T2.6 THE TRIASSIC BASALTS AND CONTINENTAL RIFTING

In the long geological time period up to the end of the Carboniferous, almost all of Nova Scotia's geological units—the old crystalline rocks of the Avalon Zone and the folded slates and greywackes of the Meguma Zone, along with younger Devonian granites and Carboniferous limestones, salts, sandstones and coal—were assembled. All these were subjected to erosion under a hot, dry climate during the Permian and Early Triassic periods.

During the 150 million years prior to the Triassic Period, Nova Scotia occupied a central position in the interior of the supercontinent Pangea, which began to form in the Devonian Period and was completed by Late Carboniferous times. In Nova Scotia, the Permian Period was quiescent tectonically, with only erosion of pre-existing rocks occurring. During the Triassic, however, a new phase of crustal motion began. It eventually resulted in the break-up of Pangea into the present-day continents, and the formation of the Atlantic Ocean. But in many respects, the earliest manifestations of this tectonic event are the most significant for Nova Scotia, for at that time the last geological component was added: the Triassic–Jurassic

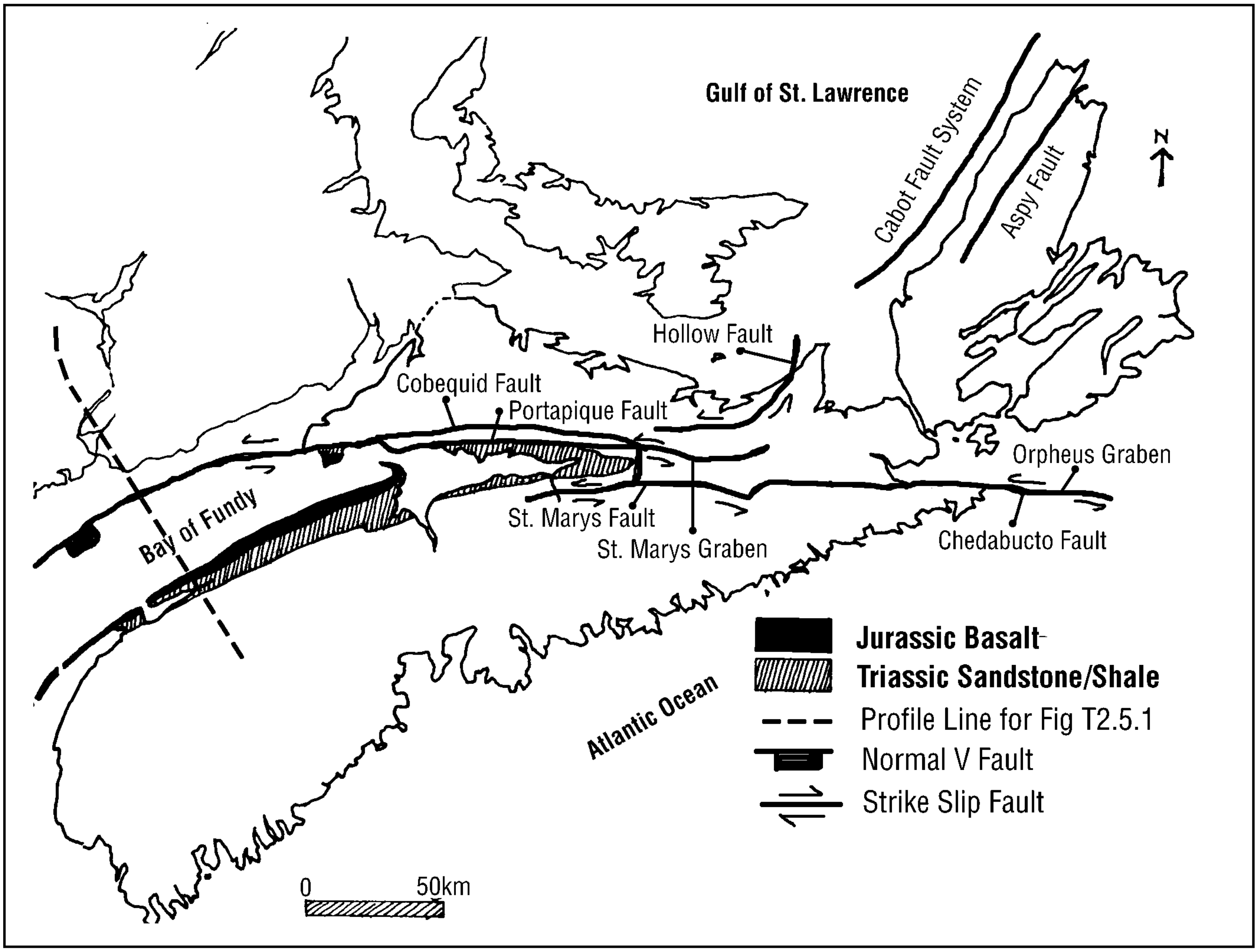

Figure T2.6.1: Major fault systems in Nova Scotia. The last major motion on any of these faults probably occurred during the Middle Jurassic, with the Meguma terrane (south of the faults) moving eastwards along the Cobequid-Chedabucto Fault system. Distribution of Middle Triassic–Early Jurassic rocks in Nova Scotia. The dashed line represents the approximate line of profile for Figure T2.5.1.

sediments and basalts. The basins into which these rocks were deposited became the precursors of the various important coastal features known today as the Bay of Fundy, Chignecto Bay, the Minas Basin and Chedabucto Bay.

CRUSTAL MOVEMENT BEGINS

Faults and Grabens

In the Triassic Period, Pangea began to break up again. The theory is that this occurred as follows. Heat loss from the mantle through the thin ocean floor is more rapid than through the thick continental crust, which acts as a blanket. Accumulation of heat expanded the continental crust, so that its surface was uplifted and the relatively brittle upper part was fractured. Upwelling currents in the mantle (mantle plumes) caused upraised blisters that broke into three rifts at 120 degrees to each other. (The Red Sea, the Gulf of Aden and the north end of the African Rift in Ethiopia would be a modern example.) Two of the rifts continued to widen, pulled apart by the movement of mantle material beneath the crust, and to extend to link with similar rifts above other mantle plumes, so building a lengthy rift system which eventually widened to become an ocean. The third rift permitted magma to reach the surface as volcanoes. The rift valley filled with volcanic rocks and with sediments eroded off its flanks, but it failed to open up. The Fundy–Chignecto Basin is considered to be such a "failed ocean."

