ATLANTIC GEOSCIENCE SOCIETY

ABSTRACTS

The origin, history and potential of sedimentary basins in eastern and offshore Canada

Symposium 1983

MARITIME SEDIMENTS AND ATLANTIC GEOLOGY
19, 89-103 (1983)

0711-1150/83/020089-14$3.10/0

Whether it's known as a symposium or colloquium, the annual A.G.S. gathering held this year in Fredericton, N.B. is rapidly becoming the highlight of the local geological scene. This year it was the turn of the symposium with the theme being, "The history, development and economic potential of sedimentary basins in eastern and offshore Canada".

The weekend activities started on Friday, 28th January, when the faithful assembled at Keddy's Motor Inn in Fredericton, N.B. About 75 geologists were on hand to hear the two evening presentations, one on offshore geology, the other on the coal basins of Nova Scotia.

On Saturday, attendance swelled to 130 and the technical sessions ran from 9 a.m. to 5 p.m. with talks covering all of the Phanerozoic. The onshore was covered in some detail, with the Meguma being a particularly popular topic. By comparison, the offshore received scant attention with only two papers falling into this category. The standard of the presentations was excellent and the accompanying illustrations were generally of a high quality. I was also impressed with the poster exhibits, especially the summation of the remapping program in the Cobequid Highlands. All in all it was a most informative and enjoyable technical program.

The Society's annual meeting was sandwiched between the end of the technical sessions and the beginning of the banquet, a procedure recommended to other societies whose business meetings last forever. The President, Laing Ferguson, after dispensing with the preliminaries, introduced the nominees for the new Executive and Council. All were duly elected. There was unanimous agreement to seek affiliation with C.S.P.G. and to postpone changes to the Bylaws. I appreciated the background information provided for the annual meeting, especially the President's and the Treasurer's reports.

The day's activities were brought to a close at the banquet where the invited speaker was Hugh Morris, President of G.A.C. He gave an entertaining talk on federalism, provincialism and separatism, and showed inspired taste by not digressing for too long. Laing Ferguson thanked the organizers of the Symposium, Walter van de Poll, Ron Rickerill and Jim Noble, for a very successful technical and social program. Walter van de Poll in turn thanked all the students and staff of the Department of Geology, University of New Brunswick for their help in running such a trouble-free meeting. The curtain came down on the ABBA II quartet who sang, "All the President's men", a spoof on A.G.S., after which we dispersed to various parties.

It was a great meeting; the weather was superb and I am already looking forward to the song entries in the Geolovision song contest at the 1984 reunion.

— Graham Williams

Lower Carboniferous volcanic rocks of the Magdalen Islands: Volcanism in the Fundy Epieugeosyncline

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

Volcanic rocks on the Magdalen Islands occur within and overlying Lower Carboniferous clastic, carbonate, and evaporitic sequences which have been correlated with the Windsor Group of Nova Scotia and New Brunswick. The volcanic units consist mostly of volcaniclastic rocks and basaltic flows, intruded by gabbroic dykes and plugs. The stratigraphy has been widely disrupted by evaporite diapirism which has produced basaltic breccia and melange, the latter particularly spectacular where gypsum and volcanic rocks are involved. Petrological studies of the basaltic flows and intrusions show that their primary mineralogy included plagioclase (labradorite ?), titaniferous augite, and olivine, but intense alteration has produced abundant chlorite, sericite, carbonate, epidote, hematite, and other secondary minerals. The alteration is reflected in wide chemical variations, especially in Ca, Na, and K, which have led to previous interpretations that the rocks are alkalic based on major element chemistry. However, the relatively immobile elements (Ti, Nb, Y, Zr) show clearly that the basalts are continental tholeiites, probably generated under moderately thick continental crust.

Other volcanic rocks formed in association with the Fundy Epieugeosyncline range in age from Middle Devonian to late Carboniferous. They are exposed at the surface in Nova Scotia and New Brunswick and have been encountered in the subsurface in Prince Edward Island and the Gulf of St. Lawrence. This wide distribution of volcanic rocks both geographically and in time implies a relatively high geothermal gradient in the Fundy Epieugeosyncline throughout its development. This may have important implications for the formation both of hydrocarbon accumulations and of mineral deposits of submarine-exhalative type.

Marginal molassic basin onlap and mineral deposits, Loch Lomond Basin, Cape Breton Island

R. Boehner, Nova Scotia Department of Mines and Energy
P.O. Box 1087, Halifax, N.S. B3J 2X1

The Loch Lomond Basin is a small structural basin that presently has the form of a northeasterly trending half graben. It is fault bound to the northwest and contains up to 800+ m of Visean to Namurian age rocks. It is bordered on the northwest by Hadrynian Fourchu Group volcanic-sedimentary rocks and plutonic rocks of the East Bay Hills. The major unconformable contact to the southwest is with similar rocks of the East Bay Hills (largely the Loch Lomond Pluton).

The Loch Lomond Basin contains a mixed Carboniferous succession dominated by marginal continental alluvial-fluvial and marine evaporite-carbonate sediments representing molassic deposition. Major rock packages recognized are comparable (with a few exceptions) with those in other parts of Nova Scotia and include in ascending order: Windsor Group evaporite, fine to coarse redbeds and marine carbonate (middle and upper parts only), Enon, Loch Lomond and Uist Formations (up to 350 m); fine grained Canso Group (up to 200 m); and upper Canso Group (dominantly grey sandstone up to 250+m).

