited in ABF and AF is different. Although absolute abundances are affected in both suites, interelement ratios are relatively constant in ABF but highly variable in AF. These differences may be explained in terms of mineralogical assemblage, internal and external buffering of the fluid composition, and chemical potential gradients of Ti-bearing phases. It is possible that variable alteration patterns may, in part, flect the relative ages of metamorphism and metasomatism.

Concretionary green beds between Halifax and Goldenville Formations: local depocentres on a Continental Margin?

B.H. O'Brien and D.A. Charles, Hi-Tec Geoconsultants Ltd.
P.O. Box 244, Hubbards, N.S. B0P 1T0

Throughout mainland Nova Scotia the Lower Paleozoic Meguma Group is everywhere separable into a lower Goldenville Formation and an upper Halifax Formation. These sedimentary rocks were deposited in a basin or trough now tectonically shortened, but once much wider and possibly longer than the present outcrop area of the two formations. Schenk (1971) postulated that this trough comprised part of the ancient continental margin of northwestern Africa. Poole (1970) suggested that deposition of the lower formation had been from turbidity currents flowing subparallel to the present NE-SW grain of the mountain belt.

The Tremadocian/pre-Ludlovian Halifax Formation is found in places throughout the entire outcrop of the Meguma Group but it is notably widespread in Lunenburg and Queens counties. This is not a function of topography or of local variation in structural style. The succession preserved in Lunenburg and Queens is apparently thicker than it is in counties farther NE or SW.

Concretionary green strata including Mn-rich beds have been reported to be locally and sporadically present at the base of the Halifax Formation or at the top of the Goldenville Formation throughout mainland Nova Scotia. They are, however, particularly well developed below the thick Halifax succession of carbonaceous black slates and pyritiferous sandstones in Lunenburg County. Here, mapping of regional anticlines has shown that these green beds thicken and thin dramatically in directions both parallel and perpendicular to the fold axes. Areas now in the hinge zones of some anticlines may have had relief during deposition of the concretionary rocks. In cross sections of regional fold trains the green beds are either locally absent in certain fold hinges or the lithofacies of the green beds change across the hinge to differ on opposing fold limbs. Stratigraphical successions of these rocks up to one km thick have also been mapped to thin and terminate along a single fold axial trace over a distance of 50 km. The wedge-shape of large sandstone bodies in the green strata has locally controlled the shape and possibly the siting of at least one major gold-producing anticline.

It appears that concretionary, manganiferous green beds accumulated in small protected basins within the much larger "Meguma Trough". In Lunenburg and Queens counties they may herald the development of a depo-centre containing a relatively thick Halifax succession. Allowing for strike-parallel extension and strike-normal flattening, it seems that the protected basins trended NW-SE across rather than along the ancient continental margin.

The pattern of Appalachian tectonics from the Jurrassic to the present

Thomas Metcalf
P.O. Box 439, Berwick, N.S. B0P 1E0

A synthesis of structural data from field work and published reports has yielded a pattern of time successive deformational events along the Appalachians. This patterns fits a tectonic model based on the motion of the North American plate derived from paleooceanic reconstructions done by Smith and Briden (1977) and Firstbrook et al. (1979).

Primary difficulties in recognizing structural patterns of post-Triassic age along the eastern seaboard of North America are caused by a dearth of clearly dated surfaces and by frequent reuse of older faults and fractures. Paleomagnetic results on mylonites and fault gouge materials have provided approximate, and dated igneous bodies maximal, ages. Structural patterns on the outcrop and regional scales have been analyzed with particular concern for cross-cutting relationships as a key to the sequence of deformations. Other reference points have been obtained from offsets of glacial surfaces and offset drill holes created during highway excavation and quarrying operations. The total data base provides a history of deformation in post-Norian times along the Appalachians.

A tectonic model based on the plate track of North America fits the stress directions from the deformation patterns obtained from the above data bases. Tectonic cycles of 30 to 40 million years duration including minor uplift, active uplift, and shear phases derive from the tectonic model and can be shown to fit the sequences of deformation along the Appalachians with a very reasonable degree of coincidence.

The deformational phases each contain a unique structural pattern. A deformational model for each structural pattern describes both the onshore and offshore effects of intraplate stress along the Appalachians.