In some cases the block of crust between two parallel faults dropped down, making a steep-sided valley-like depression called a graben. In Nova Scotia, half-grabens (downfaulted on only one side) were developed when Permian and older thrust faults and transverse faults were reactivated, such that the original compressive forces were released and extensional forces allowed the blocks to slide back down the fault plane[1] (see Figure T.2.5.1).

A series of such reactivated thrust and transverse (strike-slip) faults transected the province, and adjacent to these faults were formed several new sedimentary basins. These basins—the Fundy Basin, Minas Sub-basin and Orpheus Basin—presently underlie the Bay of Fundy, Minas Basin and Chedabucto Bay/eastern continental shelf, respectively (Region 900). Another branch of these faults may be represented by the Cabot Fault system (see Figure T2.6.1).[2,3]

These grabens gradually filled with thick sequences of continental-type sediments and volcanic rocks. The boundary faults remained as lines of weakness, however, and in the Cretaceous and Tertiary periods were exploited by erosion. They are now features of inland and coastal morphology.

VOLCANIC ROCKS—BASALTS

During this period of sustained tension, magma welled up some fractures adjacent to the sedimentary basins and either solidified as basaltic dykes and sills within the rock strata or was extruded at the surface as lava flows (see Figure T2.6.1). Several closely spaced fissure-type eruptive zones existed in the Bay of Fundy region, pouring lava out to cover eventually an area of at least 15 000 km^2. The basalts are Early Jurassic, with K–Ar ages of about 200 million years. [4,5] Onshore, the basalts of the North Mountain Formation have a maximum thickness of about 400 m, though they are estimated from seismic data to be up to 1000 m thick in the centre of the Fundy Basin.[1]

The volcanic rocks of the Fundy Rift system are continental-type basalts known as tholeiites. They now form, and are exposed along, the continuous ridge of the North Mountain (District 720), extending from Brier Island in the west to Cape Split in the east, in fault blocks along the north shore of the Minas Basin (District 710), on Isle Haute and on Grand Manan Island (New Brunswick).

The basalt at North Mountain is an erosional remnant. It is probable that the Great Dyke (from Pubnico to Sambro) also fed volcanoes, in which case basalt might have covered the entire mainland at one time.

Basalt Flows

At least seventeen flows have been identified in the Bay of Fundy area. They range in thickness from 1 to 60 m; most cover only a small area. All seventeen are exposed northeast of Digby Gut, but to the southwest along Digby Neck only two very thick ones are found. These two are separated by a layer of more easily eroded rock, which forms a valley down the centre of the Neck and out onto the islands.

