CAUSES OF GLACIATION

Glacial Advances and Retreats

in

TWO GLACIERS PARK

Fairfield County, Ohio

By
George F. Maxey, Ph.D.,
Elaine Cox, Evan Grissom, Madellen Harkay, and Michael McClure

National Park College
Hot Springs, Arkansas

April 2024

FOREWORD

By
Kimber Caito, Fairfield County Park District

Two Glaciers Park Focus of Research by Geology Students

The 357-acre park is known for its beautiful settings including Clear Creek and two original covered bridges. The parkland is of special interest to geologists for a different type of beauty – its unique glacial history. As its name suggests, evidence of two entirely unrelated glacial advances that occurred approximately 100,000 years apart is found in Two Glaciers Park. No other place is known to have experienced the exact same geological phenomenon!

Two Glaciers Park (Fairfield County, Ohio) is the focus of a research paper by George F Maxey, Ph.D., and geology students Elaine Cox, Evan Grissom, Madellen Harkay, and Michael McClure at National Park College in Hot Springs, Arkansas.

During visits to Ohio in June and December of 2023, Dr. Maxey traversed the park, examined rock specimens in situ, and obtained seventeen rock samples that were taken to the laboratory and analyzed for composition and comparison. The resulting paper entitled "Glacial Advances and Retreats in Two Glaciers Park, Fairfield County, Ohio" has been published on Fairfield County Park District's website. Read it in its entirety at fairfieldcountyparks.org > Locations > Two Glaciers Park.

Two Glaciers Park is the largest of Fairfield County Park District's properties. Before acquisition, it was used primarily for agriculture. In the past few years, the property has undergone considerable habitat restoration with help from partnering agencies. US Fish and Wildlife Service planted over 100 acres with native warm-season grasses and wildflowers. The Nature Conservancy recently completed a wetland mitigation project of more than twelve acres. This year, Fairfield County Park District will begin an additional 33-acre wetland restoration project utilizing grant funds through Ohio Department of Natural Resources' H2Ohio initiative. Future plans include trails, observation areas, and improved visitor access.

Even during restoration and development, visitors can visit the park's more recent historical features. Johnson covered bridge is located near the main entrance at 7636 Clearcreek Rd SW, Lancaster. Hannaway covered bridge can be accessed from Clearport Rd SW. When you visit Two Glaciers Park, try to imagine the vast, thick ice sheets of the Illinoian and Wisconsinan glaciers that once blanketed the entire region!

FAIRFIELD COUNTY PARK DISTRICT

9270 Pickerington Rd., Pickerington, OH 43147 | 614 321-4833 | fairfieldcountyparks.org

CAUSES OF GLACIATION

Glacial Advances and Retreats in

TWO GLACIERS PARK

Fairfield County, Ohio

By

George F. Maxey, Ph.D., Elaine Cox, Evan Grissom, Madellen Harkay, and Michael McClure

Over the last 2.0 million years, prior to the influence currently being exerted by greenhouse gases, numerous glacial advances flowed south from Canada into Ohio. These pre-industrial, worldwide periods of cooling and warming can be explained, in part, as a function of Milankovitch Cycles (Fig. 1), and three astronomical processes called Eccentricity (100,000 yrs.), Obliquity (42,000 yrs.), and Precession (23,000 yrs.). Not all scientists agree that Milankovitch Cycles consistently influence climate cycles, but the cycles do exist.

