The Minimum Model of Glaciation in Maritime Canada: Three Strikes You're Out[1]

R. R. Stea and R. J. Mott[2]

The minimum model of late Wisconsinan glaciation in Maritime Canada evolved from the recognition of autonomous local glaciers into a concept of thin, Late Wisconsinan ice restricted to lowland terrestrial areas, ending up just offshore of the present-day land areas at the glacial maximum. The minimum model was based on three lines of evidence: radiocarbon dates on total organic carbon (TOC) from the offshore glaciomarine sequence and terrestrial lakes and a few marine shell dates, the absence of raised shorelines in the region and the lack of glacial indicators in highland areas (nunataks). The 0 "isobase" in the Gulf of St. Lawrence was considered as a proxy for the Late Wisconsinan ice margin.

Geological mapping on land and offshore since the 1980's has added a wealth of data to apply to this problem especially in the chronology of ice retreat. Offshore, a marine shell radiocarbon chronology has replaced the TOC age dates. Dating of glaciomarine deposits on the continental shelf of Nova Scotia has moved the Late Wisconsinan ice limit from just offshore to the continental shelf edge. Highland areas, formerly thought to be nunataks, were found to have an erosional and depositional record from Late Wisconsinan glaciers. The chronology of ice retreat on land is now based on a reliable wood radiocarbon chronology from nearly one hundred sites including lake basins and late-glacial buried organic sites. The new data has produced a deglaciation chronology several thousand years younger than predicted by the minimum model. The construction of the Sable Island gas pipeline across Nova Scotia has provided confirming evidence of a significant re-advance of glaciers in the Gulf of St. Lawrence region as recently as 10.5 ka.

Proponents of the former maximum ice model envisioned a Hudson's Bay centred ice sheet, but the field evidence in Maritime Canada for local glaciation is overwhelming. In essence the emerging new model is one of large, dynamic Appalachian ice caps, with emphasis on powerful ice streams in the Bay of Fundy and Laurentian Channel draining ice divides over the Magdalen Shelf and Nova Scotia. The significant buildup of glacier ice during the aborted Younger Dryas glaciation, lends credence to the Denton and Hughes marine shelf glacierization model, and suggests that the region is very responsive to climate change.

[1]Presented at the Canadian Geophysical Union Annual Meeting, Ottawa, Ontario, May 17, 2001.
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Evidence of the Younger Dryas Advance of a Shelf-based Gulf of St. Lawrence Glacier: An Analogue for Ice Sheet Inception in Maritime Canada?[1]

R. R. Stea and R. J. Mott[2]

In the summer of 1999, the Maritimes and Northeast Pipeline Company excavated a 3 m deep trench across northern Nova Scotia to host the Sable Island gas pipeline. The "great ditch" of Nova Scotia exposed a continuous transect of surficial deposits along a 237 km corridor. A late-glacial paleosol with preserved A horizon (peat and wood) was found buried under 2-10 m of surface till over a wide area of the pipeline route. Ten new sites were sampled and submitted for palynological analysis and radiocarbon dating. The A horizon peaty layer throughout the region is only a few cm thick, and consists mainly of herbaceous plant material with few large wood fragments. It is relatively flat and dips under the trench while the trench follows the gently undulating, fluted glacial topography. Fabric analysis in the reddish surface till, indicated a strong trend parallel to regional glacial lineations. Samples of large pieces of wood from two sites yielded radiocarbon ages of 10.9 ka (GSC-6435) and 10.8 ka (GSC-6419).

Previous to these finds only two localities were known to reveal till overlying peat, so the extent of Younger Dryas glaciers could not be clearly established. The regional till sheet in northern Nova Scotia that overlies the paleosol can be traced to ice-marginal glacio-lacustrine deposits near the Cobequid Highlands to the south, and ice-dammed glacio-lacustrine sediments along the east coast of Cape Breton Island. Glacial flow lines indicated by fabric, fluting and ice marginal deposits imply a YD ice cap centred on the wide continental shelf area of the southern Gulf of St. Lawrence. This marine shelf area was also a centre of outflow during the Escuminac Phase at the Late-Wisconsinan maximum.

