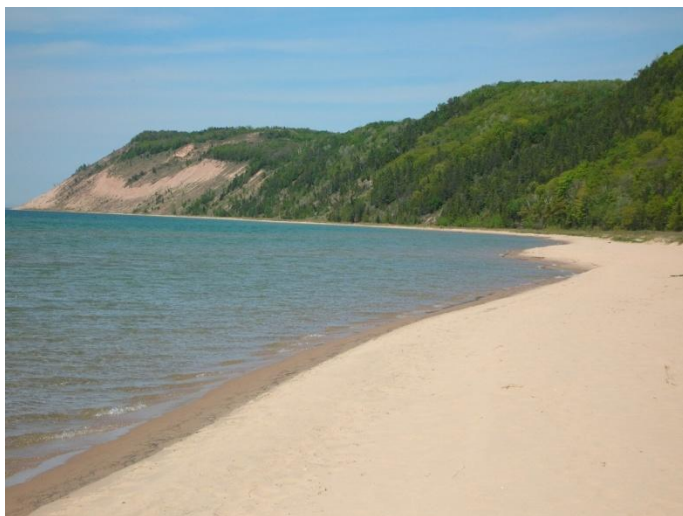


Geology

Sleeping Bear Dunes
National Lakeshore
Michigan



A Publication of
Friends of Sleeping Bear Dunes

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P.O. Box 545, Empire, MI 49630
www.friendsofsleepingbear.org
info@friendsofsleepingbear.org

Learn more about the ***Friends of Sleeping Bear Dunes***, our mission, projects, and accomplishments on our web site. Support our efforts to keep Sleeping Bear Dunes National Lakeshore a wonderful natural and historic place by becoming a member or volunteering for a project that can put your skills to work in the park.

This booklet was compiled by Kerry Kelly, ***Friends of Sleeping Bear Dunes***.

Some of the content for this booklet was taken from three different parts of the Sleeping Bear Dunes National Lakeshore web site www.nps.gov/slbe.

- Glaciers and Glacial Features
www.nps.gov/slbe/naturescience/glaciers
- Geology Auto Tour
www.nps.gov/slbe/planyourvisit/geologytour
- Geology Fieldnotes
www2.nature.nps.gov/geology/parks/slbe/index.cfm

Other content came from **Geology of Michigan** by John A. Dorr, Jr. and Donald F. Eschman, published by The University of Michigan Press, 1977.

Kerry Kelly provided the photos.

The geological features of Sleeping Bear Dunes National Lakeshore provide spectacular scenery unique to northern Michigan. The residue of the melting glaciers about 10,000 years ago left Lake Michigan bordered by moraine bluffs, hills & swales, and serene inland lakes. As time passed, the prevailing westerly winds blew the sand out of the moraine bluffs and piled it into perched dunes to create the Sleeping Bear Dunes that we enjoy today.

As you travel around Sleeping Bear Dunes National Lakeshore and northern Michigan, think about ice...

A lot of ice. Standing on the Lake Michigan beach at the base of the Sleeping Bear bluffs just north of North Bar Lake, you can look up to the observation deck on the Pierce Stocking Drive 450 feet above. During the last ice age the glaciers here were 7 to 10 times as high as those bluffs. The ice was a mile thick in some places!



Lake Michigan Overlook on Pierce Stocking Drive looking up from the beach.

The ice sheet covered more than half of the North American Continent including Minnesota, Wisconsin, Michigan and down into Iowa, Illinois, Indiana, and Ohio. It moved, it bulldozed, it scooped up huge Precambrian boulders and other rocks from the north and carried them here. It was so thick and heavy that it actually pressed down the Earth's crust! As the ice melted and with the earth's crust depressed from the weight of the glacier, huge post glacial lakes formed. Evidence of these lakes can be found in beach ridges, eroded bluffs, and flat plains located hundreds of feet above present lake levels.