> *ECCENTRICITY deals with the shape of Earth's orbit around the Sun. Over a 100,000-year cycle, the orbit changes from almost circular to egg-shaped. Eccentricity is a measure of how much that orbit deviates from a circular pattern. When Eccentricity is 0.0, the orbit is nearly circular. As the numbers increase – .01, .02, .03, etc. – the orbit becomes more egg-shaped, and the Earth receives less energy from the Sun over a year. Thus, it gradually cools. Looking at Figure 1, the eccentricity of the Earth appears to be decreasing; that should correspond with slow global warming.*
>
> *OBLIQUITY is the tilt of Earth's axis and varies between 22.1 and 24.5 degrees over a cycle of 42,000 years. Today, the axis is approximately 23.5 degrees. As Figure 1 indicates, the axis is tilting toward the plane of Earth's orbit; that is also an indicator that our planet should be warming.*
>
> *PRECESSION is the third and shortest of Milankovitch's defined cycles. Precession is the result of gravitational forces from the Sun and the Moon acting on the mass of the Earth, causing our planet to wobble. Currently, this cycle is returning from a cooling trend that corresponds with the retreat of the last glacial advance. Like the other two cycles, it is leaving its cooling stage and entering a warming trend.*

As a result of the interaction of these three cycles, Milankovitch predicted a glacial advance every 41,000 years, on average.

Cycle interactions between Eccentricity, Obliquity, and Precession may explain why Milankovitch Cycles do not precisely correspond to all glacial advances, especially further back in time. In addition, other cycle interactions such as sunspots, plate tectonic cycles, volcanic cycles, ocean warming and cooling cycles, and 'forcers' like greenhouse gases are most likely the reasons that **none** of the cycles influencing climate change exhibit *consistent* reactions.

Current Milankovitch Cycles are moving away from cooling and are driving the Earth into a warming cycle or interglacial stage. However, greenhouse gases are also contributing to planet warming. It is entirely possible that the Earth would be warming even faster than it is if it was not for the latent counter cooling effects of Obliquity and Eccentricity. Future consideration should be given to Precession because it is nearly at the zenith of its warming cycle and will start contributing to cooling in the future. Nevertheless, in the next couple hundred years the combination of greenhouse gases and Milankovitch Cycles do not bode well for Earth.

