25. At the Edge of an Ancient Ocean

Sedimentary Rocks, Features, and Fossils at Grand Ledge Eaton County

"The Pennsylvanian outcrops in the vicinity of Grand Ledge are the most extensive Michigan, and this area is the logical place from which to start a detailed study..." Kelly, 1933

The rocks at Grand Ledge are significant for several reasons. Grand Ledge is an "oasis" of bedrock in an "ocean" of glacial drift that blankets the Lower Peninsula, providing geologists a window into the distant past. The diverse set of sedimentary rocks contains a wealth of information on the plants and animals that dominated the Pennsylvanian Period, about 320 to 290 million years ago. The characteristics of the rocks allowed geologists to reconstruct the changing environment that marked the demise of a great inland ocean. The rocks have been quarried and hold economic value. Lastly, Grand Ledge is scenic and enjoyed by hikers, paddlers, and climbers.

Nearly all students of Michigan geology make a pilgrimage to Grand Ledge at some point in their careers. Good exposures of sedimentary rocks are rare in the Lower Peninsula. Not only are the rocks well exposed but they offer an opportunity to test your skills in identifying a variety of sandstones, some shale and limestone, and even

coal. The rocks are exposed in a few abandon quarries and in exposures along the Grand River. To get a good look at the rocks you will need drive between exposure north and south of the river. But don't be discouraged; the distances are short.

[Illus. 25.1] (Insert Adobe: Grand Ledge map.ai) Caption: Location of quarries and significant rock exposures at Grand Ledge.

As always in geology, the best place to start is at the base of the stratigraphic section, the oldest rocks. The lower part of the section contains shale, siltstone, and type of sandstone called greywacke. The shale is gray and so fine-grained that you cannot see the mud-sized particles that compose it. If you are brave, you might put a tiny piece in your mouth and push it around a bit. Shale feels smooth, almost creamy, a result of the mud. The shale is also soft and erodes to relatively gentle slopes. Shale is exposed at the base of the layers at the Face Brick Quarry. Think of the light-colored siltstone as a silty shale. You might rub the rock against your thumb and see if any small, visible grains come loose. Again, a taste test might be in order. Siltstone will leave a

gritty feel in your mouth. Siltstone is exposed at the base of the rock layers at the American Vitrified Quarry. The greywacke is a greenish-gray colored sandstone and the sand grains are visible to your unaided eye, no tasting required. With a hand lens you can see the rock is made of a mixture of sand sizes, what geologists call poor sorting, and a variety of sand compositions, including quartz, feldspar, mica, and fragments of pre-existing rocks. Greywacke is exposed just above the beach at the Face Brick Quarry.

[Illus. 25.2] (Insert Adobe: Grand Ledge rock columns.ai) Caption: Stratigraphic section showing the rocks at Grand Ledge. Based on Martin (1982).

[Illus. 25.3] (Insert photo: American Vitrified section.jpg)

Caption: Exposure of sedimentary layers at the edge of the abandoned American Vitrified Quarry, near the Nature Center in Fitzgerald Park. A layer of siltstone with iron concretions is below the coal. Interbedded very fine sandstone and shale are above the coal. Photo by William Neal.

The upper part of the section contains some shale, coal, limestone, and type of sandstone called arkose. Coal is easy to identify based on its black color, low density compared to the other sedimentary rocks, and ability to burn. Coal layers, or large pieces of coal ripped up from layers, can be seen at almost every location. Limestone is only found at the Face Brick Quarry. This limestone is black, a result of high organic matter content, and fizzes when a weak acid, such as vinegar, is applied. The sandstone layers near the top of the exposures are yellowish brown in color and made of about 70 percent quartz, 25 percent feldspar and 5 percent rock fragments. Geologists call sandstone with this composition an arkose. These sandstone layers also contain conspicuous cross-beds, layers in the sand that are inclined to the horizontal. Detailed measurements of the cross-bedding indicated the sand was moving to the northeast when it was deposited. Sandstone can be seen near the top of the stack of rock layers at almost every location. Cross-beds are most readily seen along the trail at The Ledges and the short trail up Sandstone Creek.

[Illus. 25.4] (Insert photo: Face Brick section.jpg)

Caption: Exposure of sedimentary layers at the northwest edge of the abandoned Face Brick Quarry. Note geologist for scale at bottom right.