Structural style in the White Rock metapelitic rocks (Silurian), Yarmouth County, Nova Scotia: a progress report

J.D. Perry, Department of Geology
Acadia University, Wolfville, N.S. B0P 1X0

The White Rock sequence near Yarmouth, Nova Scotia, has been relatively little studied structurally. The study site is located about 6 km northwest of Yarmouth, along the Pembroke Shore, on the west limb of the Yarmouth Syncline. It includes rock units at the base of the White Rock Metavolcanic sequence. Field data were collected during the summer of 1984, including measurements of bedding, cleavage, joints, folds (dimensions, styles, orientations), and boudinage strings.

The principal rock type is a metapelite whose apparent outcrop thickness has been increased by folding, possibly as much as 40%. Bedding traces are commonly obscured by movement along cleavage planes, but can generally be recognized in the hinge zones. In some cases cleavage and bedding appear to be nearly coincident, due to transposition, even though the two are rarely exactly parallel.

Small scale bedding folds (amplitudes less than 5cm) are typically associated with the edges of lensoid quartz "pods", with axes plunging at a low angle (less than 20°). Folded quartz veins have steeply plunging axes of greater than 50°. Both bedding and vein fold axes trend north-south.

Rocks have been metamorphosed to the greenschist facies. Andalusite occurs on the southern fringe of the study area whereas garnet and rare staurolite occur through the entire area.

A strong regional lineation resulting from cleavage and bedding crosscutting in thin psammites can be seen throgh the entire area. The psammite erodes out of the metapelites as long thin rods with lensoid cross-sections which have been mistaken for worm tubes by some workers.

All structures are assumed to be due to one tectonic event, the Acadian Orogeny.

Geology of the Georgeville Group: Late Precambrian development of an interarc basin in the Antigonish Highlands

J.B. Murphy, Geology Department
St. Francis Xavier University, Antigonis, N.S. B2G 1C0
J.D. Keppie, Department of Mines and Energy
1690 Hollis Street, Halifax, N.S. B3J 2X1

The Late Precambrian Georgeville Group consists of mafic and felsic volcanic rocks. The stratigraphy records a progressively deepening environment of deposition.

The geochemistry of volcanic rocks of the Georgeville Group suggests that the northern highlands has continental basement. In the northern highlands, the Chisholm Brook Formation (CBF), the oldest formation identified to date, is an ocean floor tholeiitic basalt, with some calc-alkalic tendencies. Basalts and associated dykes of the Clydesdale Formation (which occurs towards the top of the Georgeville Group) are strongly alkalic and probably represent an ocean island complex.

In the southern highlands rhyolites, basaltic andesites and basalts comprise the Keppock Formation, which is approximately at the same stratigraphic level as the Chisholm Brook Formation. Rhyolites were generated by anatexis of continental crust. Basaltic andesites, and basalts are not co-magmatic. Basaltic andesites are tholeiitic with calc-alkalic tendencies and are very similar to those of CBF while basalts are alkalic and within plate and are indistinguishable from CF.

It is inferred that alkalic basaltic volcanism in the Antigonish Highlands is related to "hot-spot" magmatism, that its "diachronous" character from south to north represents motion of the lithosphere southwards relative to the hot spot.

Deformation of the Georgeville Group is Late Precambrian in age and is heterogenous in style from north to south. The northern highlands are polydeformed by N-S isoclinal F_1 folds followed by N-S and by E-W open folds, whereas the southern highlands are mildly deformed. This hetrogeneity may be related to proximity to a basal thrust and/ or due to protection by continental basement in the southern highlands.

If the Georgeville Group is approximately a temporal equivalent of the Fourchu Group of southeast Cape Breton then the Georgeville Group may be interpreted as an interarc basin.