Milankovitch Cycles

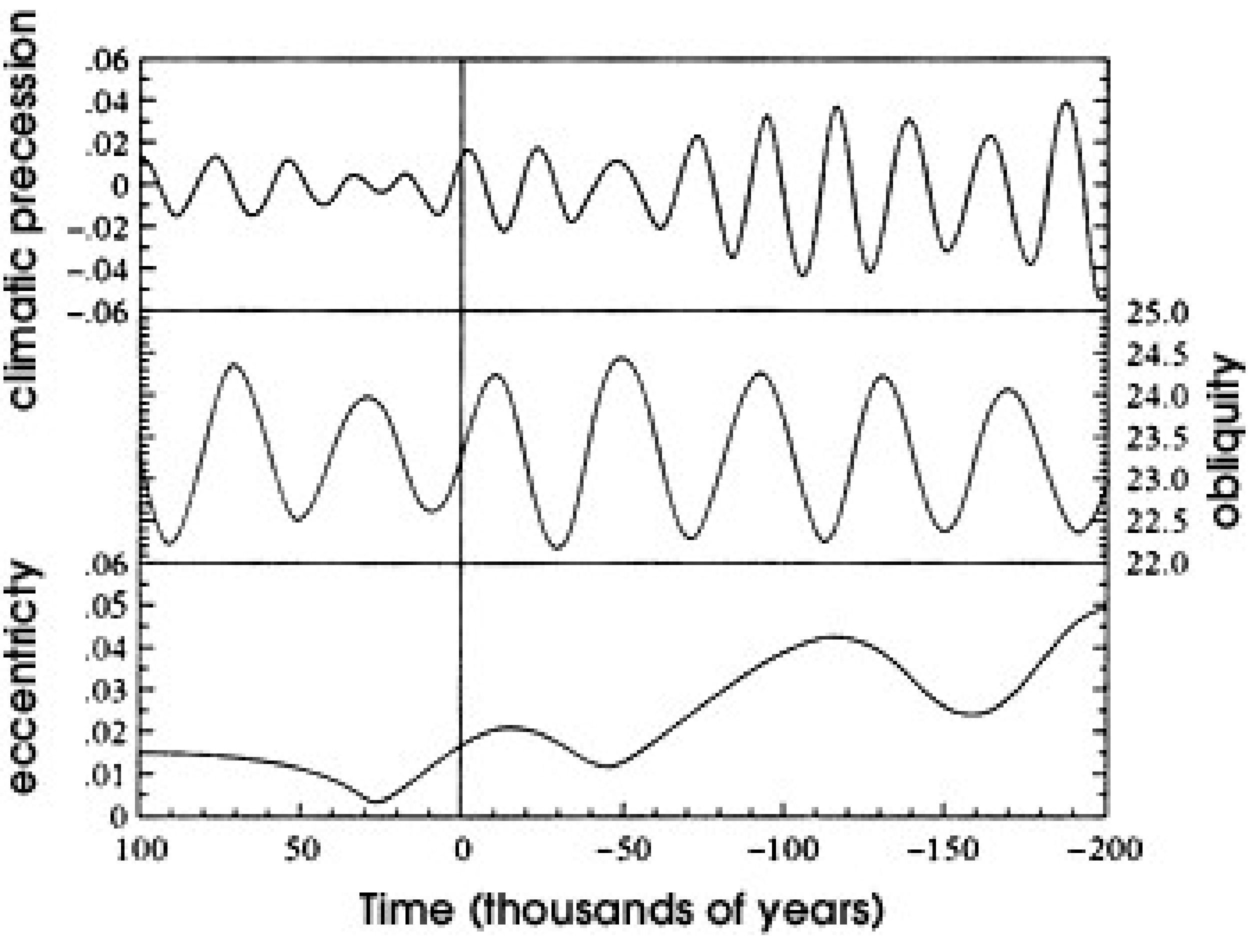

Figure 1: This chart shows the Milankovitch Cycles from the past to the present and into the future. NASA Earth Observatory, published March 24, 2000.

THREE GLACIAL STAGES

Evidence for three glacial stages can be found in Ohio: Pre-Illinoian, Illinoian, and Wisconsinan.

For the last 500,000 years, driven by Milankovitch Cycles and other earth climate change cycles, Earth has experienced some variation of glaciation approximately every 41,000 years. This article deals specifically with deposits found in Two Glaciers Park in Fairfield County, Ohio. Therefore, terminology and feature discussion are limited to Ohio and primarily the park.

Glaciologists have identified the times of these glacial advances (hereafter called stages) and retreats based on the types of materials scraped from parts of Canada and transported by the Laurentide continental ice sheet into Ohio. Optically Stimulated Luminescence (OSL) has been used to date the beginning and ending of the stages more accurately.

Optically Stimulated Luminescence is a technique used to measure the time a mineral, such as quartz, was last exposed to ultraviolet radiation (daylight).

In addition to the types of deposits left behind as a glacier retreated, carbon-14 dating and other techniques have been employed to put a physical age on each glacial event. Glacial stages were named after the states in which glacial deposits were found and identified. Interglacial stages were named after Ameri-Indian tribes who lived in the vicinity where such deposits were described (Fig.2).

GLACIAL CHRONOLOGY		
Time in years before present (ybp)	Name of event	Glacial Advance or Retreat
0-18,000	Recent	Retreat
18,000-67,000	Wisconsinan	Advance
67,000-128,000	Sangamon	Retreat
128,000-180,000	Illinoian	Advance
180,000-230,000	Yarmouth	Retreat
230,000-300,000	Kansan	Advance
300,000-330,000	Aftonian	Retreat
330,000-470,000	Nebraskan	Advance
470,000-1,800,000	26	Advances and Retreats

Figure 2: Glacial advances and retreats over the last 1,800,000 years.

As a result of cooling due to Milankovitch Cycles, glaciers made southern advances from across Canada, primarily the Hudson Bay region, into the north and central parts of Ohio.

The Laurentide continental ice sheet is divided into the Keewatin (over central Canada) and the Labrador (from the center of Hudson Bay east to Newfoundland). It was the Labrador portion of the Laurentide that carried eroded fragments of rock from Canada into Ohio. Some of the rock was ground into loess (fine, mineral-rich rock the consistency of flour) that contributed to the rich, brownish Ohio soils.