Progressive onlap and overstep of stratigraphic packages with accompanying facies changes are well documented both parallel and perpendicular to the

strike of the Loch Lomond Basin. Similar changes are also present in the Salmon River - Glengarry Basin. Details of these features remain to be fully documented (1983).

Paleotopography and tectonism greatly influenced sedimentation in the Loch Lomond Basin especially the early stratigraphic units. Their importance decreased with time as erosion and deposition of onlapping strata buried the basement topography. The stratigraphic section to the top of the fine grained Canso Group displays general fining upward and basinward trends. Coarse fanglomerate facies occur as a marginal facies of the Windsor Group at all stratigraphic levels.

The numerous mineral occurrences in the area are concluded to be closely related to paleogeography (topography), tectonics and sedimentation history (especially unconformities and stratigraphic onlap-overstep). Progressive onlap-overstep is inferred to be the principal factor which produced conditions suitable for the concentration and entrapping of contact oriented and stratabound celesite, barite, Pb, Zn, Cu, Mn and abundant, but economically unattractive Fe.

Base metals ± minor celestite ± Fe ± Mn occurrences are contact oriented and localized at or near unconformity pinchouts at all stratigraphic levels. Secondary redistribution of celestite ± base metlas ± Fe (supergene ?) is inferred to have occurred in karst related hydration zones. Barite and celestite ± Pb ± Zn ± Fe are dominantly stratabound, stratified to nodular deposits (within marine carbonate, gypsum-anhydrite, red siltstone-sandstone) and may represent diagenetic replacement during or soon after Windsor Group sedimentation.

Fresh-water fauna and flora assemblage from the Devonian La Garde Formation of northern New Brunswick

[1]*W.H. Forbes and* [2]*A.E. Kasper, Jr.*
[1]*Department of Geology, University of Maine, Presque Isle, Me. 04769*
[2]*Department of Botany, Rutgers University, Newark, New Jersey 07102*

The oldest recorded fresh-water fossil assemblage of animals and plants is reported from the Campbellton Formation of northern New Brunswick, Canada. These continental rocks outcrop along the south shore of the Restigouche River at Campbellton and are of Lower/Middle Devonian age. The unique association of plants and animals occurs within a calcareous mudstone dike cross-cutting a rhyolite breccia. The reddish-brown slightly calcareous siliceous mudstone readily weathers to a light buff color accentuating the carbonaceous plant and animal material on its surface. The plant assemblage contains several well-characterized species, *Leclercqia complexa, Psilophyton princeps, Drepanophycus spinaeformis* and numerous unidentified plant remains. *Leclercqia complexa* is known from the Middle Devonian Panther Mountain Formation of New York State; the other species are long-ranging. The strata have also yielded the following fish: *Cephalaspis acadica, C. campbelltonensis whiteaves, C. jexi, Phyllctaenaspis acadia. P. atholi.* In addition this mudstone dike contains the following invertebrate fossils: ostracodes, gastropods and occasional segments of eurypterids. The paleoenvironment was probably a pond containing fish, snails and ostracodes with vascular plants growing along its periphery. The environment of deposition was most likely over-bank deposits produced by periodic flooding. The presence of the Middle Devonian plant, *Leclercqia complexa,* suggests that the age of the formation be restricted to Middle Devonian.

Preliminary interpretation of gravity and magnetic results from the Epicentral Region of the 1982 Miramichi earthquakes

K.B.S. Burke, Department of Geology
University of New Brunswick, Fredericton, N.B. E3B 5A3

J.J. Chandra, Geology Surveys Branch
Department of Natural Resources, Fredericton, N.B. E3B 5H1

The 1982 Miramichi earthquakes occurred in a region in central New Brunswick that is occupied by the North Pole Pluton, an intrusion of Middle Devonian age, that has intruded deformed, Cambro-Ordovician, metamorphic rocks. A 300 station gravity survey of the epicentral region was completed in 1982. In addition, samples were collected for density determinations and *in situ* magnetic susceptibility measurements were made on all major outcrops. The results of this survey, together with previously flown aeromagnetic data, are being used to construct a subsurface model that should provide useful constraints in earthquake mechanism studies.

Density measurements on the samples show that the granitic rock units have the lowest mean densities (2610-2630 Kgs/m^3), whilst the diorite unit has the highest mean density (2780 Kgs/m^3). The metamorphic country rock units have a range of mean densities between 2650 to 2750 Kgs/m^3, with some individual samples of the phyllite unit yielding densities as high as 2850 Kgs/m^3. The *in situ* magnetic susceptibility measurements show that the diorite unit has a magnetic susceptibility that is generally two to three times higher than the granitic units, but the phyllite unit in the country rocks shows a much wider range in susceptibility.

On a regional basis, a large gravity low coincides with the exposed middle portion of the North Pole Pluton and also shows its much greater subsurface extent. However, in the detailed gravity survey results, this large gravity low is also seen to contain smaller positive anomalies that suggest that the higher density diorite unit is more extensive at depth than indicated by surface exposure of this unit. Initial thickness estimates from the gravity anomalies suggest that the metamorphic units are generally thin in the region (0.5-1 km) and that the Miramichi earthquakes and aftershocks are confined to the plutonic body. One explanation for this confinement of the hypocenters is that the brittle rocks of the pluton are weaker than the surrounding tougher metamorphic country rocks when exposed to the same stress system.