Once the huge weight was removed from the melting ice, the earth's crust slowly rebounded. This uplift (crustal rebound) and the shifting ice fronts caused dramatic changes in the depth, size and drainage patterns of post-glacial lakes. Although the uplift has slowed, it is still occurring in this portion of Michigan. Imagine the power of the forces and the length of time it took to form the hills and valleys, shorelines, lakes, and streams you see today.

The last advances of the glaciers, the Port Huron and Valdres substages of the Wisconsin ice sheet, followed valleys carved out by the earlier, larger glaciers that dug out what are now the Great Lakes. These glacial ice sheets also left large piles of sand, gravel, and rocks creating the moraines and headlands such as Pyramid Point, Sleeping Bear Plateau, and Empire Bluffs. The moraines and valleys are generally oriented in a north-south direction consistent with the glacial flow. They steered more recent glacial ice (Wisconsin ice sheet) into lower areas and gouged them out even deeper creating what are now Lake Michigan bays (Good Harbor Bay, Sleeping Bear Bay, and Platte Bay) and inland lakes (Shell Lake, School Lake, Lime Lake, Little Traverse Lake,

Sleeping Bear Bay, and Glen Lake, Platte Bay, North & South Bar Lakes, and Platte Lake). Look at your map of the Park to see the pattern of glacially created bays and lakes.

The last of the glacial ice melted away from this area about 10,000 years ago. As the glaciers started to melt, huge blocks of ice like icebergs would break off from the receding glaciers and became surrounded and covered by gravel, sand and debris from the glacier. When these ice blocks melted, a great conical depression would form as the material covering the ice block collapsed. The huge depressions are called kettles, and there are several in the park.

The Great Lakes basins filled with melt water as the glaciers receded. As the ice rapidly melted from the ice lobe in Sleeping Bear Bay it could not flow north because of the remaining glacial ice. A river carried this water south from present day Glen Lake, along where M-22 is now, around Empire and finally into the Lake Michigan Basin by Otter Creek. You can see this glacial drainage channel, which is now dry, as it crosses M-22 at Stormer Road just south of Empire. You will get an idea of the immense volume of melt water it once carried.



Lake Michigan from the top of a coastal bluff.

Wave action over thousands of years, from Lake Michigan and other earlier, greater lakes that filled the basin, truncated the moraine headlands so that they now appear as great headland bluffs. This formed the steep sand and gravel faces so prominent at Empire bluffs, the Sleeping Bear bluffs and Pyramid Point. This process continues, especially during years of high water

levels in Lake Michigan, so that great masses of these bluffs occasionally collapse into the lake.

North Bar and South Bar Lakes near Empire are embayment lakes and on a grander scale, so are Glen Lake and Crystal Lake. The lakes were formerly bays of the higher Lake Algonquin, which preceded Lake Michigan. They were open to the larger lake, but were cut off by sand moving steadily along the shoreline as the lake receded. This action can be seen today along the Lake Michigan shoreline. The prevailing winds are from the southwest and generate waves that move north along the shoreline. With each wave, a small amount of sand is passed to the north, and the next wave does the same continually moving sand north along the beach. Larger storm waves move big shovel-full amounts of sand to the north – wave after wave. Eventually, the lower lake levels and the

moving sand builds up a barrier and closes off the bay creating a lake behind a ridge of sand. This is most obvious at North Bar Lake.

Some of the most prominent features in the park are the perched dunes. These are not ordinary beach dunes. They are high dunes perched on top of already high glacial moraines. The moraines are the great ridges of material that the glaciers pushed before them and then deposited when they halted and began to recede. As waves and wind along the lakeshore cut away the headlands of the glaciers, the wind blew the lighter sands higher up on top of the moraines. The heavier stones fell down toward the beach. This continual sifting process can be experienced on a windy day from the Lake Michigan overlook on the Pierce Stocking Scenic Drive. You will see and feel the sand blowing upward and you may carry some of it away in your eyes, ears and hair.



