GEOFACTS
OHIO GEOLOGICAL SURVEY • DEPARTMENT OF NATURAL RESOURCES

The Glacial Grooves of Kelleys Island, Ohio

Figure 1. The megagroove at Glacial Grooves Geological Preserve on Kelleys Island.

by Mark E. Peter

Kelleys Island in western Lake Erie is home to a world-class geological wonder: giant adjoining grooves carved into limestone bedrock (fig. 1). About 130 meters (m) or 427 feet (ft) long and resembling the chutes of a fantastical alpine slide, these grooves inspire the question: "How were they formed?"

Ice Age origins

The Kelleys Island glacial grooves ("the Grooves") were discovered during limestone quarrying in the mid-nineteenth century. At the time, geologists were collecting evidence for glacial origins of planed bedrock, grooves, and striations in North America and elsewhere. Geologists have since determined that the Grooves formed during the Pleistocene Epoch ("Ice Age"), which began about 2.6 million years ago (mya) and ended about 11,700 years ago.

During the Ice Age, great flowing ice sheets advanced at least three separate times from Canada into Ohio, reaching as far as the Ohio River in the southwestern part of the state. At its greatest extent, ice in the Lake Erie region is estimated to have been nearly 1.6 kilometers (1 mile) thick. Ice frozen onto exposed bedrock plucked up pieces of rock as glaciers advanced, and glaciers planed some surfaces smooth.

Smaller-scale features of the Grooves probably formed during the most recent (Wisconsinan) glaciation, because they would have been easily overprinted by subsequent glaciations. Ice from this glacial episode began to accumulate in Canada approximately 70,000 years ago. It entered Ohio around 30,000 years ago and reached its maximum extent roughly 25,000 years ago. The main trough and larger grooves likely also formed during the Wisconsinan glaciation. Radiocarbon dating has shown that the glacial *till* (sediment deposited by a glacier) that partially filled the Grooves is roughly 17,000 years old; this date provides a minimum age for the formation of the Grooves.

Ancient limestone bedrock

The marine limestone bedrock in which the Grooves were carved was deposited about 400 mya, during the Devonian Period. Land now called Ohio was subtropical, south of the Equator, and flooded by an inland sea. Limestones, which mostly form in warm, shallow, sunlit seas, are composed primarily of calcium carbonate ($CaCO_3$) derived from shells and skeletons of marine organisms. The rock unit at the Grooves is Columbus Limestone, named for its exposure in central Ohio. Columbus Limestone at the Grooves contains abundant fossils, including corals (fig. 2).

Thick-bedded limestones may be ideal for forming features like those at the Grooves. For sedimentary rocks, limestones are resistant to erosion but are easily scratched by hard minerals, such as those within igneous and metamorphic rocks transported by glacial ice sheets into Ohio from sources in Canada. When frozen in the base of flowing ice, these rocks could have become what glacial geologists call *tools.* Under pressure from the ice, such tools were capable of scratching and gouging the softer limestone.

Figure 2. Solitary rugose "horn" corals in the Kelleys Island glacial grooves.