Slate belt tectonics in the Bickerton Barrens, N.S.: Horizontal extension and simple shear within the Meguma Basin

B.H. O'Brien, Nova Scotia Department of Mines and Energy
P.O. Box 1087, Halifax, N.S. B3J 2X1

Greenschist facies sedimentary rocks underlying the Bickerton Barrens illustrate a long history of inhomogeneous progressive deformation. A discontinuous deformation path gave rise to several phases of deformation, each governed by a particular type of crustal shortening. The earliest event produced a layer-parallel shear of variable intensity throughout a shale-sandstone multilayer exceeding 5 km in thickness. Within the multilayer bedding and stratiform quartz veins acted as both the principal planes of shear and anisotropy. Flattening associated with layer-parallel shear is evidenced by the formation of gently dipping, grain alignment cleavage and the development of gently plunging, step folds. Localities where bedding is downfolded may mark the site of underlying

faults, perhaps themselves rooting in the basement to the multilayer. The Meguma slate belt is held to be thin-skinned.

Layer-parallel shearing was followed by a period of layer-parallel shortening. Where the multilayer remained flat, gently plunging parallel folds were produced by buckling. Depending upon the ratio of competent to incompetent beds the buckle folds developed by either flexural slip folding or neutral surface folding. At an early stage in the buckling of the multilayer pressure solution cleavage began to develop with a characteristic moderate dip. This cleavage together with certain quartz veins and the grain alignment cleavage were passively folded and steepened. In having done so they provide a record of most of the limb rotation during buckling. Newer and successively steeper pressure solution stripes were initiated as the fold limbs continued to rotate and the axial surfaces approached the vertical. Subsequent to most but not all of the buckle folding and late in the episode of layer-parallel shortening the generally upright slaty cleavage was imposed on all earlier folds. Cleavage-related flattening locally produced minor folds, in particular cuspate isoclines of the bedding. Objects in the plane of the steep foliation are typically extended subhorizontally parallel to the regional fold axes. Rotation of obliquely orientated step folds into the regional E-W grain of the slate belt occurred before or during the formation of the slaty cleavage. Regional wrench movements may have been active early during buckling as well as late during the imposition of the upright LS-fabrics.

After the beds acquired slaty cleavage they ceased to behave as a multilayer. Gravitational instability following inhomogeneous layer-parallel shortening probably caused the vertical collapse of the slate belt. An associated flattening produced variably intense but regionally pervasive subrecumbent folds and gently dipping crenulation cleavage. Superimposed coaxially on the major fold structures, they are commonly seen to affect the steep cleavages but rarely to deform the bedding. There does not appear to be any preferred direction of translation during this episode of shortening

The slate belt largely acquired its present configuration in a period of shear folding which most likely succeeded gravitational collapse. At this time the strong, upright foliations were the principal planes of anisotropy and so they became the principal planes of shear. The hinges of the major folds suffered relatively large strains late in the layer-parallel shortening event and, therefore, they were naturally favoured to be the most active sites of shear folding. Reclined crossfolds and crenulations possibly result from shear related compression; their conjugate nature reflecting both dextral and sinistral movements. En echelon boudins extended equally in several directions seem to imply a plane strain and an operative simple shear.

Evolution of the Fredericton Trough

L.R. Fyffe, New Brunswick Geological Surveys Branch
Fredericton, N.B. E3B 5H1

A system of post-Taconian horsts and grabens delimit the tectonostratigraphic zones of New Brunswick. The Fredericton Trough and Matapedia Basin represent graben structures that developed astride the older tectonic grain beginning in the latest Ordovician and earliest Silurian.

Uplifted blocks of Taconian basement on the margins of the Fredericton Trough are represented by the Miramichi Massif in the northwest and Cookson Inlier in the southeast. Shallow-water Silurian sediments (Oak Bay Formation and Waweig Formation in the southeast, "Canterbury conglomerate and limestone" in the north-

west) are preserved on these positive areas.

Small inliers of similar basement are found in the Becaguimec River area (overlain by Upper Ordovician conglomerate) on the southeastern margin of the Matapedia Basin and in the centre of the Basin at Mars Hill, Maine.

Volcanism initiated during the rifting is restricted to narrow down-faulted blocks on both margins of the Fredericton Trough (Mascarene Group, Long Reach Formation, Jones Creek Formation in the southeast; Dorrington Hill Formation, Hartin Formation in the northwest). The bimodal volcanics varied from submarine in the Early Silurian to subaerial in the Early Devonian.

Late Ordovician? to Early Silurian sedimentation within the Trough consisted of fine-grained, red and green sandstone and siltstone (Queen Brook Formation in the southeast; "Stanley beds" in the northwest). Later thick deposits of Silurian greywacke (Digdequash Formation, "Burtts Corner greywacke") reflect more rapid uplift of the source areas on the flanks of the Trough. The greywacke is overlain by shallow-water calcareous sandstone deposits of Early Devonian age (Flume Ridge Formation) representing a mature rift stage of sedimentation.

