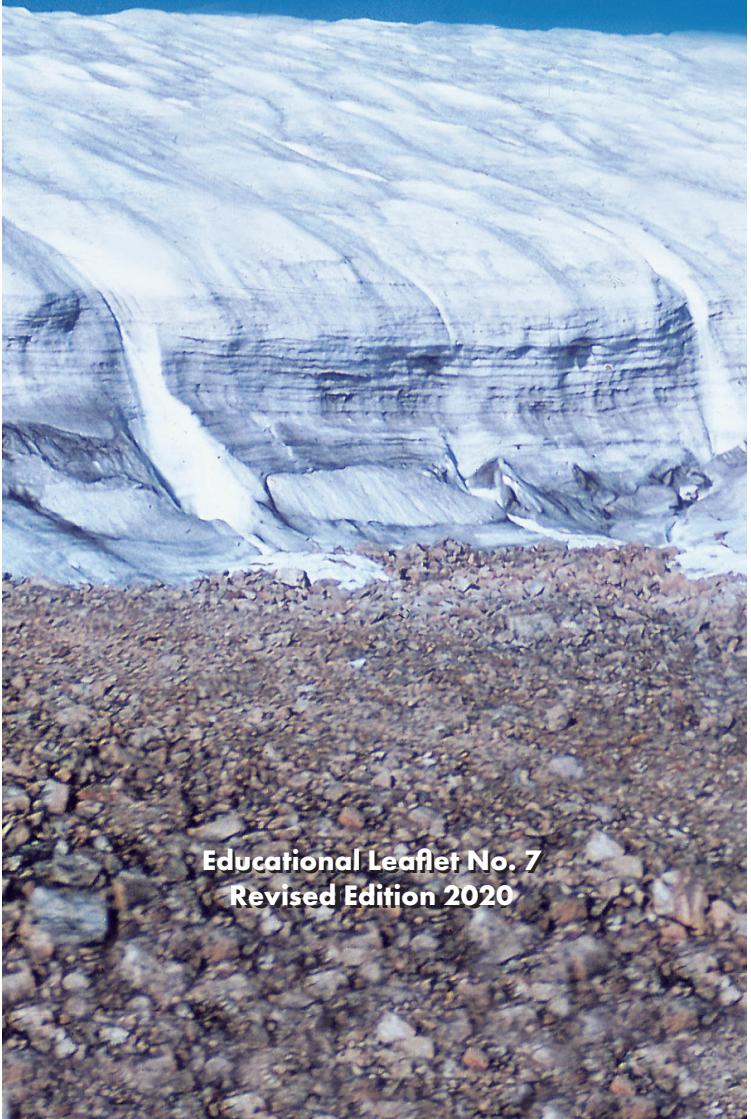


THE Ice Age in Ohio

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INTRODUCTION

The Pleistocene Epoch, commonly referred to as the Ice Age, is a small segment of geologic time spanning the last 2.6 million years of the Quaternary Period. The Pleistocene Epoch ended about 11,600 years ago, which was the beginning of the Holocene or Recent Epoch. The sediments deposited by or in association with Pleistocene glaciers represent the first well-documented deposits in Ohio since the early Permian Period, about 280 million years ago. This gap in Ohio's rock record is the result of a long period of erosion and nondeposition from the late Permian through the Neogene Period. Despite the comparatively short length of the Pleistocene, it has been one of the most influential geologic episodes in the cultural and economic development of Ohio. Sediments deposited during the Pleistocene, especially in the latter portion of this epoch, cover all but the southeastern third of the state and have been only slightly modified by erosion since melting of the last glacier. These sediments constitute the rich agricultural soils of Ohio; furnish raw materials, such as clay, sand, and gravel, for construction; and form extensive aquifers for groundwater. Pleistocene deposits are environmentally important as sites for landfills, as source material for some landslides, and as a medium that enhances ground motion during earthquakes. The configuration of the glaciated landscape has directly influenced settlement and development patterns across the state.