Foreland basin stratigraphy as a record of Appalachian tectonics

G. Quinlan, Department of Earth Sciences
Memorial University of Newfoundland, St. John's, Nfld. A1B 3X7
C. Beaumont, Oceanography
Dalhousie University, Halifax, N.S. B3H 4J1

The Appalachian basin is a multistage foreland basin that owes its existence to overthrusting associated with the Taconian, Acadian and Alleghanian orogenies. The overthrust loads bent the lithosphere down and created the depression into which the foreland sediments could accumulate. The amount of downflexing is related to the magnitude of the overthrust load while the location of the depression is related to the position of the load. Since the depression must have existed in order for sediment to accumulate, it follows that the age of the sediment is a measure of the timing of the overthrusting events. The conclusion from this line of reasoning is that the stratigraphic record of the Appalachian foreland basin can tell us much about the large scale history of Appalachian accretionary processes. The trick is to be able to relate cause and effect in a quantitative manner.

This paper will describe a numerical model relating the overthrust load history of the Appalachians to the development of the Appalachian foreland basin. Examples will be given to show that the model can reproduce presently observed stratigraphy and estimate how erosion has modified original depositional patterns. Constraints that the model places on Appalachian accretion will be outlined.

Structural development of the Canadian Appalachians

J.D. Keppie, Department of Mines and Energy
1690 Hollis Street, Halifax, N.S. B3J 2X1

Deformation in the Canadian Appalachians may be broadly grouped into two periods: Hadrynian and Paleozoic, separated by a passive period of the Early to Late Cambrian. The Hadrynian deformation, located in the Avalon Composite Terrane, ranges from localized polyphase deformation (N.S. and parts of N.B.) to tilting or may be entirely absent (Nfld. and parts of N.B.). The degree of deformation shows direct correlation with the tectonic setting and proximity to a subduction zone; volcanic arc and interarc basin in Nova Scotia and cratonic rift in Newfoundland. While an upper limit on the age of these structures is sometimes known, the lower limit is generally unconstrained.

The main structural development of the Canadian Appalachians took place between Late Cambrian and Permian times. While convergence was probably continuous, there appear to have been several plate reorganizations during this interval recognized by temporary cessations of deformation associated with erosion, changes in kinematics and rearrangement of tectonic elements. These appear to separate the major deformational events: Penobscotian (Late Cambrian-Early Ordovician), Taconian (Mid-Late Ordovician), Late Caledonian-Early Acadian (Siluro-Devonian), Late Acadian-Hercynian (Late Devonian-Permian). The Penobscot deformation is related to northward obduction of ophiolites with the trench nucleated upon the mid-oceanic ridge. The Taconian deformation is related to SE or E subduction of cratonic North America, which eventually choked the subduction zone. The Late Caledonian-Early Acadian deformation is related to NW to W subduction and accretion of Baltica and the Avalon Composite Terrane. The Late Acadian-Hercynian deformation is related to E subduction and collision of Gondwana.

Silification and silicified microfossils and stromatolites from the Scots Bay Formation, Fundy Basin, Nova Scotia: a progress report

B. Cameron, D. Rogers, Department of Geology
Acadia University, Wolfville, N.S. B0P 1X0
R. Grantham, Nova Scotia Museum
1747 Summer St., Halifax, N.S. B3H 3A6
J.R. Jones, University of Texas at Austin
Austin, Texas 78713

Silicified microfossils have been extracted from the chert-bearing, mixed carbonate and siliciclastic, non-marine lithologies of the Scots Bay Formation at the top of the Fundy Group (Late Triassic-Early Jurassic?) of the southern Fundy Basin. Silicified freshwater stromatolites (hemispheroids and algal laminites) also occur at several horizons. Many of the chert nodules are cored with well-preserved woody tissue of tree trunks, some of which are large enough to exhibit branching.

The silicified microfossils include several kinds of tiny freshwater snails, ostracodes and evidence of freshwater algae (Charaphyta). Small fish teeth, fish scales and fecal pellet-like structures are also present. Whole fish and leaf-like plant remains are extremely rare. The charaphyte fossils are silicified carbonate sheaths that once encased stems with tiny branchlets originating from nodal areas. No unequivocal gyrogonites have been found yet. Only poorly preserved palynomorphs have been found so far.