During the subsequent compressional stage, vergences of second folds indicate that the sedimentary rocks of the Trough were thrust over the uplifted blocks on its opposite flanks. Syntectonic to post-tectonic plutons (St. George and Pokiok batholiths) ranging from Early Devonian to Early Carboniferous intruded the faulted margin of the Trough. Displacement of Early Carboniferous basalt indicates 800 m of down-throw on the southeastern side of the Fredericton Fault. This latest movement was related to the development of the Carboniferous Moncton Basin farther to the southeast.

The presence of horst and graben structures trending northeasterly across the normal east-northeasterly tectonic trend of the Appalachians may result from New Brunswick's position relative to the Saint Lawrence Promontory. Since Acadian tectonism in New Brunswick can be related to block faulting, no Devonian accretionary terranes will exist here north of the Avalonian Platform.

The stromatoporoid fauna of the West Point Formation (Silurian) on the Gaspe Peninsula

C.S. Pope, Department of Geology
University of New Brunswick, Fredericton, N.B. E3B 5A3

Stromatoporoids are the major constituent of most of the facies of the West Point reef complex around Port Daniel, Quebec. Variations in the amount and grain-size of siliclastic deposition seems to have effected the biota colonizing the facies. The base of the formation is a relatively shallow, sublittoral distal deltaic sequence of siliclastic siltstones colonized by large stromatoporoids and tabulate corals. Other facies include sponge-supported (?) mudmounds, algal banks and crinoid debris layers. The complex climaxes in a stromatoporoid reef and an associated lagoon of mudflat facies with a variety of stromatoporoid morphologies suggestive of changing depth and wave energy regimes. Several small stromatoporoid patch reefs of bioherms are also present. Progressing analysis of the taxonomy and morphologies of these stromatoporoids suggest that the West Point Formation displays a normal community succession from pioneer stages to climax and dominance stages but with several setbacks in the process. These "setbacks" can probably be related to changes in water depth and sediment influx associated with contemporaneous volcanic activity in the area.

Gold potential of the Meguma Group: New Concepts

S.J. Haynes and P.K. Smith, Nova Scotia Department of Mines and Energy
P.O. Box 1087, Halifax, N.S. B3J 2X1

Gold in the Meguma Group was traditionally mined from quartz veins preferentially located in the slate units of turbidite sequences. Detailed field studies at Wine Harbour, Isaac's Harbour, Goldboro, Beaverdam, Cochrane Hill and Forest Hill have demonstrated the following new information:

(1) At some deposits, gold is present within the host-rock slates as deformed wisps of free gold and native gold inclusions in garnet prophyroblasts. This implies significant potential for increased mining widths of low-grade ore comprising both quartz veins and slate.

(2) In greenschist facies zones, eleven different quartz vein polytypes have been characterized on the basis of form, characteristic mineralogy, wall rock alteration and crosscutting relationships to each other and regional structures. However, gold is restricted to structurally early (pre-Acadian) corrugated stratiform veins (exhibiting cross-laminations and columnar structures), boudinaged stratabound veins and associated small side veins. These are cut by K-feldspar bearing crossveins, displaying arsenopyritization and sericitization of the wall rocks. The other polytypes, which range from syn- to post-Acadian, are apparently barren.

(3) In amphibolite facies zones, Acadian structures are complicated by intrusion of late Acadian granitoids, themselves deformed by at least two post-Acadian (Hercynian ?) dynamo-metamorphic events. All quartz vein types common to the greenschist facies appear to be present. In addition, gold is present in both deformed andalusite-bearing pegmatoid veins. Late Acadian static metamorphism incorporated gold as inclusions in garnet porphyroblasts. These porphyroblasts are, in turn, cut by deformed auriferous, syn-Hercynian (?), stratiform and stratafound quartz veins. The final stage of gold-quartz deposition appears as undeformed, post-Hercynian (?) crosscutting veinlets.

A polygenetic model for gold is proposed involving initial deposition from submarine hydrothermal vent systems as chemical sea-water precipitates, hydrothermal sills and fault-controlled feeders. Later, polyphase Acadian, Hercynian (?) and post-Hercynian (?) dynamo-thermic solutions remobilized both gold and quartz.

A deformed accretionary terrane in the Newfoundland Appalachians

B.A. van der Pluijm, P.F. Williams and K.E. Karlstrom
Department of Geology, University of New Brunswick
Fredericton, N.B. E3B 5A3

An imbricate stack of three thrust sheets is present on New World Island, northeast Newfoundland. These sheets are separated by movement zones, commonly marked by melange. Because of the tectonic setting and the geometry the area is interpreted as part of an accretionary terrane.

Our work shows northwest directed thrusting indicating southeasterly subduction. The presence of an U. Llandovery olistostrome near Cobbs Arm in one of our movement zones, date that thrust as U. Llandovery. Since this sheet is one of the lowest in the pile, the formation of the accretionary prism, as now exposed, must have started prior to the U. Llandovery.