Perched Dunes at Lake Michigan Overlook

All of these awesome geologic forces happened over thousands of years. The Pleistocene Epoch, considered the Ice Age, may have lasted, according to geologists, 500,000 to 2,000,000 million years. The last great glacier that covered all of this land, the Wisconsin Ice Sheet, occurred 50 to 70 thousand years ago. This was preceded by earlier ice sheets during the Illinoian, the Kansan, and the Nebraskan ice ages. Each advanced and retreated over many thousands of years.

Sleeping Bear Dunes Geology Tour

Now that you have an overview of the geological activity that created this beautiful area, you may want to go out and see some of these features for yourself. The remainder of this book describes suggested areas in the Park to visit so you can view effects of the forces of nature that created this area. In most cases, you will be able to drive to these points of interest and view them from your car or take a short walk to get a better view. There are a few points that require a bit of a hike, but the view will be well worth your effort, and the text will note when a hike is required. We will start our tour in the southern part of the park, but of course, you can use this as a reference and design your own tour.

Platte River Point

Platte River Point is at the end of Lake Michigan Road in the southern part of the park. Follow M-22 to where it crosses the Platte River and then follow Lake Michigan Road about 2 miles to the Lake Michigan shore. Parking, restrooms, picnic area, and benches are available.

NOTICE: During the spring and early summer, part of this beach may be CLOSED to protect the nesting area of the Piping Plover, an endangered shore bird.



Platte River where it meets Lake Michigan. Note the sand barrier that directs the river parallel to the beach. Also note the coastal bluffs.

On a map, you can see that Platte River Point juts out into Lake Michigan. The Point is a river-mouth deposit. The Platte River carries a load of sediment, which settles out where the river empties into Lake Michigan. Prevailing southwesterly winds drive shoreline currents in Lake Michigan. The currents have shaped a sand spit at the mouth of the river, directing the river's flow to the east just before it empties out into Lake Michigan.

For a panoramic view of the shoreline, take a short stroll north along the beach. The vast size of Lake Michigan reflects the size of the glacier that formed it. The Lake Michigan lobe of ice was just a small part of a great continental ice sheet that once covered much of North America.

Glacial ice, like water, seeks valleys and lowlands. The front of the ice takes on a lobate shape as it conforms to the terrain. Imagine glacial ice twice as thick as the highest hills you can see. As the ice melted, the runoff waters carried sand and gravel that had been frozen into the ice. This debris was deposited between lobes of ice to form highlands. Looking north from Platte River Point, you can see two such highlands: Empire Bluffs and



Coastal bluffs north of Esch Rd.

Sleeping Bear Bluffs. The pattern of bay and bluff is repeated along the park's entire shoreline, reflecting the earlier array of ice lobes and interlobate moraines.

Esch Road & Otter Creek

As you drive north along M-22 toward Empire, turn left onto Esch Road and drive to Lake Michigan. If you were unable to walk the beach at Platte Point, this is another good opportunity to see the bluffs that boarder Lake Michigan. Get out of the car and walk the short distance to the beach where Otter Creek empties into Lake Michigan. On a smaller scale than at the Platte River, you can see how the wave action affects the direction of the creek as it approaches Lake Michigan. This is a favorite place for families to enjoy the flowing, warm water of the creek and the waves of Lake Michigan. You can also see the formation of beach dunes as the wind blows the sand up from the beach into dunes stabilized by dune grass and other hardy plants.



Otter Creek meets Lake Michigan at Esch Rd.

Stormer Road & M-22

Continue to drive north on M-22 toward Empire. In less than a mile, you will see the road dip to a lower plane before you get to Stormer Rd. This area is the glacial drainage channel described earlier, where enormous volumes of water flowed from the melting glacier near what is now Glen Lake to Lake Michigan near where Otter Creek is now. Note how deep and broad the channel is to get an idea of how much water was flowing.

