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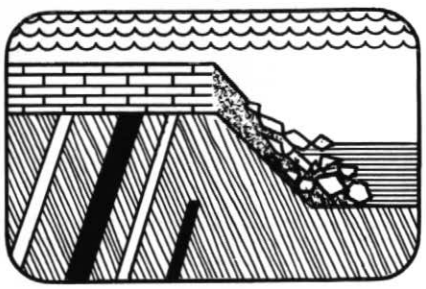

Taconic Orogeny and the Development of the Ancient Continental Margin of Eastern North America in Newfoundland

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For about 150 million years since the beginning of the Paleozoic, the western part of Newfoundland formed a segment of the ancient continental margin of eastern North America. The margin was initiated in the late Precambrian by rifting with accompanying thick clastic deposition and tholeiitic volcanism (Fig. 1). Possibly as much as 10 km of deep water turbidites accumulated locally at the thickest part of the continental rise prism.

A thinner sequence of rocks deposited in shallow water, locally supratidal, formed on the continental shelf from Lower Cambrian to latest Lower Ordovician (Fig. 2). These sediments thicken eastward and record an upward transition from immature arkosic sandstones to mature quartzites overlain by limestones and dolomites.

Rocks deposited at the morphological margin, between the shelf sequence and the thicker parts of the continental rise prism are now preserved above the shelf within the Humber Arm and Hare Bay Allochthons. These consist of turbidites, lime breccia beds with distinctive shelf-edge faunas (Fig. 3), and interbedded pelagic shales.

A reconstruction of the ancient continental margin in Newfoundland, compared with the present Atlantic margin of North America at Cape May, is shown in Figure 4.

The uppermost slices of the Humber Arm and Hare Bay Allochthons consist of ophiolite suites up to six km thick that are interpreted as oceanic crust and mantle. As such, they provide direct evidence that the Appalachian System evolved during a cycle of oceanic growth and destruction, rather than one of ensialic rifting. Similar ophiolites, in a more easterly belt above the now-metamorphosed continental rise prism, may be deformed and dissected erosional remnants of this same sheet. If so, then it was obducted across the ancient continental margin in the same way as the Semail Nappe of Oman and the Papuan Nappe of New Guinea. This simplistic view is contrasted with an alternate interpretation that relates each ophiolite belt to an equal number of small ocean basins at the ancient margin.

The width of the ancient ocean is unknown but the 150 million years between initiation and destruction of the ancient continental margin would suffice for the generation of a major ocean comparable in size with the present North Atlantic, itself initiated 150 million years ago in the Jurassic. The eastern margin of the Appalachians, on the eastern side of the inferred ancient ocean, may have evolved independently so that its present proximity to rocks of the ancient North American margin is due to the random interaction of wandering continents. It is also possible that the late Precambrian volcanism and rifting in the eastern Avalon Zone related to the initiation of the continental rise prism in western Newfoundland, and that the ancient proto-Atlantic formed only a small ocean behind a migrating micro-continent. Nonetheless, the evidence for an ocean basin to the east of a continental shelf is especially strong and the destruction of this

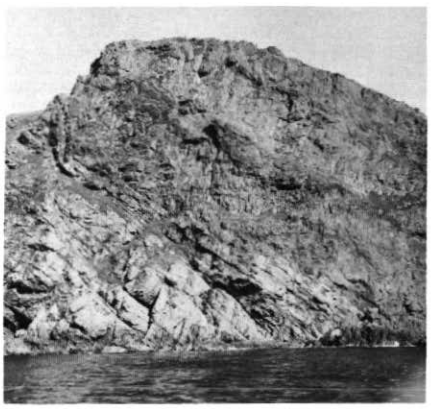

Figure 1
Late Precambrian plateau basalts above Grenvillian basement at the rifted ancient continental margin.

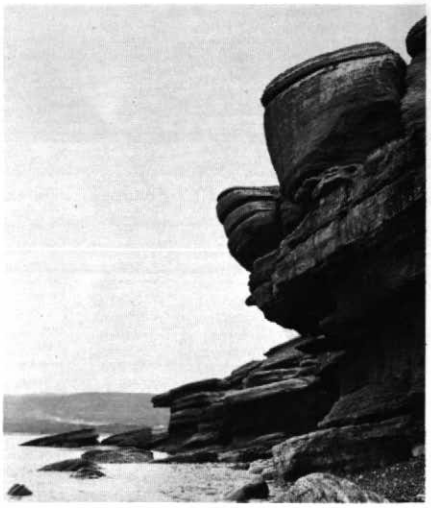

Figure 2
The carbonate shelf at the ancient continental margin.