The Pleistocene Epoch began when the climate cooled and ice and snow accumulated in northern Canada to a depth sufficient enough to form a great ice sheet that spread outward under its own weight. Eventually the ice pushed into the northern United States. Geologists estimate that the ice may have been a mile thick in the Erie basin and 1,000 feet thick in the central part of Ohio. The buildup, spread, and melting of an ice sheet occurred several times during the Pleistocene Epoch. Each glaciation was followed by an interval of warmer climate known as an *interglaciation*.

The cause of the climatic fluctuations of the Pleistocene that led to the development of huge continental glaciers is poorly understood, and scientists have advanced many hypotheses to explain these perturbations. It is probable that glaciations result from natural, long-term variations in the amount of solar radiation that reaches Earth's surface, especially in the northern hemisphere. Three factors—the tilt of Earth's axis, its wobble, and its path around the Sun—all vary

slightly, yet periodically, through time in what are called Milankovitch cycles. When the cycles of these three factors coincide to give the northern hemisphere less than average solar radiation, Earth's climate becomes cooler and glaciation eventually results.

The earliest series of ice advances in North America were formerly referred to as the Nebraskan and Kansan Stages, but now are referred to as pre-Illinoian glaciations. These advances are named for the states where their deposits were first studied and described. Early glaciers greatly disrupted drainage patterns and modified the landscape; however, their deposits are poorly known in Ohio. Deeply weathered pre-Illinoian glacial deposits have been recognized in southwestern Ohio near Cincinnati and in a few isolated exposures in northeastern Ohio.

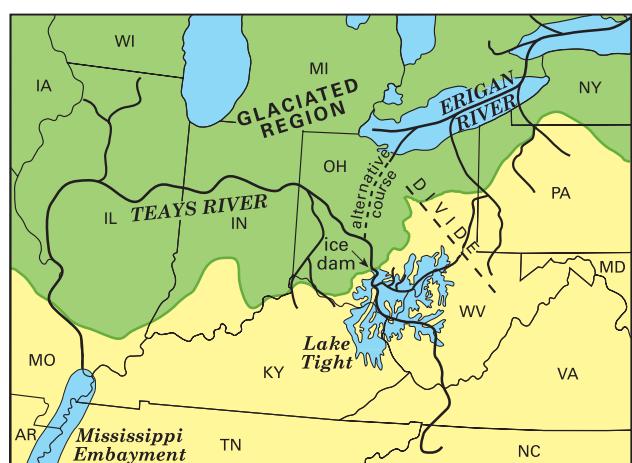
Following a relatively warm interglaciation, perhaps warmer than our present climate, ice of the Illinoian glaciation advanced far into Ohio, reaching into northern Kentucky. This event began about 300,000 years ago. The Illinoian ice caused further drainage modifications and left distinctive morainic deposits extending from southwestern to north-central Ohio and into northeastern Ohio. Outwash deposits presumed to be of Illinoian age are preserved as high terraces along the valley walls of major rivers, such as the Hocking, Great and Little Miami, Muskingum, Ohio, and Scioto.

After a long period known as the Sangamon Interglacial, which featured extensive weathering of Illinoian glacial deposits, the Wisconsinan ice sheet began to form in Canada about 70,000 years ago. However, radiocarbon dates suggest that Wisconsinan ice did not reach northern Ohio until about 24,000 years ago. The Wisconsinan glaciation (and probably also the earlier glaciations) was marked by several major fluctuations of the ice margin. Wisconsinan glacial deposits blanket the surface throughout the northern, central, and western portions of the state. The last of the ice was gone from Ohio by about 14,000 years ago. Wisconsinan deposits are well preserved because of the relatively short interval of erosion and weathering since their deposition. Events that occurred during the last 50,000 years, including much of the Wisconsinan, can be accurately dated by measuring the amount of radioactive carbon (C^{14}) in organic material, such as wood, shell, and bone collected from glacial deposits. The glacial map shows the types and distribution of these deposits in Ohio.

Changes to the Ohio landscape wrought by the ice sheets have greatly influenced our modern culture and economy. Some of the major modifications are presented herein.