Fossils are an integral part of the story at Grand Ledge. They tell us what life was like 300 million years ago and provide valuable clues in reconstructing the environments where the rocks formed. One of the most significant fossils is the brachiopod of the genera Lingulla. Brachiopods are filter feeding animals, protected by two shells, which lived on the bottom of shallow oceans. They were greatly abundant in the Paleozoic, with more that 12,000 known species, but only about 350 species remain today. Brachiopods are identified by a plane of symmetry that cuts each shell into a right and a left half; not to be confused with mollusks that are symmetric between the two shells. Lingulla are about an inch long, oval in shape, and the two shells are about equal in size. Looking closely, you might see growth lines on the shells. Unfortunately, the shale layers that contain Lingulla are in the Clay Products Quarry on private property and covered by water. The presence of Lingulla indicates the rocks that contain them formed in a shallow ocean environment.

Five casts of lungfish burrows were found in the Clay Products Quarry by a geologist from Michigan State in the 1960s. A cast refers to the filling of the original burrow. The casts of the burrows were found in the shale near the bottom of the quarry. Unfortunately, no remains of the lungfish were found. Lungfish are famous for their ability to survive dry spells by burrowing into mud and enveloping themselves in protective mucus. During this time they breathe through a modified bladder, not their gills. Three genera have survived to the present. How do geologists know that lungfish made these burrows? Similar burrows in slightly younger rocks contain fossils of lungfish. The burrows at Grand Ledge were 2 to 4 inches in diameter and nearly a foot and a half tall. When in use, the body of the fish was straight in the burrow with its tail at the base. You probably won't find a burrow but if you do it will be a great find. However, you might consider Grand Ledge's place in providing information about evolution. Based on similarities in lungs, nostrils, and limbs, most paleontologists think that lungfish were the ancestors to amphibians. The presence of lungfish burrows suggests the rock that contained them formed in a transitional environment, between marine and continental conditions.

Perhaps the most striking feature of ancient Grand Ledge would be the forest. Although similar in height, this forest was not of maple, oak, and pine. Growing to heights of up to 130 feet, club mosses such as Sigillaria and Lepidodendron dominated the forest. Stigmaria, the root systems of Sigillari, are well preserved at Grand Ledge. Calamites, super-sized horsetails, grew to 50 feet in height. Fronds of seed ferns filled the under story. Other seed-bearing plants, like Calamites, also flourished. The genera persisted to modern times but not in the giant forms of the past. Plant spores and pollen extracted from the shale indicated the area contained 36 genera and 63 species, enough to keep any botanist busy. You can find fossil ferns in the greywacke at the Face Brick Quarry. Stigmaria are best displayed at the Clay Products Quarry but can also be seen at the American Vitrified Quarry. A diorama of this forest is on display at the University of Michigan's Museum of Paleontology. The presence of tree fossils indicates that the rock containing them formed in a continental environment, a swamp cut by stream channels, perhaps as a delta extended into the ocean.

[Illus. 25.5] (Insert photo: Stigmaria at Am Vit.jpg)

Caption: *Stigmaria* fossils are common at several of the rock exposures at Grand Ledge.

[Illus. 25.6] (Insert photo: fern fossils.jpg)

Caption: Fern fossils are common in the greywacke near the base of the exposures at the Face Brick Quarry.

As noted above, geologists use numerous clues to determine the environment where the rocks formed. For example, the dark color of the shale indicated that the water was oxygen-poor, probably in a restricted basin. Freshwater clams in some shale indicated lake or ponds. The limestone indicates burial of the land by ocean. The general consensus among geologists converges on a near shore marine environment adjacent to a delta and floodplain. The presence of large channels filled with cross-bedded sandstones indicates the presence of shifting rivers. Cross-bedded sandstone is abundant along the Ledges and an impressive channel is located on the east side of Sandstone Creek. One of the original researchers at Grand Ledge noted four advances and retreats of the sea. It is the shifting of sea level, and thus the lateral movement of adjacent environments, that provided the diversity of rock types at Grand Ledge.

[Illus. 25.7] (Insert photo: channel.jpg)

Caption: channel or x-beds.

A shifting stream cut the channel exposed just above the geologist's head. The channel was later filled by inclined beds of sand.

The presence of coal should spark your curiosity. Unlike other fossil fuels, which form by the accumulation of microorganisms in marine environments, coal forms by the accumulation of large amounts of plant material. At Grand Ledge the source material was the luxuriant forests of ferns, club mosses, and horsetails. The material accumulated in the swamps and marshes of the deltas. Over time, as the organic layers were buried deeper, pressure compacted the material, driving out the water. An increase in temperature produced more complex hydrocarbons. As you examine the coal, look closely for the remains of the ancient plants.