Syngenetic as well as diagenetic silica occurs in the Scots Bay Formation. Possible preserved algal and/or fungal filaments within the cherts suggest some very early penecontemporaneous silica precipitation that fixed some nonskeletal materials. Structures resembling stromatolites occur within and on the chert nodules. These resemble "pseudo-stromatolites" that are known to form on logs from precipitation of silica in some hot springs. Extensive infilling of void spaces and replacement of carbonates by diagenetic silica indicates

a complex silica paragenesis. Hot springs could have been a common occurrence in the North Mountain Basalt extrusive terrane. The interpretation of a siliceous hot spring association provides a source for the silica that pervades the Scots Bay and North Mountain Basalt formations.

We confirm the interpretation of a nearshore lacustrine origin for the Scots Bay Formation. The limited and discontinuous occurrence plus other features suggest that several small lakes, rather than one large lake, may have formed in collapse structures at the top of the North Mountain Basalt. We hope to determine the age and paleoenvironments of the Scots Bay Formation more accurately with these newly discovered silicified fossils.

Sandstone lithology in the Solver Mine Formation and its relation to galena occurrence in the Yava deposit, Cape Breton Island, Nova Scotia

P. Vaillancourt, Geological Survey of Canada
601 Booth St, Ottawa, Ont. K1A 0E8

The Yava deposit in Cape Breton Island, Nova Scotia is in an Upper Carboniferous fluviatile sandstone above an unconformity over Lower Carboniferous sediments and a Devonian intrusive basement. Yava is situated along the southeast margin of the Glengarry Half-Graben of the Fundy Basin system in the Appalachian Orogen. The deposit is located at an unconformity pinchout in contact with the crystalline basement and consists of three zones of galena disseminated in sandstone. Each zone overlies a basement depression and is separated from the adjacent zone by an intervening basement high. Sandstone mineralization occurs in a three to seven metre thick layer which is discordant to bedding but follows the basement profile.

Recent work has shown that the mineralized and unmineralized portions of the host sandstone can be subdivided into a grey and a green sandstone respectively. Grey sandstone is a more mature, porous rock containing less clay than the green sandstone. The grey sandstone is also distinguished by the presence of silicified coal which is heavily mineralized with galena, pyrite and sphalerite, as well by the coincidence of detrital heavy minerals in galena rich thin, discontinuous bands. The green sandstone is distinctive only by its colour, uniform composition and appearance, and randomly distributed pyrite clusters. It is proposed that the grey sandstone represents a nearshore equivalent of the green sandstone in a transgressive phase of sedimentation.

Structural history of allochthonous Continental Margin sediments, western Newfoundland

J.W.F. Waldron, K.M. Stevens and D.S. Turner, Geology Department
St. Mary's University, Halifax, N.S. B3H 3C3

Deformed continental margin sediments of the Humber Arm Supergroup underlie ophiolites in the allochthons of western Newfoundland. Within the allochthons, tectonic slices of sediments are separated by zones of mélange. The earliest structures in the slices are probable synsedimentary features produced by soft-sediment deformation on the continental slope or rise. Later, west-facing asymmetrical F_1 folds without penetrative axial plane cleavage were probably produced during the emplacement of the allochthon by continent - island arc collision in the Mid-Ordovician Taconic orogeny. Associated extensional structures include shear-fracture and extension-fracture boundins. Pervasive cataclastic shearing produced "web structure" in shale; boudinage of competent beds led to the formation of mélange between slices. Shear surfaces and the original bed-parallel fissility of the shale both contribute to the anastomosing fabric of the mélange matrix.

A subsequent folding event of probable Acadian age produced upright to moderately inclined F_2 folds with axial plane cleavage increasing in intensity eastwards across the allochthon. This event refolded the folds, thrust slices and mélange zones produced during emplacement. Later gentle cross-folds, associated with sporadic development of crenulation cleavage, produced culminations and depressions on the F_2 fold hinges.

Appalachians on the equator - Late Paleozoic paleogeography

P.E. Schenk, Department of Geology
Dalhousie University, Halifax, N.S. B3H 4J1

The Late Devonian through Permian sedimentologic framework of the Appalachians is divisible into two distinct and different domains at the present latitude of New York City. Each domain is characterized by striking differences in: 1) geologic location of the preserved Carboniferous System; 2) shape of the deposits; 3) size of the deposits; 4) tectonic controls on sedimentation; 5) sizes of the dispersal system; and 6) inferred paleoclimate.