Sedimentological work in the area by a group of workers from Oxford University reveals three distinct sequences which were interpreted as being deposi-

ted in three different basins, bounded by high angle faults which were active during sedimentation. More recently it has been suggested that the faults are northwest dipping thrusts. Either interpretation is incompatible with our structural data. There are no suitable high angle faults and they assume the opposite sense of movement on the thrusts to that determined in the field. Furthermore, the youngest basin is associated with the oldest thrust and the oldest basin with the youngest thrust; this is not normal in accretionary terranes where the piggy-back relationship is observed.

We present an alternative explanation which agrees with both the sedimentological and the structural information. First we assume that the fault delinated basins were parts of a single continuous basin and that the pre-deformational spatial distribution of the parts was the reverse of that assumed by the Oxford group for the basins. Thus the northwest basin, in their interpretation, becomes the southeast portion of our continuous basin and so forth. This we believe, fits the sedimentological data better than the assumption that the spacial distribution was the same, before deformation, as now. In our model the present distribution is a product of thrusting and later folding.

Sedimentation occurred on the west margin of the Iapetus Ocean during Ordovician and L. Silurian times. Current directions and composition of the sediments show the source to be to the northwest where there was an island arc and the North American craton. Starting in L. Silutian times, underplating of the basin floor took place with subduction to the southeast and an accretionary prism was formed. Continued shortening caused folding of the thrust pile and finally the collision between North America and Europe resulted in modification of these folds.

This deformation sequence offers an explanation of the observed variation in deformational history in this part of the Appalachians. In the northwest the Taconic event represents Ordovician subduction along the edge of the North American continent and the Acadian event represents the Silurian/Devonian collision. In the southeast the deformation is related to subduction on the southeast side of Iapetus plus the final collision. It is continuous from at least as early as L. Silurian through to Devonian.

Basement studies in the Southern Central Carboniferous Basin - New Brunswick

J.J. Chandra and T.C. Webb
Department of Natural Resources, Fredericton, N.B. E3B 5H1

A geophysical study of the Pre-Carboniferous basement in the southern Central Carboniferous Basin is presently being undertaken by the Mineral Resources Division. The purpose of the investigation is two-fold: (1) to determine the geothermal potential and (2) to aid in the recognition of buried Windsor salt masses.

Filtered gravity data shows a major low underlying the basin in this area. This major low has been interpreted to reflect an extension of the St. George Batholith beneath the Carboniferous cover. The filtered data also suggest that the Pokiok Batholith does not extend into the basin to any degree and is perhaps in faulted contact with the Silurian sedimentary rocks.

At the northwestern tip of the interpreted St. George Batholith extension is another major gravity low which trends northeasterly. It starts at Harvey Station and terminates as a globular low in the Minto-Meadow Brook area. This feature has also been interpreted to reflect a granite body, however, the shape of this granite body and its relationship to the St. George and Pokiok Batholiths are still not understood. It

is possible that this intrusive body is the source of the volcanic units exposed in this part of the basin.

The residual gravity map of the southern Central Carboniferous Basin also defines two additional gravity linears. One linear is coincident with the anomalously radioactive Mt. Pleasant volcanic sequence which appears buried under the Pennsylvanian cover and extends as far as French Lake where higher radioactivity in the soil and water has been confirmed. The other feature has been interpreted as a grabben which extends from South Oromocto Lake through to Fredericton.

Detailed gravity mapping of this part of the Central Basin has been completed in the summer and fall of 1982. This coverage has provided adequate data for three dimensional modelling of these structures.

Upper Devonian plant-bearing strata from Cape Breton Island, Nova Scotia

[1]*W.H. Forbes*, [2]*A.K. Kasper*, [3]*R.A. Jamieson, M.C. Blanchard-Williamson*
[1]*Department of Geology, University of Maine, Presque Isle, Me. 04769*
[2]*Department of Botany, Rutgers University, Newark, New Jersey 07102*
[3]*Department of Geology, Dalhousie University, Halifax, N.S. B3H 4J1*

Plant-bearing sandstones from Cape Breton Island, Nova Scotia, represent the first report of Upper Devonian continental strata for the Province. The thinly laminated greenish-gray fine-grained sandstones are exposed along a woods road north of Forest Glen Brook, east of Cheticamp, Cape Breton Island. These sandstones are interbedded with rhyolitic breccias and flows, that in turn are overlain by beds of probable early Carboniferous age. The igneous rocks have yielded a wide range of radiometric dates. The plant fossils are assigned to the genus, *Archaeopteris* of the Division Progymnspermophyta - the progymnosperms. Species of *Archaeopteris* are characteristic of Upper Devonian continental strata in the Escumanic Formation of Gaspe Peninsula, in the Perry Formation of eastern Maine and in Upper Devonian beds of the central Appalachians of the U.S. Plants assigned to this taxon were arborescent with large trunks of conifer anatomy. Vegetative foliage consisted of branch systems bearing fan-shaped laminar leaves with dichotomous venation. Reproductive foliage consisted of non-laminar divided leaves with numerous sporangia. The specimens assigned to *Archaeopteris* consists of both sterile and fertile foliage. The presence of this genus in sandstones from Cape Breton Island is the first evidence of Upper Devonian continental strata in Nova Scotia.