DRAINAGE CHANGES

Prior to glaciation, the western and southern portions of Ohio were drained by a major river system known as the Teays, which had its headwaters in the Appalachian highlands of North Carolina and Virginia. The northeastern third of Ohio was drained by the Eriean River, which flowed northeasterly through the basins now occupied by Lake Erie and Lake Ontario.



Preglacial Teays River in north-central U.S.

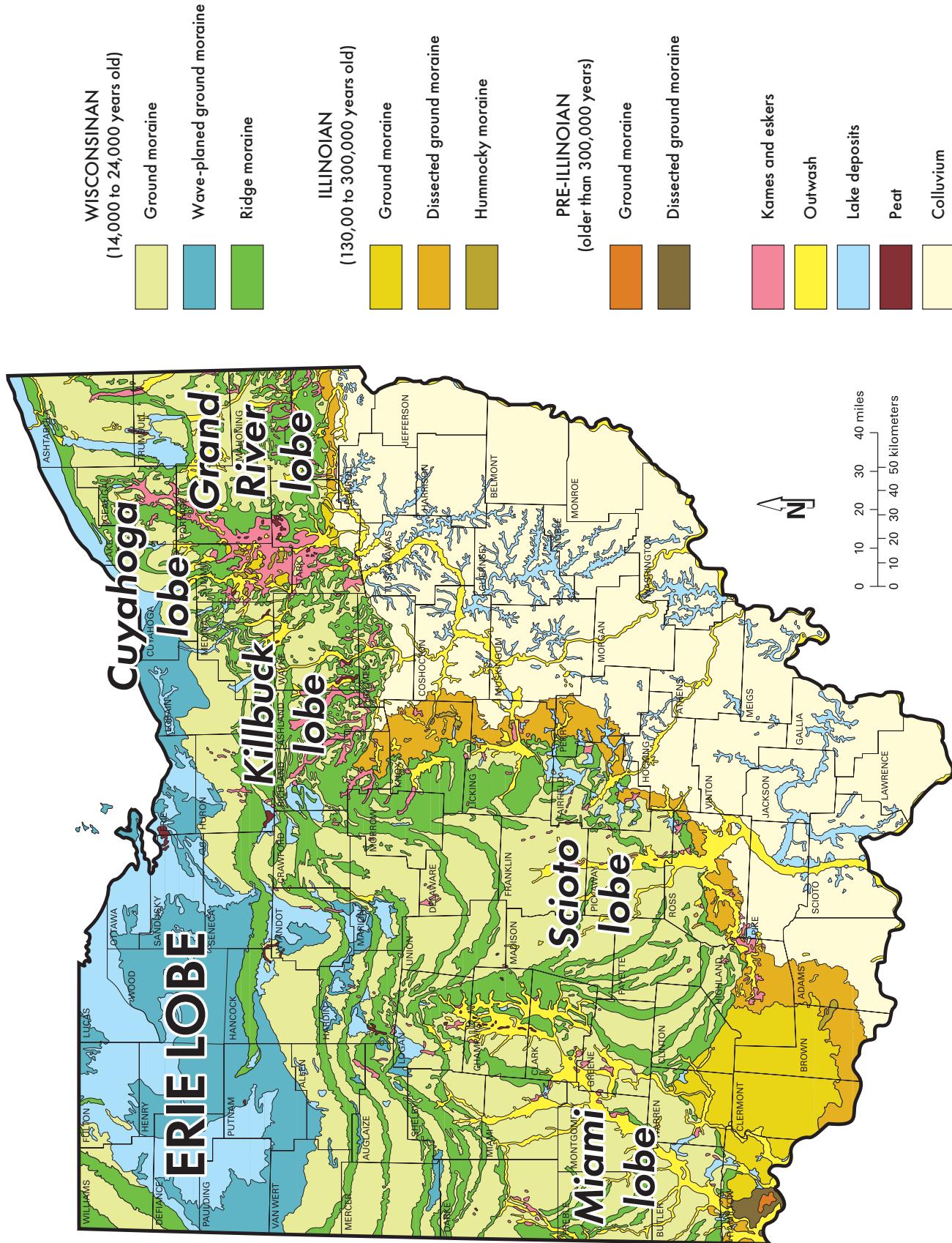
called the Minford clay, which are believed to be pre-Illinoian. The lake eventually spilled over low drainage divides and established new drainage systems. These new drainage channels cut below the elevation of the Teays, forming a drainage system known as Deep Stage. The modern Ohio River was formed as a result of these complex drainage changes.