South of New York, in the foreland fold-thrust belt, siliciclastic wedges of two different ages (Middle Devonian - Early Mississippian, and Late Mississippian - Pennsylvanian) constitue the sedimentologic record of the Acadian and Alleghanian orogenies. The widespread semicircular wedges prograded cratonward across broad foreland basins from orogenic provenances. Distribution of siliciclastic sediments suggests a genetic relation to large-scale curves (salients and recesses) of the orogenic belt and indicates variation in time of orogeny along strike.

North of the New York in the more interior part of the orogen, Devonian to Permian siliciclastic sediments derived from local fault-block uplifts filled and overflowed pull-apart basins associated with wrench faults. History of sediment supply and deposition varies from basin to basin. Parts of the northern domain are covered by more widespread siliciclastic sediments.

Possible reasons for the perceived differences include: 1) depth of erosion; 2) climate; 3) large-scaled wrench tectonics; 4) incorrect model for the Canadian Appalachians.

Late Carboniferous structure in southern New Brunswick and its relationship to the Meguma Block

S.R. McCutcheon, Department of Natural Resources
Geological Surveys Branch, P.O. Box 1519, Sussex, N.B. E0E 1P0

Northwesterly verging, open to tight, folds with attendant cleavage are present in Viséan and younger rocks along the Bay of Fundy coast between Lepreau and St. Martins. They are best developed in proximity to thrust faults where a younger cleavage, which is co-planar with the thrusts, occurs. Older rocks are also involved, including volcanics and granitoids. The volcanics were originally considered to be part of the, now abandoned, Mispeck Group, and the granitoids were thought to intrude the Carboniferous sequence, but in fact are unconformably overlain by it. The angular unconformity that separates these older rocks from Carboniferous strata commonly dips steeply or is overturned to the north.

It is believed that northwesterly movement of the Meguma block, which is bounded by the right-lateral Cobequid-Chedabucto and left-lateral Oak Bay Fault zones, produced the belt of penetrative Carboniferous deformation observed in southern New Brunswick. Sedimentological evidence suggests that this deformation occurred in Late Westphalian-Stephanian time.

'Shuffle' tectonics at convergent margins: modern example from the Mediterranean

J.M. Woodside, Atlantic Geoscience Centre
Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2

Active collisional tectonics within a wide zone between the African, Arabian and Indian plates to the south and the Eurasian plate to the north, provide modern analogies to processes between ancient convergent margins. Large-scale horizontal motions of detached pieces of the colliding plates, normal to convergence directions, are defined by major wrench faults. Slipline field theory for a rigid-plastic medium in-

dented by a rigid die has been used previously to model parts of this modern collision zone, as well as ancient ones (e.g. Superior-Churchill suture). Non-rigid behaviour of plates within these zones is described by complex faulting. Important wrench zones like the North and East Anatolian Fault Zones bound such regions of deformation. Another, less understood, young example is the Medina Wrench Zone which breaks the central Mediterranean from the Tyrrhenian Sea to the Hellenic Arc, through the Pelagian and Ionian Seas. Producing a series of pull-apart basins, up-thrust blocks and flower structures along its trace, the Medina Wrench Zone defines the southern boundary of a region of deformation in which the Calabro-Peloritan Arc of southern Italy is bowing eastward over the Ionian Basin (a Mesozoic embayment in northern Africa). This is mirrored to the east by the south-westward extension of the Aegean region and Turkey.

SID was conceived during the Appalachian Orogeny

I.A. Hardy, D.R. Langdon, A. Fricker and D.R. Holt
Atlantic Geoscience Centre, Bedford Institute of Oceanography
Dartmouth, N.S. B2Y 4A2

The Atlantic Geoscience Centre (AGC) through its Program Support Subdivision (PSS), at the Bedford Institute of Oceanography (BIO) curates and is responsible for organizing any sampling information for the more than 30,000 marine geological soft-sediment samples that were sired by the Appalachians. During the past year, an integrated data system that had originally been implemented to store only site specific data and sedimentary size analyses has slowly been expanded to include storage history, subsampling information, routine laboratory operations and analyses as well as nondestructive testing data. Each basic entry into the system describes a specimen as either a whole sample collected in the field or as a subsample taken in the lab at AGC.