Today, evidence of Pre-Illinoian, Illinoian, and Wisconsinan glacial advances covers three quarters of the state.

PRE-ILLINOIAN STAGE

A glacial advance and retreat can greatly alter the surface of the earth by eroding away superficial materials during the advance and subsequently deposit transported materials from distant sources.

Before Pre-Illinoian glaciation, the Ohio River as we know it today did not exist. The main waterway that drained surface water from southwest and central Ohio was called the Teays River. In 1943, Wilber Stout mapped the path of that ancient river and some of its tributaries. The Teays River (Fig. 3) seems to have originated in the Appalachian Mountains and flowed through West Virginia before entering Ohio near

Wheelersburg in Scioto County. It continued to flow northwest, eventually turned west, then flowed out of Ohio just south of the town of Willshire, where Van Wert County is located today.

During this stage, ice dammed the Teays River creating a large lake called Lake Tight; it covered portions of southeastern Ohio, northern Kentucky, and West Virginia (Fig, 3). As Lake Tight filled, advancing ice and rising waters cut through ridges and old tributaries of the Teays River. This process diverted water along the glacier's ice margin and was responsible for creating the modern path of the Ohio River.

Little is known about the extent of the Pre-Illinoian stage because subsequent glacial stages destroyed or buried most of its deposits. Only a small area of ground moraines is preserved at the surface near Cincinnati, Ohio. Using the alignment of magnetic minerals preserved in sediments deposited in former Lake Tight, geologists determined that the pre-Illinoian glaciation occurred roughly 780,000 years ago during a time when Earth's magnetic poles were reversed. The combination of Lake Tight and the Appalachian foothills of southern Ohio slowed the southern progress of glaciation to the Two Glaciers Park area.