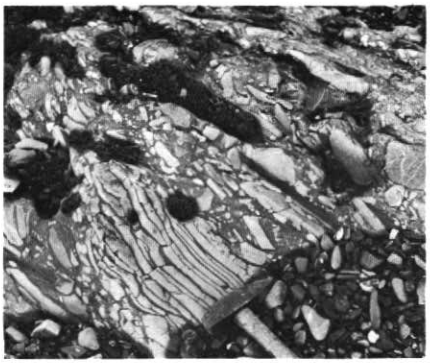

Figure 3
Limestone breccia off the edge of the carbonate bank at the ancient continental margin.

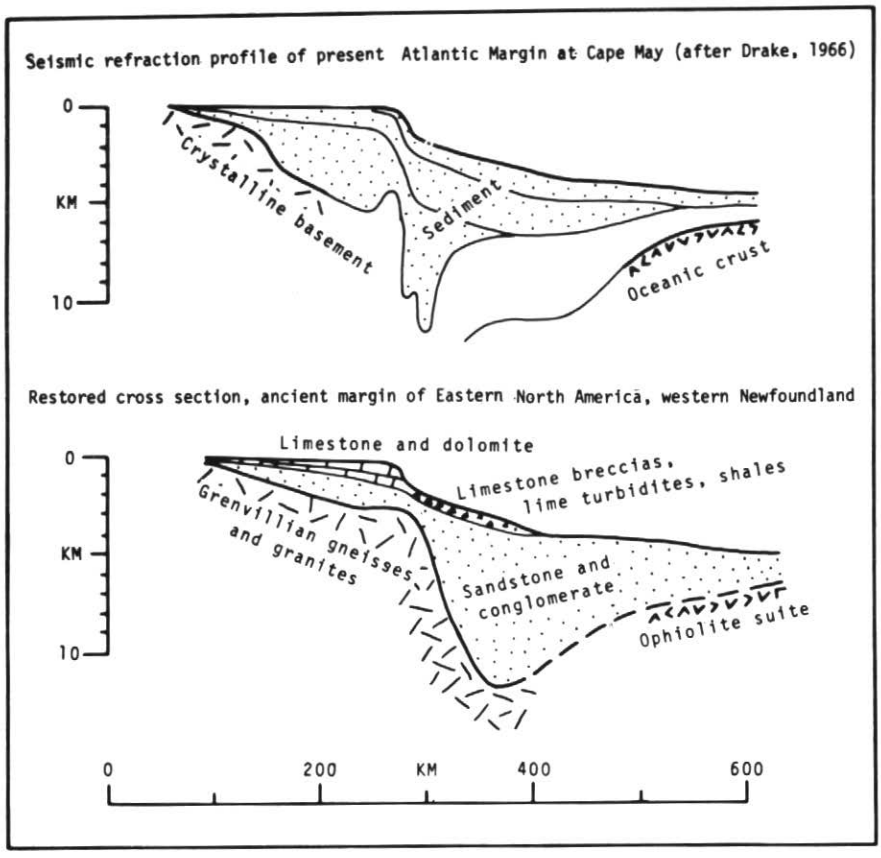

Figure 4
The ancient continental margin in Newfoundland, compared with the present Atlantic margin.

paleogeography during ensuing orogeny is similar to current processes at active plate margins.

Destruction of the ancient stable margin began towards the end of the Lower Ordovician and periods of deformation, intrusion and volcanism continued into the Carboniferous. In Newfoundland, the earliest phases of change, attributed to Taconic Orogeny, seem most profound.