Empire Bluffs

Now you have an opportunity experience the costal bluffs from the top. This stop requires about a hike (1.5-mile round trip) through beautiful maple-beech forest to the edge of the Empire Bluffs. If you decide to take the hike, follow M-22 and turn left on Wilco Rd. and follow it to the top of the hill. Look for the Empire Bluffs Trailhead parking and picnic area on the left. Trail maps are



available at the trailhead. Follow the moderate trail to the observation deck and boardwalks overlooking Lake Michigan, where you get a good view of Sleeping Bear Bluffs and the plains around the village of Empire. Along the hike, there is also a beautiful view of South Bar Lake, which is a good example of an embayment lake described earlier.

North Bar Lake

Follow M-22 into Empire past the junction with M-72 and when the road veers to the right, go straight on Lacore Street, and follow it to the end. Turn right on Voice Road, then left on Bar Lake Road until you arrive at the parking lot for North Bar Lake on your left. There is a vault toilet at the parking lot. Take the short hike to the lake and follow the boardwalk over the beach dunes to Lake Michigan.



North Bar Lake and Empire Bluffs in the background as seen from Pierce Stocking Drive.

North Bar Lake lies within the Empire Embayment, a former bay on ancestral Lake Michigan, now a lowland surrounded by hills. The lake developed when a sand bar closed off the mouth of the bay.

At the north end of North Bar Lake you can see beach dunes formed by wind blowing beach sand onshore.

The wooded hills on the north side of North Bar Lake are also dunes but much older, formed a few thousand years ago during the Lake Nipissing stage, when the water level was higher in the Lake Michigan Basin. Lake Nipissing was the result of a gradual rise in water level. Over a period of several thousand years, the shoreline advanced inland. Onshore winds carried sand in front of the rising water to form high beach dunes.

Pierce Stocking Scenic Drive

From North Bar Lake, head back to Voice Rd. and turn left to go back to M-22. Turn left and drive about ½ mile to M-109 where you will follow M-109 about 2 miles to the Pierce Stocking Scenic Drive on your left. There are vault toilets at several stops along the drive and two picnic areas.

The Scenic Drive offers some of the most impressive views in the Park. Be sure to stop at the Glen Lake Overlook for a spectacular view of this glacial depression surrounded by moraine hills and bluffs. If the parking area is full here, go on to the Dune Overlook where you get another view of Glen Lake as well as the perched dunes. In the distance, you can see the Sleeping Bear Dune, a perched dune that formed about 2,000 years ago. It is classified as a perched dune because it is perched on top of a plateau, high above the lake. When the dune was forming, it was not at the edge of the bluff, but somewhat inland. Wind carried sand from the upper portion of the Lake Michigan bluff inland and deposited it here.

You may notice some dead trees within the eroded bowl of the dune. This is called a "ghost forest" and tells a story of alternating stability and change. After an initial phase of active sand accumulation, a period of stability followed when trees began to grow on the dune. Later, more sand moved in and buried the trees. Two layers of buried soil within the dune indicate that there was a second period of stability and growth followed by another period of sand build-up and then the final growth of the trees and shrubs that now cover the sheltered portions of the dunes. You may be able to see these layers of soil at the Lake Michigan Overlook.

The trailhead for the Cottonwood Trail is just beyond the parking lot for the Dunes Overlook. Hiking the 1.5 mile loop through the moraine and perched dunes will give you a good idea of how the perched dunes are formed by the wind blowing the sand out of the moraine bluffs and piling it up on top of the plateau. You will also see how the dune vegetation grows in this arid environment and stabilizes the dunes.

Continue along the Scenic Drive to Stop #9. Take the short walk to the observation deck of the Lake Michigan Overlook where you will see the beach 450 feet below. Notice the composition of the bluff below your feet. While many people assume this is a dune, you will notice the rocks and gravel mixed with sand which indicates it is a moraine created from debris pushed up by the action of the glaciers. On a



Lake Michigan Overlook on Pierce Stocking Drive

clear day you can also see South Manitou Island and the coastal bluffs and dunes there. The North Bar Lake Overlook stop will give you a "bird's-eye view" of an embayment lake with Empire Bluffs in the distance.