When thick lava flows cool and contract, six-sided vertical joints form, which divide the flow into columns (columnar jointing). If these columns are undercut at their base by the sea, they tend to fall like chimneys. Cliffs formed by these flows, therefore, tend to be high, vertical and with a wave-cut platform at the base. Coastal features related to such columnar basalt are well displayed at many points along the southern Fundy shore from Cape Split to Brier Island, at Five Islands Provincial Park and at Partridge Island near Parrsboro (District 710).

Mineralization

As the lavas cooled after extrusion, escaping gases were trapped in the rock and formed cavities into which various minerals were precipitated; filled cavities are called amygdules. The minerals include agate, amethyst, jasper, calcite and many members of the zeolite family. At some locations, small deposits of native copper and magnetite are found in fracture zones within the basalts. Agate and jasper can be found as pebbles and cobbles along the beach at Scots Bay, and zeolites occur at various localities along the Fundy shore. (For an extensive listing of minerals found in the basalts and the location of their occurrences, see Sabina.[6])

Sills and Dykes

A sill is a layer of magma which was injected in between two layers of strata and therefore lies parallel to them. In Colchester County the basalt near Five Island Provincial Park is very fine grained and does not contain amygdules. It may, therefore, not have been extruded as lava, but injected between the Wolfville sandstone and the Blomidon shales as sills.

Dykes crosscut the sedimentary banding and structures, occupying the tensional fissures produced during the rifting process. In southern Nova Scotia, basalt is found in small dykes in the Yarmouth area and in the Great Dyke of Nova Scotia—a feature that runs from Pubnico 150 km eastwards to just off Sambro near Halifax Harbour.

MORPHOLOGY OF THE TRIASSIC–JURASSIC AREA

At some time during the Middle to Late Jurassic Period, sediments within the rift basins were tectonically disturbed through the reactivation of the basin-bounding faults and the formation of new ones. The principal strike-slip faults parallel the Colchester/Cumberland shore south of the Cobequid Highlands, but new splays from these faults developed and had a northeast orientation. The blocks of strata between these faults were thus shifted and tilted and now form the irregular hilly topography along the north shore of the Minas Basin from about Great Village to Five Islands. Further to the east, around the Minas Basin and into the Truro area, undisturbed and relatively flat-lying Middle Triassic deposits of the Wolfville Formation form coastal lowlands.

On the south side of the Bay of Fundy, the sandstones, shales and basalts gently sag down to form a spoon-shaped basin or syncline, with an axis that plunges towards the west. The trough of this gentle fold can be seen in the hook of Cape Split. The south side of North Mountain is truncated by a sharp scarp slope, behind which the soft Wolfville and Blomidon formations have been eroded to form the Annapolis–Cornwallis Valley.[7]

CONTINENTAL SEPARATION

When the continents finally separated in the Early Jurassic, the split did not occur along the lines of the early tensional features but further to the east, beyond the edge of the present continental shelf. Thus, the Meguma rocks which had originally been a margin of Gondwana were left behind on the west side of the Atlantic Ocean, and sutured to eastern North America.

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Associated Topics

T2.1 Introduction to the Geological History of Nova Scotia, T2.2 The Avalon and Meguma Zones, T2.5 The Nova Scotian Desert

References

1 Wade J. and D. Brown (in prep) "The Triassic-Jurassic Fundy rift system—A synthesis." *Bulletin of Canadian Society of Petroleum Geology*.

2 Stevens, G.R. (1980) Mesozoic Vulcanism and Structure—Northern Bay of Fundy Region, Nova Scotia. *GAC/MAC Field Trip Guidebook* No. 8. Department of Geology, Dalhousie University, Halifax.

3 Colwell, J.A. (1980) Zeolites in the North Mountain Basalt *GAC/MAC Field Trip Guidebook* No. 18. Department of Geology. Dalhousie University, Halifax.

4 Wark, J.M., and D.B. Clarke (1980) "Geochemical discriminators and paleotectonic environment of the North Mountain basalts, Nova Scotia." *Can. J. Earth Sci.* 17.

5 Hayatsu, A. (1979) "K-Ar ischron age of the North Mountain Basalt, Nova Scotia," *Can. J. Earth Sci.* 16: 973.

6 Sabina, A.P. (1964) Rocks and Minerals for the Collector: Bay of Fundy Area. Geological Survey of Canada, (*Paper* 64-10).

7 Roland, A.E. (1982) *Geological Background and Physiography of Nova Scotia*. Nova Scotia Institute of Science, Halifax.

Additional Reading

- Brown, D.E., and R.G. Grantham (1992) Fundy Basin Rift Tectonics and Sedimentation. *GAC/MAC Field Trip Guidebook A*-3.