This information has been stored and/or updated within a large organized information package called SID or Sample Inventory Database that is designed to be easily accessed by earth scientists. It is supported by the BIO mainframe CYBER computer, using System 2000.

Paleozoic in the Northumberland Strait and tectonic significance of intercalated igneous rocks

L.F. Jansa and G. Pe-Piper***
**Atlantic Geoscience Centre,*
Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2
***Department of Geology, St. Mary's University,*
Halifax, N.S. B3H 3L3

The HB Fina F-25 well located in the Northumberland Strait penetrated about 3 km of Devono-Carboniferous sediments resting unconformably on Lower Paleozoic metamorphic basement. Two basalt units are intercalated within Silurian and Devono-Carboniferous rocks. Geochemical and radiometric analyses show that the older basalts are Early Silurian continental tholeiites, with their radiogenic clock thermally reset during the Late Devonian. The other igneous unit is several dykes of high alumina oceanic tholeiite, characterized by flat, relatively unenriched REE spectra and a positive Eu anomaly. This basalt resembles olivine tholeiites derived directly from primary magma melts. Two K/Ar dates suggest an age between Late Permian and Late Triassic. The occurrence of such basalts north of Nova Scotia, where Late Triassic and Early Jurassic continental tholeiites and sub-alkali basalts are found, provides evidence of geochemical evolution of rift volcanics from oceanic tholeiites to alkaline basalts. Further, this occurrence indicates that unless these igneous rocks can be demonstrated to be extrusive or their age proved to be Paleozic by other geologic or geochronologic methods, the possibility that they may be of Mesozoic age has to be considered.

Paleoenvironmental and tectonic control on coal deposition in eastern Canada

P.A. Hacquebard, Atlantic Geoscience Centre
Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2

In eastern Canada Carboniferous coal deposition occurred under both orogenic and epeirogenic conditions.

Of the five coalfields discussed in this aper, only the Sydney field originated in a subsiding foreland basin, probably in the alluvial region of a large paralic coalfield.

The other fields represent intra-continental basins affected by variable epeirogenic dislocations, such as quiet but continuous subsidence or pronounced vertical movements in tectonic grabens. These conditions existed in the St. Rose, Springhill, Minto and Pictou coalfields.

The paleoenvironment in these land-locked basins represented the following: (a) a marginal zone of a flood-plain environment (St. Rose), (b) a shallow lacustrine environment (Springhill), c) the backswamp of fluvial channels (Minto), and d) an intermontane lake basin (Pictou).

These different geological conditions are reflected by: 1) the overall seam development with regard to the number, thickness and continuity of the seams and their mode of termination; and 2) the coal substance itself as expressed by the petrographic composition in terms of microlithotypes and macerals.

Deep-water flysch and trace fossils of the Cretaceous Kodiak Formation, Alaska

T. McCann and R.K. Pickerill, Department of Geology
University of New Brunswick, Fredericton, N.B. E3B 5A3

The Kodiak Formation, Alaska, outcrops in a broad northeasterly trending belt through the centre of Kodiak Island. It is related both lithologically and stratigraphically to coeval rocks on the Alaskan mainland, termed the Chugach terrane and which outcrops in a long arc from Sitka to the Shumagin and Sanak Islands. The rocks of the Kodiak Formation are in fault contact with both the older Uyak Formation to the northwest and the younger Ghost Rocks Formation to the southeast. The sediments are turbiditic in origin consisting of 5000m of interbedded sandstones and shales, the sequence being repeated structurally by folds and faults.

The formation contains an abundant and diverse trace fossil assemblage consisting of **Circulichnis montanus, Cochlichnus** aff. **anguineus, Cosmorhaphe sinuosa, Desmograpton fuchsi, ?Glockerichnus** sp., **Gordia molassica, G. arcuata, Helminthoida crassa, H. labyrinthica, H. subcrassa, Helminthoida** sp., **Helminthopsis** sp., **Muensteria** sp., **Nereites** sp., **Neonereites** sp., **Paleodictyon** sp., **Paleophycus striatus, Paleophycus** sp., **Planolites** spp., **Protopaleodictyon** sp., **Spirophycus bicornis, Spirorhaphe involuta, Taenidium isseli, Taphrehelminthopsis** sp., **Terebellina mackayi** and **Yakutatia emersoni.**

Of these forms only **Paleophycus** sp. and **Helminthopsis** sp. are abundant, the remainder are rare to moderately common. Of particular interest is the occurrence of **Yakutatia emersoni,** an ichnogenus previously noted only once, and which has been subject to misinterpretation in recent years.