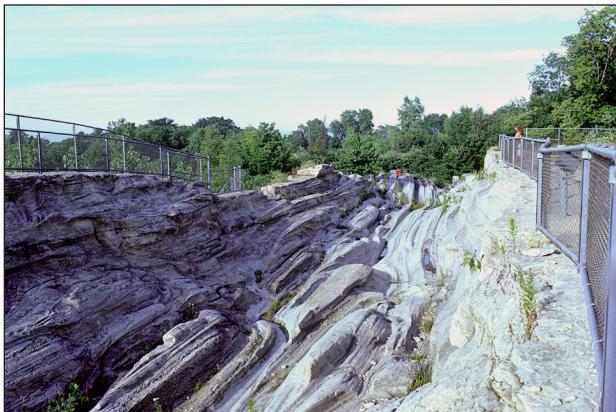
Abundant evidence of drainage changes can be seen in Ohio. In the glaciated portion of the state, the old Teays River system is represented by deep valleys cut into the bedrock. Today, the valleys are filled with glacial sediments. In unglaciated southern Ohio, the Teays River valley and the valleys of its tributaries can be seen as broad flat valleys at an elevation higher than that of modern stream valleys.

From its source, the Teays River flowed northwestward across West Virginia and entered Ohio near Portsmouth. The Teays River took a northward route across southern Ohio and, in a classic interpretation, swung westward across central Ohio into Indiana. Continuing its westward path across Indiana and Illinois, the Teays eventually joined the ancestral Mississippi River in western Illinois. Some geologists suggest that the deep, buried valley in western Ohio represents an ice-front stream formed in association with the earliest glacier and that the Teays River actually continued northward and joined the Eriean River. Multiple glaciations have greatly eroded and deeply buried these river valleys, making interpretations difficult.

Arrival of the earliest pre-Illinoian glacier blocked the northwestward-flowing Teays River and its numerous tributaries, creating a 7,000-square-mile lake in southern Ohio and adjacent parts of Kentucky and West Virginia. Named Lake Tight, after William G. Tight, a geologist who first studied the Teays River, this lake was partially filled with lake clays.

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These intricately gouged and polished grooves in the Devonian-age Columbus Limestone on Kelleys Island in Lake Erie are among the largest and best-preserved glacial grooves in the world. The grooves likely were cut by subglacial meltwater and rocks frozen in the base of the mile-thick Wisconsinan ice as it advanced across the Erie basin about 20,000 years ago. These grooves were designated as a National Natural Landmark in 1967 and are maintained as a State Memorial site by the Ohio History Connection.



Exposure of till, an unsorted glacial sediment that is a mixture of rock fragments ranging from clay size to boulders. Till represents material scraped up by the ice during its southward advance and deposited beneath advancing ice or as a sediment blanket when the ice melted. Multiple Wisconsinan-age till beds, representing several ice advances and retreats, are visible in this exposure along Rocky Fork Creek, near Gahanna, Franklin County. Glacial erratics, many of Canadian origin, have been eroded from the till and litter the stream bed.

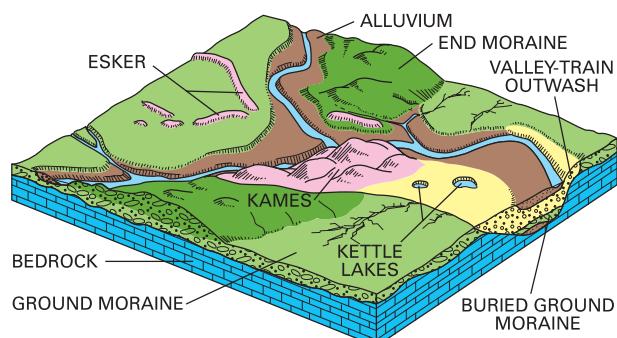
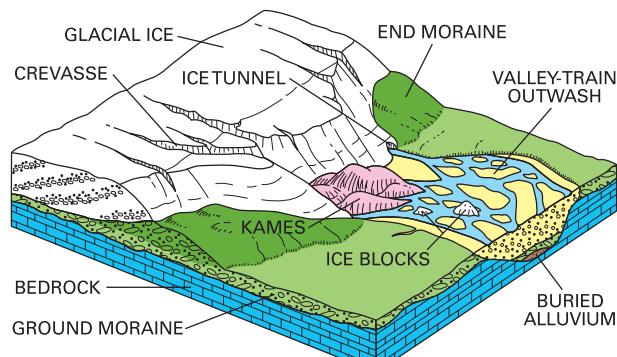
GLACIAL DEPOSITS