The first indication of instability at the ancient margin was the upwarping of the carbonate shelf at the end of the Lower Ordovician. Karst topography, which developed at this time, provided an important site for base metal mineralization. Later subsidence is recorded first by the deposition of deeper water carbonates across the disturbed bank, then by a flood of clastic rocks bearing ophiolite detritus from the east. These were, in turn, structurally overridden by a sequence of contrasting rock assemblages in separate slices. The structurally lowest slices are comprised of sedimentary rocks from the continental margin and the highest slice of ophiolites represents farther travelled oceanic crust and mantle. The geometry of the slices and facies relationships indicate that the structural pile was assembled from the east, possibly through peeling of successively landward sections by the overriding oceanic lithosphere. A contact between the stratigraphic base of the ophiolite sequence and a metamorphic aureole of supracrustal rocks, now frozen into the wrinkled ophiolite slice, represents the actual zone of obduction where the hot oceanic plate moved across the continental margin (Fig. 9). The contacts of latest emplacement of the structural slices are marked by thin zones of shaly mélange with exotic blocks (Fig. 6). These are the result of mass wastage and tectonic mixing associated with gravity sliding.

Polyphase deformation (Fig. 7) and

Figure 5
Autochthonous conglomerates at the top of the shelf sequence in Northwest Arm were derived from, and overrun by the Hare Bay Allochthon (Photo courtesy of the Geological Survey of Canada).

Figure 6
Shaly mélanges with exotic blocks separate structural slices of the Hare Bay and Humber Arm Allochthons (Photo courtesy of the Geological Survey of Canada).

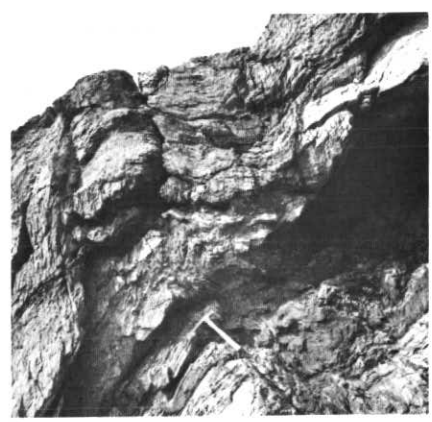

Figure 7
Cleavage associated with transport of structural slices (Taconic) was refolded after emplacement about steep axial surfaces (Acadian) (Photo courtesy of the Geological Survey of Canada).

metamorphism in the continental rise prism probably accompanied ophiolite obduction (Fig. 8) and an attempt to submerge the leading edge of the ancient continent along an eastward dipping subduction zone. Farther east a Lower to Middle Ordovician island arc is represented in Notre Dame Bay of central Newfoundland. There, thick calc-alkaline volcanics and associated volcaniclastic sediments are built upon oceanic crust. Possibly the transported ophiolites of western Newfoundland and Burlington Peninsula were once continuous with this same oceanic lithosphere, as suggested by a progressive increase in calc-alkaline rocks above the ophiolites from western Newfoundland through Burlington Peninsula to Notre Dame Bay. In this case the island arc formed above an eastward dipping subduction zone. Eastward polarity is further suggested by an increase in the potassium content of granitic rocks from central to eastern Newfoundland and a zone of discontinuous ultramafic bodies east of the central volcanic arc that may represent mantle diapirs.

Late Ordovician sedimentation records the infilling of the ancient central Newfoundland ocean, and terrestrial conditions were attained almost everywhere by the beginning of the Silurian. Acadian Orogeny records a compressive event across the system which in places was manifest until the Carboniferous.

The modern margin of eastern North America parallels the ancient margin from Newfoundland to Alabama and farther west where the Gulf of Mexico trends in unison with the Ouachita System. The modern margin therefore mimics the Early Paleozoic continental edge. In a similar fashion, the Early Paleozoic margin parallels the Grenville Structural Province and its subsurface extension to Mexico. The Early Paleozoic margin may therefore mimic a still older continental edge ancestral to the Grenville Structural Province.