Polygonal patterns, sedimentary facies and basin analysis

H.W. van de Poll and A.M. D'Orsay, Department of Geology
University of New Brunswick, Fredericton, N.B. E3B 5A3

Polygonal patterns ranging from approximately 15 cm to 300 m in diameter are familiar features in sediments. Two pattern types can be recognized: 1) orthogonal polygons with straight and/or curved sides and 90° intersection angles and 2) non-orthogonal (usually hexagonal) polygons with tri-radial intersections of approximately 120°. The origin of sediment polygons can be attributed to a variety of processes, which include: 1) contraction, 2) contraction and expansion, 3) sediment loading and buoyancy displacement and 4) sediment intrusion.

Volume reduction (e.g. desiccation, syneresis, frost shrinkage) locally with secondary infilling (e.g. ice-wedge and evaporite polygons) and alternating periods of contraction and expansion

(e.g. "patterned" ground in permafrost areas) are examples of the first two processes. Polygonal patterns resulting from loading and sediment intrusion are less well known. They reflect intrastratal transposition of sediments along reverse density gradients that take place with or without the aid of induced shear.

Considering the variety of conditions and circumstances that can lead to the formation of polygonal patterns it is clear that the correct interpretation of sediment polygons is essential in facies and basin analysis.

Reference will be made to the polygonal patterns occurring in Permo-Carboniferous strata of the Maritime Provinces, Canada, with particular emphasis on those of the West Bay Formation of the Parrsboro area, Nova Scotia. Current research suggests that the polygonal patterns within this formation are not desiccation features but are polygonally oriented clastic dikes that reflect sediment intrusion in response to unstable sediment density distributions and possibly earthquake motion.

Sedimentology of the Halifax Formation, Nova Scotia: Ordovician fine-grained turbidites

D.A.V. Stow, M. Alam and D.J.W. Piper, Atlantic Geoscience Centre
Geological Survey of Canada, Bedford Institute of Oceanography
P.O. Box 1006,Dartmouth, N.S. B2Y 4A2

The Halifax Formation is a several kilometre thick shale-rich succession that forms part of the (?) Cambro-Ordovician Meguma Group of Nova Scotia. The Meguma sediments were mostly deposited by sediment gravity flows on a prograding deep-marine slope-rise complex. Eight separate facies of the Halifax Formation are recognized on a facies continuum from very shaley to very sandy. The two most sandy facies show partial Bouma sequences of structures; the others are best interpreted in terms of a more detailed 'ideal sequence' for fine-grained turbidites. Vertical sequences have beeen measured that show thinning-upward, thickening-upward and irregular patterns of sandstone and siltstone beds on a large-scale (100-200 m). There is also much wedging, subdivision and amalgamation of these coarse lithologies. Erosional features are locally common at the base of turbidite beds and still more widespread at the top. Slumps and bioturbation are less common. The depositional setting of most of the Halifax Formation appears to be the mid- or upper-fan area of a muddy deep sea fan, passing upwards into a prograding continental slope.

The Mabou Mines section: Implications of fossil plant collections

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

The Mabou Mines section of Cape Breton Island represents the land-based portion of a supposedly large off-shore coalfield (Mabou Coalfield). This section contains an abundant, unoriented phyllocenosis in which the neuropterids (pteridosperms) predominate. Of the phytostratigraphically important macrofossil forms (alethopterids, pecopterids, fortopterids and sphenophylls) that were instrumental in determing a Westphalian D plant age, certain forms of the *neuropteris - Linopteris* complex are additionally interesting. Four reasons are cited. First, transitional phases in the development of *Linopteris münsteri* (loose and meshing venation), *i.e., Neuropteris obliqua* (highly flexuous venation) and *Neuropteris semireticulata* (venation between that of *L. münsteria* and *N. obliqua*), are recorded in the sedimentary rocks; secondly, in some specimens *Linopteris obliqua* characteristics (anastomosis, or cross-over

of veins) are clearly shown; thirdly, much of this material is cutinized allowing epidermal investigations; and fourthly, this mode of preservation allows a more accurate determination of mesh formation than it is possible with compression/impression material (which may eventually contribute in defining natural species). Moreover, the (thick) cutin and the vein-mesh formation in certain pteridosperms of Upper Carboniferous time can be explained by physiological and paleoecological factors (amount of sunshine, height of plant, soil moisture, strength of pinnules).

The present paper is primarily concerned with illustrating the transitional aspects of the *Neuropteris-Linopteris* forms. On evidence collected, it is also interesting to note that both floras and faunas of the Mabou section are of low diversity (as compared with the Sydney Coalfield) and that lacustrine conditions appear to have had a higher frequency at Mabou than at Sydney.

Not enough stratigraphic specimens have been examined to broach the question of gradualism versus punctuated equilibrium as it relates to the evolution of the *Neuropteris obliqua - Neuropteris semireticulata - Linopteris münsteri* complex.

Cruziana stratigraphy of the ?Cambro-Ordovician Bell Island and Wabana Groups, Conception Bay, eastern Newfoundland

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

Unfossiliferous or poorly fossiliferous sedimentary sequences can potentially be dated and correlated by detailed examination of contained trace fossils. Such an approach has been widely applied to many such sequences in England, Wales, southwest Europe and the Metiterranean region, particularly those of Cambro-Ordovician age. In particular, these sequences have been dated by perhaps the most useful of all trace fossils in stratigraphy, trilobite-produced species of *Rusophycus* and *Cruziana*. To date, however, the ichnostratigraphic paradigm developed in Europe has not been successfully applied to any coeval succession in North America.

