Grand Manan Geology from the Sea

The best places to see the rocks that make up the island of Grand Manan are along the shorelines, which have almost continuous exposures as eroded by the sea. Although a geologist or mineral collector must walk along the beaches to examine things up close, it is much easier to travel on a boat cruising along the shores, where you can see the "big picture" of rock formations and structures. We are lucky to have several boat and kayak touring companies that take people out.

Grand Manan geology has been studied in a rigorous way by field geologists only since the late 1990s. This work has been helped a lot by some new radiometric dates that nail down ages for several key rock formations. Names for the various formations have been assigned too, usually based on locations that are especially good "type localities." The simplified geological map (page 3) shows some of these names and areas where we think the formations exist under the island soil, as well as along the shorelines.

Western Rocks

Grand Manan has a "split personality" regarding its physical geology. The western 2/3 of the island shows thick lava flows of Early Mesozoic age called the *Dark Harbour Basalt*, which are little changed from when they cooled at the end of the Triassic Period. They are part of the enormous "flood basalt" that underlies most of the Bay of Fundy, which erupted 201.4 million years ago.

The Dark Harbour Basalt is divided into three sections, or members, something like a cake with several thin layers of frosting in the middle. At the bottom is the *Southwest Head Member*, a single massive flow which forms cliffs up to 100 meters high along much of the western shoreline. As it slowly cooled in a huge lava lake, vertical columns formed from bottom to top. Above this the *Seven Days Work Member* is comprised of 12 to 14 lava flows each a few meters thick. Many interesting minerals crystallized in old gas bubbles in the cooled lava. Above the flows is the *Ashburton Head Member*, a massive lava flow at least 70 meters thick at the top of the basalt. The upper two basalt members have been removed by erosion from many western areas of the island.

Eastern Rocks

The Mesozoic formations rest upon a surface of much older metamorphic rocks, the nature of which is not so easily understood where they lie several kilometers beneath the basalts. But on Grand Manan, these "basement" formations are also at the surface of the low-lying eastern third of the island. This is due to vertical movement along a great fault that runs from Red Point (where it is well exposed) northward to Whale Cove (where it is covered), and far out to sea in both directions. The ridge just west of our highway from Seal Cove to North Head is held up by *Dark Harbour Basalt* along this fault. The *Red Point Fault* must have caused many Jurassic earthquakes, but it has probably been quiet since Mesozoic times, so not to worry if you live near it.

The metamorphic formations are organized into groups called *Castalia Group, Ingalls Head Group*, and *Grand Manan Group*, along with plutonic masses such as *Stanley Brook Granite, Rockweed Pond Gabbro*, and *Kent Island Granite*. They are now known to range in age from about 618 to 535 Ma (Ma is mega-annum or millions of years). Many folds and faults have bent and broken the formations into tortured-looking outcrops.

The continent in eastern North America is assembled from many sections of crust that contain different rock types with different geological histories, called *terranes*, which must have formed in other areas of the planet before being moved here along plate tectonic faults. Geologists are still comparing our Grand Manan rocks to terranes on the mainland of New Brunswick and Maine.

Recent Materials

Near the end of the Ice Age (the *Pleistocene Epoch*) about 14 thousand years ago, sea level was almost 130 meters (400 feet) lower than now, and Grand Manan was part of a high area on a large dry piedmont extending far from the shoreline. Even areas now far offshore such as the Grand Banks were land, possibly with some icy lakes. As the climate warmed more continental glaciers melted, the ocean rose into the Bay of Fundy, and Grand Manan became an island. The melting ice dropped a blizzard of stones, silt, and sand carried from the mainland in Maine and New Brunswick, as every island gardener knows all too well. Many of the colorful stones along the beaches have fallen out of this layer that we call *till*, which exists almost everywhere beneath the soil.

Key to Features on the Map

A. Stanley's Beach. At the southern end of the beach are gray to green quartzite and schist of the *Flagg Cove Formation*, which might also be earliest Cambrian in age (550 Ma). The layers are bent and twisted, showing the effects of at least one tectonic mountain building event or orogeny. Pinkish "*Stanley Brook Granite*," now metamorphosed into granitic gneiss, cuts these rocks a little farther south and has a radiometric date of 535 Ma.

B. Pettes Cove. The ancient rocks of this cove are mainly graphite schist and phyllite of the *Thoroughfare Formation*, which is Ediacaran in age, or around 620 Ma. This rock formed from carbon-rich mud on a sea floor in the Earth's southern hemisphere and was moved here by slow plate motions during the past half-billion years.