The sediments left behind by ice sheets and meltwater are referred to as *glacial drift* and consist of boulders, cobbles, sand, silt, and clay that had been gouged and scraped from the landscapes across which the ice moved. Drift deposits can be classified according to their mode of origin, the materials of which they are composed, or the landforms which they created.

An unsorted glacial sediment composed of materials ranging in size from boulders to clay and deposited directly by ice is called *till*. Till is deposited directly at the bottom of advancing ice or by the melting of stagnant ice. Till that forms a fairly flat blanket over bedrock or older sediments is called *ground moraine*. Where the ice sheet halted for a period of time, a thick, linear ridge of till was deposited along the ice edge. Such ridges are called *end moraines*. The wide distribution of end-moraine belts in Ohio is evident on the map of glacial deposits. Morainic deposits commonly contain boulders, some weighing many tons, that were carried by the ice from as far away as Canada. These boulders of crystalline igneous and metamorphic rocks, called *erratics*, are a familiar sight in glaciated portions of Ohio.

Kames and eskers, another major group of glacial deposits, formed in contact with ice and running water. *Kames* are hummocky mounds of stratified (layered) sand and gravel deposited by meltwater flowing across the ice and pouring its sediment load into holes and *crevasses* (crevices) along the ice margin or in stagnant ice. Kames are numerous in some portions of Ohio.

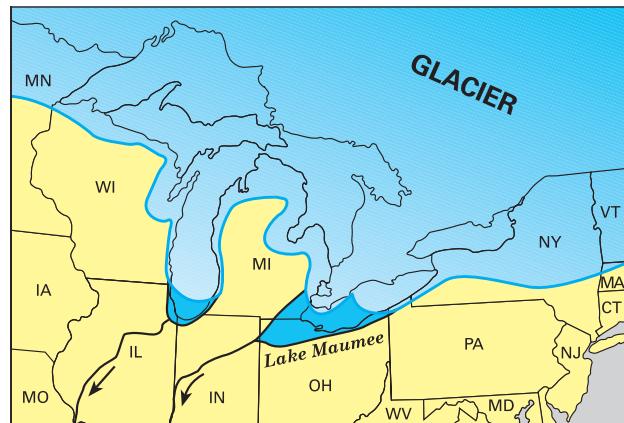
Eskers are ridges of stratified sand and gravel deposited on, within, or beneath the ice by meltwater rivers flowing on the ice surface or under hydrostatic pressure in pipelike tunnels. When the ice melted, the long, linear or sinuous deposits were left behind, marking the courses of the former channels or tunnels. Eskers, which are commonly oriented parallel to the direction of last ice movement, may be found in several areas of Ohio.



Landscape during maximum advance (top) and after (bottom) retreat of ice.



Stage's Pond, one of many lakes left behind by the retreating Wisconsinan ice sheet. Stage's Pond, near Ashville in Pickaway County, is a state nature preserve.



Highest Lake Maumee (Maumee I) stage in the Erie basin. Drainage was westward across Indiana into the Wabash River system. Modified from Hough (1958).

As the huge ice sheets melted, great volumes of meltwater flowed in the river valleys, carrying with it, far beyond the glacial border, large amounts of sediment that had been scraped up by the glacier on its long journey from Canada. This sediment, termed *outwash*, consists mostly of sand and gravel, and it filled the valleys of such rivers as the Hocking, Great and Little Miami, Muskingum, Ohio, and Scioto. These sand-and-gravel deposits are an important economic resource for the construction industry and benefit areas of the state that are beyond the southern limit of glaciation. Outwash deposits also are a major source of groundwater.