On Bell Island, Conception Bay, eastern Newfoundland, the ?Cambro-Ordovician sequence (Bell Island and Wabana Groups) of shallow subtidal siliclastics, contains a diverse, abundant and well-preserved trace fossil assemblage. Amongst this assemblage are spectacularly-preserved trilobite-produced trace fossils - *Cruziana* (furrowing traces). *Rusophycus* (resting traces), *Diplichnites* (walking tracks), *Dimorphichnus* (sideways grazing traces) and *Monomorphichnus* (swimming grazing traces). Detailed examination of the distribution of *Cruziana* species within the sequence has enabled a more accurate definition of the Tremadoc-Arenig and Lower-Upper Tremadoc boundaries than previous paleontological studies have permitted. The former is based on the final occurrence of *C. semiplicata*,, which is an Upper Cambrian-Tremadoc species, and the latter on the initial occurrence of *C. furcifera* and *C. goldfussi*, previously only reported from Upper Tremadoc and younger strata. It is suggested that the Tremadoc-Arenig boundary be placed at the 1200 m level within the sequence and the Lower-Upper Tremadoc boundary at 1020 m.

Structural evolution of the Quaco Head area, southern New Brunswick

A.G. Plint and H.W. van de Poll, Department of Geology
University of New Brunswick, Fredericton, N.B. E3B 5A3

Re-mapping of the Quaco Head area of southern New Brunswick has revealed a more complex structure than was previously recognized. The structure is dominated by two major thrust slices, separated by south and southeasterly-

dipping thrust planes. The lower thrust emplaces amygdaloidal basalts and bedded tuffs (?Precambrian, ?Devonian) over sediments of the Tynemouth Creek Formation (Westphalian A-B). Close to the thrust plane, the underlying sediments have been overturned towards the north. Resting unconformably on the upper surface of the basalt is a thin layer (<5m) of Windsor limestone (Visean; probably zone A or B) which is disconformably overlain by coarse, polymict conglomerates of inferred Hopewell/Canso Group age (Namurian). This sequence, which may be a few metres or tens of metres thick dips to the southeast at up to 50°. It is truncated by a major fault extending in a northeast-southwest direction and dipping southeast at 45°. To the southeast of the fault, lie thick-bedded Hopewell conglomerates, overturned towards the west and northwest, and dipping towards the east and southeast between 30° and 90°. These beds appear to be part of a large recumbent fold which was subsequently thrust over the lower, non-inverted limb. Folding and thrusting in the Quaco area was certainly post-Westphalian B and may be viewed as a local response to dextral strike-slip movement on the Cobequid Fault which is inferred to lie a few km to the south. Following Alleghenian/Hercynian deformation, the area underwent extensive erosion prior to deposition of a thick sequence of Triassic alluvial sediments (Quaco Formation). The upper thrust plane was reactivated as a normal fault during a phase of post-Triassic rifting along the Bay of Fundy (presumably related to early Atlantic rifting). During this period, blocks of the Triassic were downfaulted (100s or even 1000s of metres) against rocks ranging in age from ?Precambrian to Westphalian.

Regional bedrock geology of the Baffin Island Shelf

B. MacLean and G.L. Williams, Atlantic Geoscience Centre
Geological Survey of Canada, Bedford Institute of Oceanography
Dartmouth, N.S. B3J 2X1

During the last decade geophysical and geological cruises in Davis Strait and Baffin Bay have outlined the regional bedrock geology of the Baffin Island continental shelf.

On the southeastern Baffin shelf Precambrian metamorphic rocks form the bedrock adjacent to the coast. Lower Paleozoic carbonate rocks underlie much of the shelf between Frobisher Bay and Cumberland Sound and extend northward toward Cape Dyer. These rocks also occur in Hudson Strait and Frobisher Bay and may be present in Cumberland Sound. Sedimentary and volcanic rocks mainly of Tertiary age occur over much of the central and outer parts of the southeastern shelf. The stratigraphic section off Cumberland Sound has been disturbed by the emplacement of northeast-southwest trending subsurface ridge-like structures. Mesozoic strata on the southeastern Baffin shelf appear to be confined to the subsurface except where locally involved in structures such as those off Cumberland Sound.

On the northeastern Baffin shelf the presence of Paleozoic rocks beneath younger sequences shoreward of the continent-ocean transition zone has been suggested from seismic refraction results, but it has not been possible to confirm this by sampling. Upper Cretaceous (Senonian) marine sediments sampled at Home Bay and Buchan Trough occur extensively along the northeastern shelf beneath a variable cover of Lower Tertiary sediments.

Post-Ecocene erosion has bevelled much of the southeastern Baffin shelf and developed deep transverse troughs on the northeastern shelf.

The presence of an active submarine oil seep, recovery of samples of promising source rocks by seafloor sampling and exploratory drilling results indicate that conditions favourable for the generation of hydrocarbons have existed in the area.

Coal rank changes in the Sydney and Pictou coalfields of Nova Scotia: Cause and economic significance

P.A. hacquebard, Atlantic Geoscience Centre, Geological Survey of Canada
Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2

In eastern Canada the coalification is essentially post-deformational, resulting in a general increase of rank with depth in individual seams. However, within the confines of the Sydney Coalfield and between the Sydney and Pictou fields the rate of increase is not constant, signifying differences in geothermal gradients and/or thermal conductivity of the sediments.