C. Swallowtail Head. Swallowtail Head is made of "greenstone" or metamorphosed lavas perhaps 540 Ma (Early Cambrian), of the *North Head Formation*. The footbridge crosses a rusty volcanic intrusion or dike that might be Early Triassic in age, and which is eroding to make The Sawpit. A Mesozoic fault in the northern side of Pettes Cove separates these rocks from the Thoroughfare Formation.

D. Hole in the Wall. The *Fish Head Formation* is also thought to be Early Cambrian in age, possibly around 540 m.y. old. It is made of meta-gabbro, a plutonic rock that has been metamorphosed to a "greenstone" or fine-grained rock with green mica and epidote. East-west fractures in the have eroded on the western side of Fish Head to leave a wall of rock standing out into Whale Cove, and its lower section has also been eroded to produce a large hole. The result looks a bit like a flying buttress on the side of an old cathedral, or one of the natural bridges we may see out west.

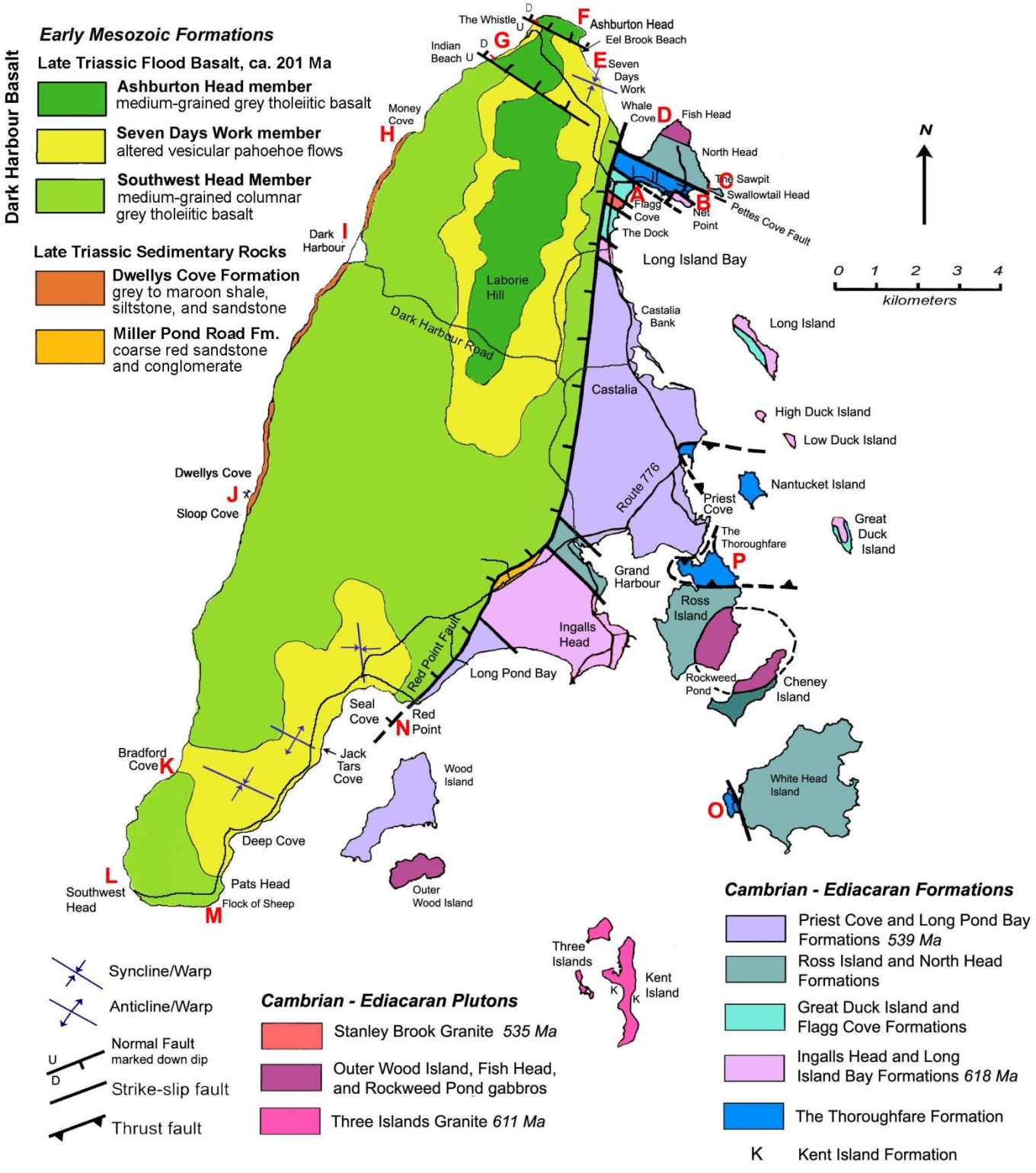
E. Seven Days Work. The cliffs west of of Whale Cove show layers called *Seven Days Work*, which are Triassic lava flows in the middle of the *Dark Harbour Basalt*. There are actually about 14 flows here, with vegetation marking some of their surfaces. Each flow took some months or years for their lava to harden, and they stayed hot for many years afterward. This is also the best mineral collecting beach on Grand Manan, especially for zeolites and agates that filled the lava's gas bubbles (beware of rock falls!). The *Red Point Fault* runs under Whale Cove to north and south.