Dune Climb

As you leave the Pierce Stocking Scenic Drive, turn left and follow M-109 north a couple of miles to the Dune Climb. You will see it on the left. From the back of the Dune Climb parking lot, you get a broad view of the eastern edge of the Sleeping Bear Dunes. The scene shows the role of wind as a geologic force. Prevailing winds carry sand from the high glacial plateau to this neighboring lowland. The tree at the left is gradually being buried, indicating that this is an advancing dune. You can also see evidence of the role of plants in stabilizing dunes. On both sides of the climbing area, grasses have covered the dune slope.

At the crest of the dune, you can see the tops of cottonwood trees, another stabilizer of the dunes.



The Dune Climb (late fall). Notice the Cottonwood trees on the left and at the top of the dunes.

To learn the rate of dune movement, stop at the measuring beam at the base of the dune at the north end of the parking lot. Also notice that the dune is composed of particles of uniform size, unlike the rocky glacial deposits of the Lake Michigan bluffs. Pick up a handful of sand and look at it closely. You will see different colors of the different minerals in the sand. Most of the sand is composed of quartz, a hard mineral that is resistant to chemical and physical breakdown.

If you are prepared for a strenuous hike, the 3.5 mile round trip walk up and down through the dunes to Lake Michigan will give you a good idea of the immensity of this perched dune area. Be sure to wear good shoes and take plenty of water.



Trail from Dune Climb to Lake Michigan

Sleeping Bear Point Trail

Another trail that gives lets you experience the variety of vegetation, sand, and Lake Michigan is the Sleeping Bear Point Dunes Trail. Drive north on M-109 to Glen Haven and follow the signs to the Maritime Museum. The trailhead is just past the Maritime Museum parking lot. The 2.8 mile loop trail takes you past ghost forests formed when trees were buried by the drifting sand and then later uncovered as the sand blew away again. You will experience the terrain left from the melting glaciers and the sculpting of perched dunes by the wind. Instead of walking the whole loop, you may choose to walk through the dunes to

the beach. It is only ½ mile to Lake Michigan if you take the spur trail to the Lake. Once on the beach, turn left and walk down to Sleeping Bear Point.



Coastal Dune on the Sleeping Bear Pt. Trail

In 1914 and again in 1971, landslides occurred at Sleeping Bear Point. Each time about 20 acres of land slid into Lake Michigan. A smaller slump occurred in early 1995 moving about 1 million cubic meters of sand and gravel including about 500 feet of shoreline. Slide materials extended up to 3 miles offshore. Because of geologic conditions, it is likely that landslides will occur again in the future.

Shoreline currents and wind carry sand to the Point where it accumulates until it becomes unstable. The sloping bottom of Sleeping Bear Bay can tolerate only a limited amount of accumulation. When too much sand builds up, storms or saturation with melting snow can trigger a landslide. Looking off to the right, you will see Pyramid Point at the far end of Sleeping Bear Bay. The high, sandy spot is a dune, made of pure sand sorted out by the wind from the layered sand and gravel deposits of Pyramid Point. Landslides also occur at Pyramid Point. The most recent one was in 1998.

Crystal River

Drive to Glen Arbor on M-109 until it connects up to M-22 again in town. Continue through town until you see the river on your right side. Turn right on Dunn's Farm Road and you will see glimpses of the river as it turns back on itself several times on it's way to Lake Michigan. The river drains water from Glen Lake following a tortuous path through the troughs between low sand ridges formed by the beaches of ancestral Lake Michigan as it receded.



Crystal River from Dunn's Farm Rd.

Pyramid Point

Drive north along M-22 about 4 miles north of Glen Arbor to Port Oneida Road. Turn left and follow the signs to the Pyramid Point trailhead. The ½ mile hike to the top of the dune is well worth the effort. You'll be about 400 feet above Lake Michigan with a great view of North Manitou Island and the North Manitou Shoals Lighthouse. Linger on the bluff and enjoy the view for a while and you will probably see a Great Lakes Freighter sail through the Manitou Passage.



Pyramid Point