Glacierization of Maritime Canada during the Younger Dryas proceeded simultaneously in the uplands and offshore shelf areas by concomitant upland snowfield and lowland aufeis accretion with small remaining outliers of Late Wisconsinan ice acting as "seeds" for incipient glaciers. Ice-advance glacial lakes that developed during the Early Wisconsinan in Maritime Canada suggest the development of similar lowland-based ice masses, before the onset of regional glaciation. The Younger Dryas in Maritime Canada in essence, represents an aborted glaciation. Please view our website for photos and a description of the trench discoveries http://www.gov.ns.ca/natr/meb/field/ditch.htm#ditch

[1]Presented at the "Glacial Inceptions" Conference, Iore Sweden, June 20-25, 2001.

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Hidden Cretaceous Basins in Nova Scotia[1]

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Early Cretaceous unconsolidated quartz sand and kaolinitic clay deposits in the lowlands of Nova Scotia are preserved in narrow half-grabens obscured by glacial drift. The Chaswood Formation sediments can be subdivided into three members; upper and lower members dominated by cyclical sand-mud facies of fluvial origin and the middle member with lignitic clay of lacustrine origin. Ferruginous oxisols are common in the fine-grained facies of the upper and lower members. Seismic data indicate that Chaswood Formation strata in the Elmsvale Basin are deformed into steeply dipping faults and fault-related folds (Rutherford Road Fault Zone). An Aptian-Albian age for this tectonic event is inferred from synsedimentary deformation and from the angular unconformity spanning the Late Cretaceous and Tertiary that truncates the Chaswood Formation. Exhumation of a thick cover of Mesozoic sediment (1-2 km) is needed to account for the preservation of Chaswood Formation outliers after ~80 Ma of erosion. The half-grabens which host the Chaswood Formation were formed in the Mesozoic and were antecedent to the present day structurally-controlled lowlands.

[1]Presented at the Canadian Institute of Mining, Metallurgy and Petroleum conference, Halifax, Nova Scotia, October 2001.
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Stratigraphy and Structure of the Horton Group in the Lochaber-Mulgrave Area, Nova Scotia[1]

P. J. Ténière[2], S. M. Barr[2] and C. E. White

A detailed stratigraphic and structural study has been undertaken of sedimentary rocks in the Lochaber-Mulgrave area of northern mainland Nova Scotia. The sedimentary sequence in this area is bounded on the north by the Glenroy Fault and on the south by the Roman Valley Fault, and has been tentatively assigned to the Early Carboniferous Horton Group. It has been divided into three units (from oldest to youngest): (1) Clam Harbour River Formation, (2) Tracadie Road Formation, and (3) Caledonia Mills Formation. The Clam Harbour River Formation contains polymictic conglomerate, light grey to maroon quartz arenite and siltstone, and minor inter-bedded black laminated siltstone, and is interpreted to have been deposited in an alluvial fan-fluvial environment. The overlying(?) lacustrine Tracadie Road Formation consists of grey to black laminated siltstone interbedded with minor quartz arenite and pebble conglomerate. The overlying(?) Caledonia Mills Formation consists of red to greenish-grey, massive to well laminated, siltstone and slate interbedded with minor pebble conglomerate, and is interpreted to have been deposited in a fluvial-lacustrine environment. Based on lithological similarities, the Clam Harbour River, Tracadie Road, and Caledonia Mills formations closely resemble the Creignish, Strathlorne, and Ainslie formations, respectively, of the Horton Group in western Cape Breton Island. However, the stratigraphic sequence appears opposite to that of similar rocks assigned to the Horton Group in the St. Marys Basin. In addition, the Caledonia Mills Formation closely resembles red siltstone exposed west of Lochaber that, based on fossils, has been assigned to the Silurian Arisaig Group.

In comparison to the Horton Group in other areas, the rocks in the Lochaber-Mulgrave area are highly deformed. The western part of the area has open to tight, upright to overturned, northeast- and northwest-trending folds with well-developed axial planar cleavage. The eastern part of the area has tight to close, upright, north-south-trending folds with moderately developed axial planar cleavage. The folded axial plane traces and the scattered cleavage orientations indicate that the area has undergone polyphase deformation and is much more structurally complex than previously thought. Possible complications in Horton Group stratigraphy in the Lochaber-Mulgrave area and its structural complexity may be related to interaction between the Avalon and Meguma terranes during their juxtaposition along the Cobequid-Chedabucto fault system.