The thin coal seams at Grand Ledge were mined from the 1870s to the 1940s. A mine near Tallman Road was active for over 60 years. Some mines were located near the river where miners could walk in until they intersected the seam and then mine it on an incline. A few mines were accessed

by vertical shaft. Coal of similar age underlies much of central Michigan and the state does have an interesting history of mining coal. Coal was extracted from numerous underground and a few surface mines in the Saginaw Valley from 1860 to 1949. Miners were typically extracting coal from a seam about 3 feet thick. At peak production, in 1907, about 2 million tons of coal was mined in Michigan. Why did production stop? From a geological perspective the coal was of low quality, the seams are thin and limited in their lateral extent, and there is just too much glacial material to remove. Labor strikes and the lower cost of importing coal from out of state led to a decline in mining in Michigan. In 1952, the last mine closed. But don't give up company stock just yet. Michigan contains about 100 million tones of coal that can be mined with present technology. In a state where one-quarter of our energy comes from burning coal, that's enough to meet our current coal needs for about three years.

The quarries at Grand Ledge were there for the clay in the shale. As early as 1859 the clay was used to make jugs, crocks, and household goods. By 1886, American Vitrified had opened a factory to make sewer and drain tile. Grand Ledge Clay Products opened in 1906 and made

conduits for underground telephones wires. They later switched production to agricultural drain tiles, chimney tops, and sewer pipe fittings. The Face Brick Company started in 1914 and focused on making bricks. The shale was transported to the factories where it was crushed, powdered, and then mixed with water. The soft clay was then formed into the various products and fired in kilns at 1860-1940 degrees F for 50 to 140 hours. The last company to shut down, Grand Ledge Clay Products, closed in mid 1980s, primarily due to greater utility of plastic pipe. The Grand Ledge Area Historical Society displays numerous photographs of the plant and describes its role in Grand Ledge. Their museum is at 118 W. Lincoln.

[Illus. 25.8] (Insert Adobe: CLPROD120x180.jpg)

Caption: The Grand Ledge Clay Products pipe factory in its heyday ca. 1920s. Photo used by permission of the Grand Ledge Area Historical Society.



Grand Ledge Clay Products

Where was Michigan when all this was happening? Reconstructions of plate positions show North America near the equator in the Pennsylvanian Period. The warm, wet climate promoted abundant vegetation and, in turn, coal deposits.

The shift from marine to continental conditions reflects an event of great significance. From the Late Cambrian through the Early Pennsylvanian, roughly 200 million years, the Michigan Basin was dominated by marine conditions, accumulating many thousands of feet of carbonates and shale. By the Late Pennsylvanian, the ocean had retreated, never to return to Michigan again.

The rocks at Grand Ledge are also the youngest exposed rock layers in the state. Younger, Mesozoic rocks have

been encountered in the subsurface by drillers seeking water or oil but these rocks are not exposed at the surface. Across the Michigan Basin the top of the layered rocks is marked by an erosional surface called an unconformity. The unconformity marks the gap in time during which no rock layers were deposited or any that were deposited were eroded away. In Michigan, a blanket of glacial material, less than one or two million years old, rests on the unconformity. The gap in time is hundreds of millions of years.

GETTING THERE:

The town of Grand Ledge is four miles south of I-96 on state route 100 and 11 miles west of Lansing on state route 43. Two exposures are north of the river. Oak Park, a popular destination for climbers, is at the end of West Front Street. Face Brick Quarry is now part of the town's Lincoln Brick Park. From state route 100 follow Main Street northwest for about one mile. The road then turns directly north and is called Tallman Road. Follow this well-maintained gravel road a quarter-mile north to the turn off for the park. A loop road leads to the main parking area and then follow the Tallman Trail south to the

quarry. South of the river the best place to start is Fitzgerald Park. From state route 100, also called Bridge Street, go west on state route 43 for just less than one mile. The park has a \$2 entry fee and provides a map of the walking trails. The best exposure of the American Vitrified Quarry is about 50 feet west of the Nature Center. Although the Clay Product Quarry is on private land you can stand on the park boundary and look into the quarry by following the Heron Hollow trail to the west. By walking east along the river from Fitzgerald Park on the Deer Run Trail you can see the cross-bedded sandstones and erosional channels.



25.3 American Vitrified section



25.4 face Brick Section



25.5 Stigmaria at Am Vit



25.6 fern fossil



25.7 channel