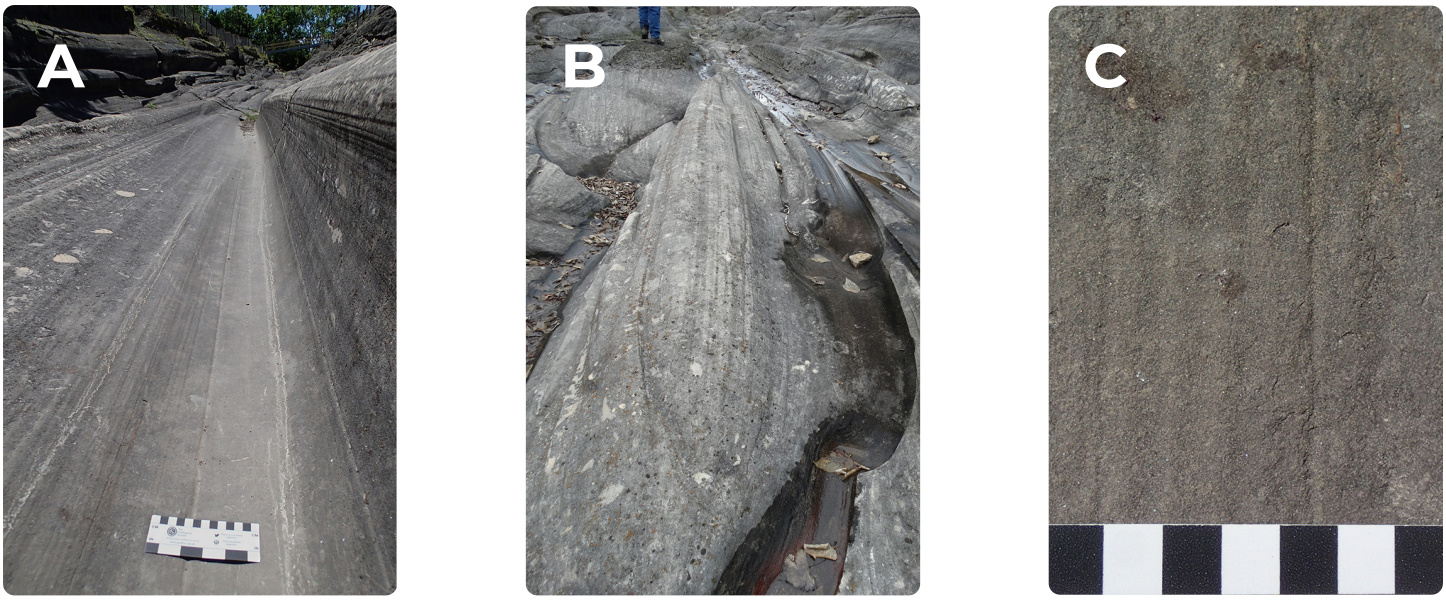

Figure 3. (A) Second-order groove; scale within groove is 13 cm (5 in) long. (B) Whaleback ridge defined by second-order grooves and ornamented with striae. (C) Striae; scale bars are 1 cm (0.4 in) each.

Grooves within grooves, within grooves

Visitors to the Grooves will notice their fractal nature: the main trough contains smaller grooves, which in turn contain fine scratches in the rock called *striae* (striations). In 1979, glacial geologist Richard P. Goldthwait of The Ohio State University described several scales of erosional features. At the largest scale, the main trough is what geologists call a *megagroove* (fig. 1). Multiple megagrooves were uncovered on the island, but all except the one at the geological preserve were quarried away. The remaining megagroove measures about 130 m (427 ft) long, 10 m (33 ft) wide, and as much as 3 m (10 ft) deep. It once extended 50 m (164 ft) farther inland and 100 m (328 ft) to the island's north shore, more than twice the length remaining today. Megagrooves may have formed in preexisting stream channels.

Within the megagroove are multiple second-order grooves (fig. 3A), measuring about 10–90 centimeters (cm) or 4–35 inches (in) deep and extending up to 40 m (about 130 ft). Most run roughly parallel to the megagroove, but some have more sinuous courses. Some grooves diverged, perhaps around resistant areas within the limestone (such as concentrations of corals) and merged again to form elongated ridges that have been given descriptive names, including *whaleback* (fig. 3B). Whaleback ridges resemble a surfacing baleen whale, with a broad head tapering gradually to a narrow tail. These features indicate direction of flow, which is from the head toward the tail. At the Grooves, orientation of these ridges indicates that ice or liquid water under pressure was flowing slightly uphill, from east-northeast to west-southwest.

The process or processes that formed the megagroove and second-order grooves has been much debated among geologists. Because several grooves have features such as overhanging lips, meanders, and even right-angle bends, some geologists have suggested they were shaped by liquid meltwater, perhaps at the base of the ice sheet, rather than by gouging tools frozen in the slow-moving ice. Under pressure from thick ice above and laden with rock particles, powerful jets of fast-moving water may have played a role in carving these channels.

A third-order set of grooves are striae (fig. 3C). Striae at the Grooves average 1–2 millimeters (mm; 0.04–0.08 in) wide and 1 mm deep. Within and mostly parallel to the second-order grooves and wrapping over whaleback ridges, striae overprinted the larger grooves. There is some agreement among geologists that striae are gouges made by individual rock tools embedded in advancing ice.

A final scale of erosion was *glacial polish.* When the Grooves were initially uncovered, they had a smooth, polished surface. The polish may have resulted from clay-sized particles of glacial till called *rock flour* being transported over the limestone. Polish was the last feature to be eroded before the Grooves were buried and protected by glacial till. Once uncovered by humans and exposed to acidic rainfall, the limestone became pitted and dull and after several years, the polish was no longer evident.

References & Further Reading

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