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[1]*In:* Atlantic Geoscience Society Colloquium, Program and Abstracts, Moncton, New Brunswick, Feb. 9-10, 2001, p. 32.
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Tectonic Setting of Silurian Magmatism in Nova Scotia and New Brunswick[1]

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Over the past 15 years, various models for the evolution of the northern Appalachian orogen have suggested that Silurian volcanic and sedimentary units in southern New Brunswick, southern Nova Scotia, and the Antigonish and Cape Breton Highlands of northern Nova Scotia represent a Silurian overstep sequence. Although recent geochronological work has confirmed that these units are of similar early Silurian age (ca. 440 Ma - 430 Ma), mapping and petrochemical studies show that they have different petrochemical characteristics, and do not constitute an overstep sequence.

The Kingston terrane of southern New Brunswick consists of mainly felsic tuffaceous rocks intruded by comagmatic high-level granitic rocks. Both have yielded U-Pb (zircon) ages of ca. 438-435 Ma. Their chemical compositions indicate calc-alkalic affinity and emplacement in a continental margin volcanic arc. These rocks are similar in age, petrologic features, and inferred tectonic setting to volcanic and granitic rocks of the central Aspy terrane in Cape Breton Island, and direct correlation between these now widely separated units is proposed here. They are interpreted to represent a Silurian ocean-closure event between Late Proterozoic-Early Paleozoic peri-Gondwanan terranes. U-Pb dating has shown that volcanic rocks in the White Rock Formation of the Meguma terrane in southern Nova Scotia are of similar Silurian age, but they are a bimodal alkalic basalt-rhyolite suite formed in a within-plate continental extensional setting, and differ chemically from the arc-related Kingston-Aspy volcanic-granitic suites.

Silurian volcanic and fossiliferous sedimentary sequences in the Arisaig Group of the Antigonish Highlands are located in the Avalon terrane. Although published descriptions of their petrochemical features suggest that they formed in a continental extensional setting like that of the White Rock Formation, some chemical characteristics are distinct from those of the White Rock Formation, and the two units show little similarity in lithology.

Hence, we suggest that it is not valid to use these widespread Silurian units to infer that the various outboard terranes of the northern Applachian orogen were amalgamated by the Silurian.

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[1]*In*: GAC/MAC Joint Annual Meeting, Abstracts Volume 26, p. 160 and In Northeastern Section, Geological Society of America 36th Annual Meeting, March 12-14; *in* Geological Society of America, Abstracts with Programs v. 33, No 1: A-80.

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Geology of the Cape Porcupine Complex, Guysborough County, Nova Scotia[1]

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Varied igneous and metamorphic rocks termed the Cape Porcupine Complex form a prominent hill adjacent to the Canso Causeway. These rocks are situated in a strategic position in the configuration of tectonostratigraphic terranes in the northern Appalachian orogen. Hence this study was undertaken to describe the rock types that form Cape Porcupine, determine their age, and compare them to other "basement" rocks in northern mainland Nova Scotia and adjacent parts of Cape Breton Island.

A fault-bounded metasiltstone unit occupies the central area of the complex. The metasiltstone is typically well foliated with a strong north-trending subhorizontal lineation. A fault-bounded metavolcanic unit forms part of the eastern part of the complex, and consists dominantly of grey crystal to crystal-lithic rhyolitic tuff with phenocrysts of quartz, anorthoclase, and/or plagioclase. Like the metasedimentary unit, it is strongly foliated with a shallow, north-plunging lineation defined by stretched quartz crystals and lithic clasts. Granitoid rocks occur in both the western and eastern parts of the complex. In the west they include bodies of leucodiorite to tonalite, monzogranite to alkali-feldspar granite, and alkali-quartz syenite. In the east the granitoid rocks are dominantly alkali-feldspar granite with minor monzogranite. In addition, the easternmost granitic rocks locally display mylonitic fabric parallel to that in the metasedimentary and metavolcanic units. The Cape Porcupine Complex is intruded by several generations of variably altered mafic dykes. The complex is in faulted contact on its northern and western margins and unconformably overlain on its southern margin by Carboniferous sedimentary rocks of the Clam Harbour River Formation of the Horton Group.