Repeated metamorphism of the Meguma Zone, southwest Nova Scotia

C.E. White, B.D. Wentzell and R.P. Raeside
Department of Geology, Acadia University, Wolfville, N.S. B0P 1X0

The folded psammitic and pelitic metasedimentary rocks of the Cambro-Ordovician Meguma Group of southwest Nova Scotia were moderately metamorphosed by a regional event. The metamorphic grade was later enhanced by the thermal effects of Carboniferous granitoid intrusions. The metamorphic grade ranges from upper

greenschist facies through a medium grade amphibolite facies (andalusite + staurolite + cordierite zone) to a higher grade sillimanite zone. Marked irregularities in the isograds were produced by non-uniform pressure across the region, deformation of isograds and faults.

The main episode of metamorphism occurred during regional folding in the early part of the Acadian Orogeny. Pelitic assemblages far removed from the major plutons indicate maximum temperatures and pressures of 650° and 325 MPa.

The intrusion of the Shelburne Pluton is fixed by the development of sillimanite overgrowths on staurolite, andalusite and garnet at the bathozone 2/3 boundary (about 10 km depth). A wide zone of migmatites and a narrow zone of sillimanite-cordierite-K-feldspar-garnet assemblages, confined to pelites around the Barrington Passage Pluton, was produced by contact metamorphism at a considerably shallow level, implying uplift of about 4 km before the intrusion of the Shelbourne and Barrington Passage plutons.

Stratigraphy and deformation of the central Cape Breton Highlands

R.P. Raeside, Department of Geology
Acadia University, Wolfville, N.S. B0P 1X0

About 40% of the southern two-thirds of the Cape Breton Highlands is composed of stratified rocks. Three major units have been recognized. In the west, the western Highlands volcanic-sedimentary complex includes a series of basalts, rhyolites, pyroclastic rocks, volcanogenic sedimentary rocks and the metamorphic rocks derived from them. In the east, the Ingonish River metasedimentary unit includes metamorphosed clastic, carbonate and mafic volcanic and volcanicalstic rocks. The Ingonish River metasedimentary unit is intruded by, and deformed along with, probable Late Hadrynian diorites. In the central Highlands, a high grade gneissic unit displays evidence for a deformation which predated the main foliation-forming event in the Ingonish River metasedimentary unit.

Stratigraphic correlations can be made within each unit, but correlations outside of the Cape Breton Highlands are unknown. Previous correlations between the rocks of the Ingonish River sedimentary unit and the George River Group appear very tenuous - at best the Ingonish River metasedimentary unit represents a deeper water facies equivalent of the George River Group.

The stratified rocks have been deformed by at least one Precambrian event, in addition to the Ordovician and Devonian events represented by the various plutonic units throughout the Highlands. The Acadian Orogeny was apparently primarily responsible for extensive retrograde metamorphism.

Correlation between the Late Pennsylvanian Morien Group (Sydney, Nova Scotia) and the Silesian Pennant Measures of South Wales

E.L. Zodrow, Department of Geology
University College of Cape Breton, Sydney, N.S. B1P 6L2

The Pennsylvanian (Upper Carboniferous) coalfields of Eastern Canada were formed in a series of small, linear, non-marine basins in what are now the Atlantic Provinces. In fact, these Canadian coalfields appear to have been westerly extensions of the area of coal deposition which extended over much of northern Europe. So, despite their present geographical position, the conceptual correlation of these Canadian sequences are to be found in Europe, particularly Great Britain.

For the correlation, the three macrofloral interval zones, 1) **Lobatoperis vestita,** 2) **L. micromiltoni,** and 3) **Linopteris bunburii** recognized in the Westphalian D of Europe are also present in the Morien Group/Pictou Group. These zones allow a more refined correlation to be made between western Europe and North America in general, contributing to the establishment of a comprehensive scheme for strata of this age in the paleoequatorial belt.