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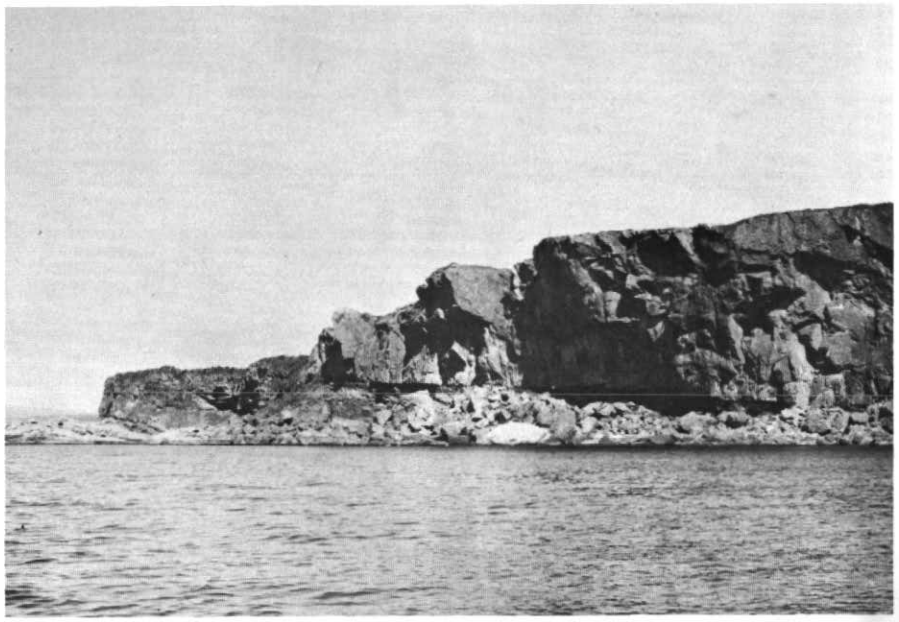

Figure 8
Subhorizonal ophiolite slice above continental rise greywackes of the Maiden Point slice, Hare Bay Allochthon (Photo courtesy of the Geological Survey of Canada).

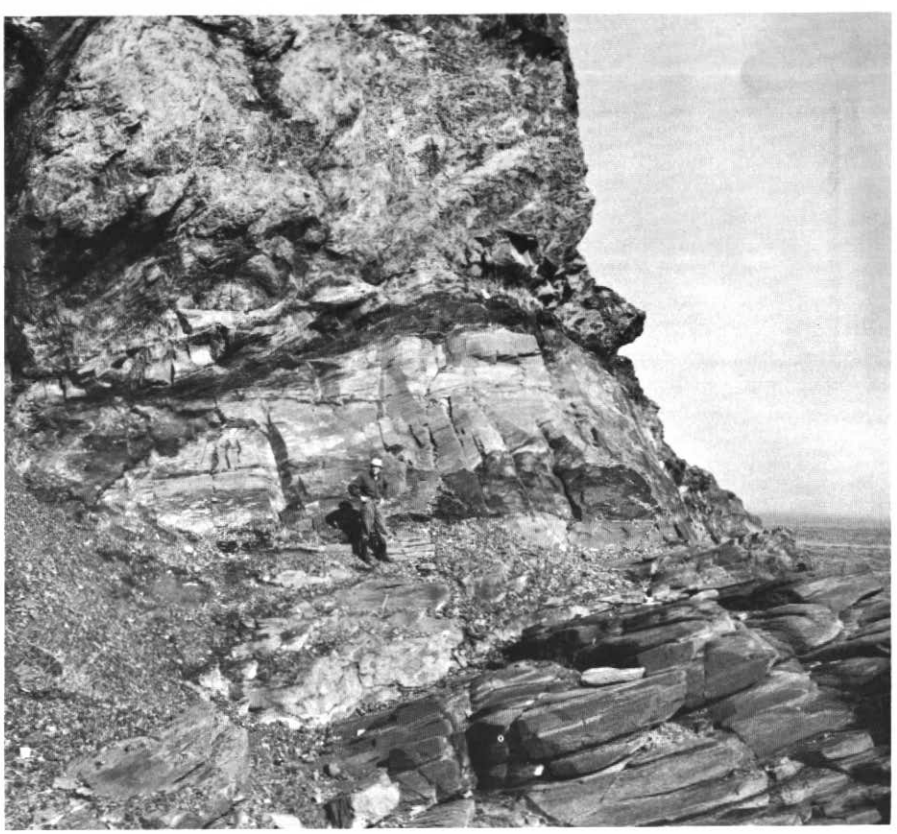

Figure 9
Subhorizonal schistosity and recumbent fold in basal ophiolite aureole relates to transport of hot oceanic crust and mantle across the ancient continental margin (Photo courtesy of the Geological Survey of Canada).