The granitoid units in the Cape Porcupine Complex are Late Neoproterozoic, based on a U-Pb (zircon) age of 610±3 Ma from a syenogranite sample, and hence are similar in age to some granitoid units in southeastern Cape Breton Island and to the Georgeville Pluton in the Antigonish Highlands. However, analysed samples from Cape Porcupine are chemically distinct from the Georgeville Pluton and appear more similar to the felsic components of ca. 620 Ma calc-alkaline plutons of the Mira terrane. The ages of the associated metasedimentary and metavolcanic units are uncertain. The mylonitic units in the Cape Porcupine Complex provide direct evidence for the existence of the Canso Fault and indicate that it is a major pre-Carboniferous, north-south trending feature, and not parallel to the present-day Strait of Canso.

[1]*In*: Atlantic Geoscience Society Colloquium, Program and Abstracts, Moncton, New Brunswick, Feb. 9-10, 2001, p. 34.
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New Insights to the Geology of the Southwestern Meguma Terrane, Nova Scotia[1]

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A detailed mapping project in the Meguma terrane, from Digby to Shelburne, was initiated in 1998 by the Nova Scotia Department of Natural Resources to produce a series of updated, 1:50,000 scale geological maps of the area.

The oldest units in the map area are the Cambrian to Ordovician Goldenville and Halifax formations. The Goldenville Formation consists mainly of grey metasandstone interlayered with minor metasiltstone, slate and conglomerate. Trace fossils are common in one regionally extensive metasiltstone layer. The overlying Halifax Formation has been divided into three members; Bloomfield, Acacia Brook-Cunard, Bear River-Sissaboo River. These units consist of varying amounts of black to grey and green to maroon slate with minor metasiltstone and metasandstone. Early Tremadocian graptolites have been recovered from of the Bear River member. $^{40}Ar/^{39}Ar$ detrital muscovite ages yield a provenance age of ca. 550 to 600 Ma for the Goldenville and Halifax formations.

The White Rock Formation in the Digby area disconformably overlies the Halifax Formation and consists of grey slate, metasiltstone, and a distinct (<30 m thick) quartzite layer. Late Silurian fossils have been collected near the top of the formation. Detrital $^{40}Ar/^{39}Ar$ muscovite ages indicate a ca. 500 Ma source area. In the Yarmouth area, this formation is in faulted contact with the Halifax Formation and is composed of metavolcanic and metasedimentary rocks, and intruded(?) by the granitic ca. 439 Ma Brenton Pluton. Geochemistry of mafic volcanic rocks indicate an alkalic affinity and a within-plate tectonic setting. The felsic volcanic and granitic rocks have some characteristics similar to within-plate A-type granites. A felsic volcanic unit yielded a U-Pb age of ca. 438 Ma.

Conformably overlying the White Rock Formation in the Digby area is the Early Devonian Torbrook Formation. It consists of grey, locally fossiliferous metasiltstone, slate, metasandstone, marble, and rare ironstone.

Numerous mafic sills intrude all above units and, along with the stratigraphic units, were deformed during the Devonian Acadian Orogeny into regional NE- to NNE-trending, moderately plunging folds with axial planar cleavage. Metamorphism was at greenschist facies; however, in the southwest, metamorphism reached amphibolite facies and was accompanied by ductile deformation. The ca. 370 Ma South Mountain Batholith and related plutons produced andalusite- and cordierite-bearing contact metamorphic aureoles that overprint regional fabrics. $^{40}Ar/^{39}Ar$ data suggest that the ca. 400 Ma Acadian Orogeny occurred immediately after deposition of the Torbrook Formation. A locally occurring intense post-Acadian crenulation fabric reflects regional deformation postulated to be related to Carboniferous aged shear zones.

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