Deposits of layered silt and clay accumulated in lakes in basins or in valleys whose outlets were dammed by glacial ice or glacial deposits. Lake deposits commonly are preserved as terraces along valley walls where the modern stream has eroded the lake deposits in the center of the valley. Other lake deposits are found in shallow basins between moraines, which acted as barriers to drainage. Small ponds and lakes, known as *kettles*, formed in association with moraines when blocks of ice became detached from the glacier and were buried by sediment. When the ice melted, a water-filled depression was formed. Commonly, kettles contain deposits of calcareous marl which are overlain by peat. Many of these kettles have become filled with sediment and peat and today are represented by swampy depressions.

Lake Erie is one of Ohio's most important resources that formed as a direct result of the Pleistocene glaciers. The initiation of lakes in the Erie basin began after ice had retreated north of Ohio about 14,000 years ago. A complex series of lakes, some of which were up to 230 feet deeper than the present lake, occupied the Erie basin during the last phases of the Pleistocene. Some of these lakes drained into the Mississippi River via the Wabash River when the modern drainage outlet into the St. Lawrence River was blocked by ice. Northern Ohio, particularly northwestern Ohio, has abundant lake deposits that formed in these early, more extensive lake stages. Several sets of sandy ridges, each set of which is at a similar elevation, mark beaches formed along the shorelines of these lake stages. Modern Lake Erie reached its present form only about 4,000 years ago.

At many places in Ohio, bedrock surfaces show scratches and grooves cut by pebbles, cobbles, and boulders frozen in the base of moving ice. These scratches, known as *striations*, are useful to geologists because they indicate the direction of movement of the glacier. The exceptionally large, world-famous glacial grooves on Kelleys Island in Lake Erie, however, may have been formed by a complex process involving gouging ice and sand-charged water running under hydrostatic pressure beneath the ice.

PLEISTOCENE LIFE

Northern species of plants that today occur in Canada were common in Ohio during the Pleistocene. These plants include trees such as spruce, fir, tamarack, cedar, hemlock, and larch. Owing to unique environmental conditions, several places in Ohio retain this glacial vegetation as relict species. Cedar Bog in Champaign County is one example. This northern or glacial vegetation persisted in Ohio until about 10,000 years ago when the climate warmed and the coniferous forest was replaced in a comparatively short time by oak-dominated deciduous forests such as are now found growing in Ohio.

Many, although not all, animals that roamed Ohio during the Pleistocene were quite different from those found here today. Species that are either extinct or no longer present in Ohio include mammoth, mastodon, muskox, caribou, peccary, short-faced bear, elk-moose, ground sloth, and giant beaver. Skeletal remains of these animals commonly are found in clay, marl, and peat that was deposited in former glacial lakes; in sand and gravel deposited by glacial meltwater; and in caves

and sinkholes. Sabretooth cats and dire wolves have not been found in Ohio as yet, but it is probable that they lived here because their remains have been found in nearby states. About 10,000 years ago, many of these animals disappeared from North America. Their extinctions may be related to rapid climatic and vegetational changes that occurred at this time, as well as the arrival of humans and overhunting of these animals.

The first human migrants into North America, a culture known collectively as *Paleoindians*, lived in Ohio during the last phase of the Wisconsinan glaciation. They were nomadic hunters and gatherers who followed the great herds of Pleistocene animals across the Bering Strait from Asia into North America. Although no skeletal remains of Paleoindians have been found in Ohio, several mastodon skeletons found in the state show evidence that the animal was butchered. Exquisitely crafted flint spear points, known as *fluted points* because of the groove or flute on each side, are unique to the Paleoindian culture and are widely distributed in the state.