In the Sydney Coalfield the Harbour seam shows variations in the coalification gradient of 0.032 to 0.046% Ro/100 m, which compares with a gradient of 0.052% Ro/100 m for the Acadia seam of the Pictou coalfield. Variable gradients were also obtained from sequences of separate coal seams cut in twelve boreholes, which in the Sydney field ranged from 0.050 to 0.086% Ro/100m. The highest gradient was obtained in the offshore Murphy *et al.* P-05 well, which is located over a pre-depositional high, where a higher plaeotemperature likely existed.

In addition to the vertical changes there are also regional variations in rank within one seam at the same depth. In the Sydney field an easterly increase of two V-types in rank over a distance of 48 km can be related to a difference in the original depth of burial.

This eastward shift in rank is economically important, because it means that high quality coking coal of medium volatile rank is reached at a depth of 700 m in the eastern part of the field, in contrast to a depth of 900 m in the central portion. The coal presently mined is high volatile "A" bituminous, and requires additions of low volatile American coal to produce coke of metallurgical quality. This low volatile coal, however, could also be obtained from the Acadia seam in the Pictou field, where it occurs between depths of 580 and 990 m. The Acadia reserve (comprising 14 million tons) is the only known low volatile coal deposit in eastern Canada.

Fluvial style and its influence on coal deposition in the Carboniferous Sydney Basin of Nova Scotia

B.R. Rust, G. Masson, S. Dilles, Department of Geology
University of Ottawa, Ont. K1N 6N5

M.R. Gibling, Department of Geology
Dalhousie University, Halifax, N.S. B3H 4J1

The abundance, thickness and quality of coals in fluvial deposits is strongly influenced by the nature of the river channel and floodplain systems. In the Morien Group (Westphalian C, D age) of the Sydney Basin, three fluvial facies assemblages have been recognized. The pebbly sandstone assemblage is characterized by trough cross-bedded sandstone, thin pebble-conglomerate units, and a paucity of mudrocks; *in situ* coal is absent but carbonized logs and thin coal lenses are common. The assemblage represents a moderately high energy braidplain. The sandstone assemblage contains sandstones (trough cross-bedded with some rippled and horizontally stratified units), thin granule-conglomerates, and about 10% mudrocks; thin coal seams are uncommon, coal logs and lenses are abundant. The assemblage represents a distal braidplain. The third assemblage, about 50% mudrocks alternating with fining-upward sandstone sequences, contains trough cross-bedded and rippled sandstones with large-scale lateral accretion sets. Significant coal seams are present, and erect trunks

are common within thin coarsening-upward units. The assemblage represents a meandering alluvial system, with *in situ* vegetation on levees and floodplains. The alternating assemblage was initiated earlier in the eastern part of the basin than in the west, but developed fewer, thinner coal seams at that time.

Paleocurrent studies indicate consistent northeastward transport through space and time. There is little indication of basement influence at present basin margins, implying that the basin formerly extended further to the southwest. A basement high along the Boisdale Anticline apparently influenced paleodrainage in the southern Boularderie Island area.

Geophysical modelling of salt masses and basement structures in the Moncton and Cumberland Basins

J.J. Chandra and T.C. Webb
Department of Natural Resources, Fredericton, N.B. E3B 5H1

Salt masses are usually characterized by distinctive gravity lows on Bouguer anomaly maps due to their negative density constrasts with surrounding rocks. Despite this rather unique feature, regional gravity variations due to large scale, deep-seated geologic structures as well as density effects caused by intra-basement lithologic variation tend to distort and obscure gravity signatures of salt masses and other smaller structural features. For this reason, it is necessary to remove these regional effects from observed gravity values in order to isolate and more clearly interpret the physical properties of the structural features in which we are most interested.

Several negative gravity anomalies, interpreted to be buried evaporites have been identified throughout parts of the Moncton and Cumberland Basins. Although some of these anomalies are no doubt related to Albert salt masses, gravity modelling studies were completed only for those anomalies interpreted to be associated with Windsor Group evaporites which locally contain significant potash deposits. These included anomalies at Smithtown, Salina, Cassidy Lake, Millstream, Plumweseep, Penobsquis, Anagance, Portage Vale, Five Points, and Pointe de Butte. Gravity coverage in these areas is considered adequate for the construction of two dimensional models.

Model studies indicate that most Windsor salt masses form elongate, semi-diapiric to lensoidal structures. Most appear to be influenced one way or another by faulting and/or topographic irregularities in the basinal floor.

Near Portage Vale, two distinct salt masses indicate a bifurcating of the "Windsor" depositional basin either by faulting or by the presence of an intervening basement high resulting in two separate, possibly interconnected basins. The regional gravity field in this area suggests a major upthrusted basement block which starts just northeast of Portage Vale and continues through Middlesex to Moncton.

Basal Windsor strata from all constructed models from Plumweseep to Portage Vale indicate a regional paleoslope of approximately 5 degrees to the northeast. This revelation may be of value in estimating the thickness of post-Windsor sediments in the eastern part of the Moncton Basin.