F. Ashburton Head is another very thick basaltic lava flow, with columns that are bent and broken by later tectonic forces. A fault wraps around Northern Head and can be seen at Eel Brook Beach and in the cliff just east of The Whistle, where it separates the thin *Seven Days Work* lava flows from this much more massive *Ashburton Head Member*.

G. The Gully Beach. Cliffs of *Dark Harbour Basalt* run along the entire western side of the island. The thin lava flows of the *Seven Days Work Member* continue along this section but change abruptly at a fault in the cliff face toward Indian Beach, just SW of The Gully. From here south are broken colonnades of *Southwest Head Member*, the thick (110 meters) lower lava lake that

GEOLOGICAL MAP OF GRAND MANAN

simplified from Fyffe, L.R., Grant, R.H., and McHone, J.G., 2011
Bedrock Geology of Grand Manan Island
New Brunswick Department of Natural Resources, Plate 2011-14



covered low areas of this region. Geologists use the name *talus* for the piles of broken basalt along the base of the cliffs.

H. Money Cove Head. The *Southwest Head Member* of *Dark Harbour Basalt* flowed upon horizontal layers or strata of shale and sandstone of the *Dwellys Cove Formation*. These sedimentary rocks are visible at many places above the beaches between here and Sloop Cove.

I. Dark Harbour. Exactly why there is a harbour here is not geologically clear, but a special feature is its large sea wall of basalt boulders and cobbles, which create and shield the harbour's pond or lagoon. It takes a strong current to move and pile up such big stones.

J. Dwellys Cove/Sloop Cove. Between these two shallow coves is a copper prospect in the form of two tunnels, which around 1870 were dug into the Dwelly's Cove shale directly beneath the basalt. There is not much copper here, but it continues to attract interest. The tunnel entrances were covered over for safety reasons.

K. Bradford Cove. An outlier of Seven Days Work basalt is visible where some lava flows form a volcanic arch called a *tumulus*, due to pressure from lava pushing up under it.

L. Gull Cliffs. The lower member of the *Dark Harbour Basalt* is the *Southwest Head Member,* which forms most of the spectacular cliffs along the western shoreline (here about 60 meters high). The basalt was part of a giant lava lake that poured from fissure volcanoes along what is now coastal Maine and New Brunswick, filling the Fundy Basin up to 1000 meters deep about 201 million years ago. As it cooled and hardened, the lava shrank and cracked to make these vertical polygonal columns, called a colonnade.

M. Flock of Sheep. Thin layers of glacial till lie between the solid ledges and organic soils of Grand Manan, and in this area the till has boulders of light-gray granite. They are perched on the low cliff at just the right height for storm waves to wash out smaller rocks while leaving behind the pale boulders, which from the sea resemble a "flock of sheep."

N. Red Point. This point and shoreline to the north are made of the *Long Pond Bay Formation* of Cambrian age, which here are argillites (metamorphosed siltstone). The famous *Red Point Fault* is well exposed, the same fault that runs north to Whale Cove and separates western Triassic basalt from the much older eastern formations. The fault moved about 3 kilometers vertically, with a series of earthquakes over millions of years in the Jurassic Period. Friction or drag from the fault movement has bent and broken the basalt columns, which originally were nearly vertical.

O. White Head. White quartz veins are common in the *Thoroughfare Formation* at its various exposures from Net Point to Ross Island, and at this high area of White Head Island. If you look closely you might see small white sand grains that have been fused together, while gaps and cracks reveal glittery crystal faces. From the sea, this head of snow-white quartz is a fine landmark and visible from a great distance.

P. The Thoroughfare and the eastern lowlands. Except for a few headlands along faults, the eastern shoreline is remarkably low and level. The various old and hard metamorphic rock formations along the eastern side of Grand Manan ought to make the coast much more rugged, like other shorelines of New Brunswick. I think our eastern landscape was flattened by erosion during the Triassic Period, and the ancient surface was preserved in its flat state because it was buried by our Mesozoic strata and lava flows. The last remnants of those layers have only recently been eroded away, so in fact, we live on a 220 million year old "fossil landscape."

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