LEGACY OF THE ICE AGE

All Ohioans benefit daily from the legacy of the Pleistocene Ice Age. The rich agricultural soils formed on glacial deposits across two-thirds of the state produce a bounty of vegetable and animal products that are consumed by Ohioans and constitute a valuable export. Waterways formed in association with the ice sheets, such as Lake Erie and the Ohio River, are avenues for transport of these and other products. These bodies of surface water, as well as abundant supplies of groundwater stored in some glacial sediments, provide a nearly limitless supply of this vital commodity for both domestic and industrial use. For example, groundwater obtained from sand-and-gravel deposits accounts for more than 80 percent of the water used for high-volume industrial and municipal water wells.

Mineral commodities formed in association with the glaciers include sand and gravel, peat, and clay. Sand-and-gravel deposits, in addition to being aquifers, are an integral commodity for the construction industry. Historically, Ohio has had a robust sand-and-gravel industry, ranking among the top ten states in production for decades. Sand and gravel are used in road construction, building, concrete, and asphalt. These low-cost-per-unit resources are available inexpensively at

construction sites because they are so widely distributed that transportation costs are low. Glacial clays are mined in several Ohio counties for manufacture of common clay products such as brick and for use as liners in landfills. Peat is mined in several Ohio counties for use as mulch and as a soil conditioner. Numerous streams in the glaciated portion of the state produce a few small flakes of gold of presumed Canadian origin. Panning for this placer gold is an enjoyable hobby for many people. In addition to gold, six diamonds have been reported from glacial deposits in Ohio.

Glacial deposits are environmentally important as well. Thick, uniformly impermeable deposits of clay-rich till and lake clays may be good sites for landfills because the clays prevent landfill fluids from leaching into groundwater supplies. Glacial deposits of sand and gravel provide excellent, well-drained sites for homes, businesses, and other structures.

A few of the many types of glacial deposits in Ohio have the potential to create environmental problems. Some lake



Esker north of Circleville, Pickaway County, exposed in a sand-and-gravel pit. An esker is a long, snakelike ridge of sand and gravel formed by streams of meltwater beneath the glacier. These valuable deposits of sand and gravel are used in the construction industry.

clays, particularly where they are associated with sloping ground, are prone to landsliding. Notable for landslide problems are clays in the Cuyahoga Valley of northern Ohio, valleys filled with Minford clay in southern Ohio, and some deposits of glacial clay in the Cincinnati region of southwestern Ohio. Some glacial silts and sands are of concern if a large earthquake would strike Ohio because they are prone to *liquefaction*, a phenomenon in which strong shaking causes a sediment to lose its bearing strength and collapse. These glacial sediments may also magnify ground motion during an earthquake, thus making some buildings built upon them more susceptible to damage.

An intangible, but nonetheless important, benefit to Ohioans from the glaciers are the scenic vistas and pastoral views throughout the state. Flat till plains stretching to the horizon, hilly moraines, and broad valleys would not be here if the glaciers had not reached Ohio.



A depiction of the Burning Tree mastodon site in Licking County. The mastodon stands in a plant-filled bog with a conifer forest in the background. Artist: Steven Kirk, ©1992, reprinted with permission of *Discover Magazine*.

INTERACTIVE RESOURCES

<http://www.sfu.ca/archaeology/museum/exhibits/virtual-exhibits/glacial-and-post-glacial-archaeology-of-north-america.html>

A Journey to a New Land – Explore how people first arrived in the Americas through photos and interactive features at this site from Simon Fraser University.

glaciers.pdx.edu/Projects/LearnAboutGlaciers/ROMO/BasicsIceAges.swf

Timeline of Recent Ice Ages – Interactive map from Portland State University illustrates the advance and retreat of Pleistocene glaciers in North America.

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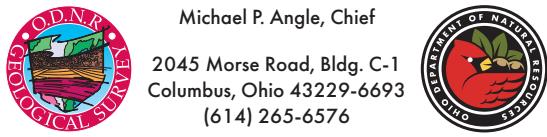
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Established in 2012, *Ohio Rocks!* provides grants to Earth Science students at Ohio colleges and universities for research on the geology of Ohio and funds outreach to Ohio's K-12 schools.

Cover: Terminus of a modern glacier, Nunatarssuaq, Greenland.
Photo by Richard P. Goldthwait.