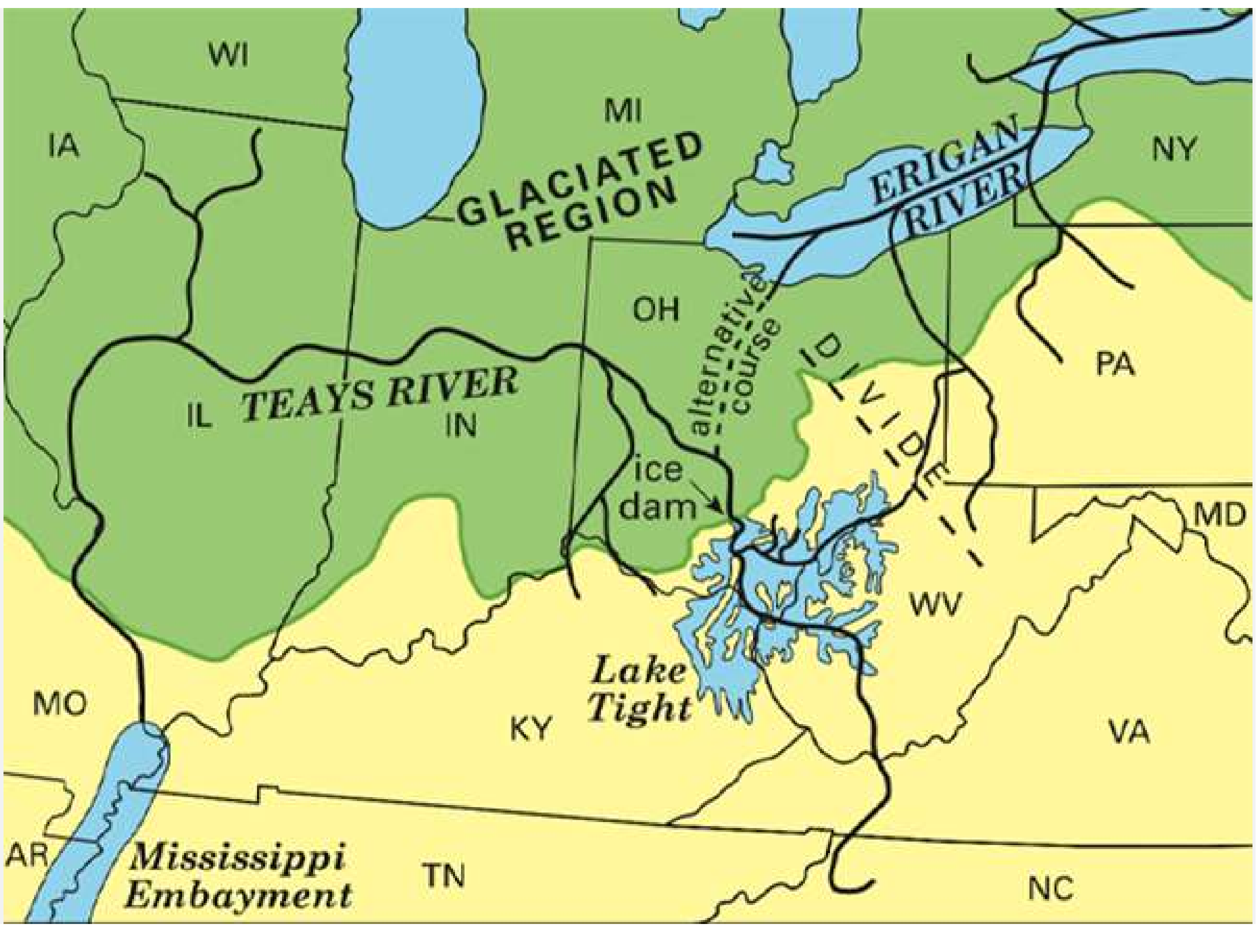

Figure 3: Map of the pre-glacial Teays River and Lake Tight, Ohio Department of Natural Resources, Division of Ohio Geological Survey, Glacial Geology, The Ice Age in Ohio.

ILLINOIAN STAGE

About 180,000 years ago, the Illinoian glacial stage advanced into Ohio, eventually covering all of Ohio except the southeast portion. The foothills of the Appalachian Plateau acted like an earthen dam and slowed the glacial advance. Geologists have estimated the ice sheet was a mile thick in places over northern Ohio. This stage of glaciation marked the southernmost covering of Ohio. Today, all that can be seen of the Illinoian glacial stage (Fig. 4) are deposits that form a narrow band of glacial moraines in parts of Hamilton, Clermont, Brown, Highland, Adams, Ross, Hocking, Fairfield, Perry, Licking, Knox, Wayne, Richland, and Columbiana Counties. Illinoian glacial deposits sit directly on top of the underlying Ordovician and Silurian age bedrock in Adams, Brown, and part of Clermont Counties. In those counties, the Illinoian deposits are buried under the Wisconsinan stage glacial advance. However, Two Glaciers Park in Fairfield County (Fig. 4) has moraine deposition from both the Illinoian and Wisconsinan stages.

WISCONSINAN STAGE

Optically Stimulated Luminescence (OSL) studies have recently modified the dates for the last glacial advance, called the Wisconsinan. OSL indicates that the Wisconsinan began roughly 35,000 years ago and ended 12,000 years before present. Further studies using OSL indicate that in between the Illinoian and Wisconsinan there was an interglacial period called the Sangamonian, starting 125,000 and ending 35,000 years ago.

Research into glacial stages will most likely reinterpret the dates for all the glacial stages. In addition to the three glacial advances discussed above, there were approximately 26 glacial advances in the last 1,800,000 years. These changes in climate affected all aspects of past environments in Ohio, including plants and animals that thrived during those time periods.

GLACIAL LANDFORMS

There are two main categories of glacial landforms: erosional and depositional.

EROSIONAL landforms are created when the actions of glacial movement carve or scoured the pre-existing landscape or substrate.

DEPOSITIONAL landforms are created when the action of glacial movement constructs or builds a new landform on top of the existing landscape from sediment entrained below, within, or on top of the ice.

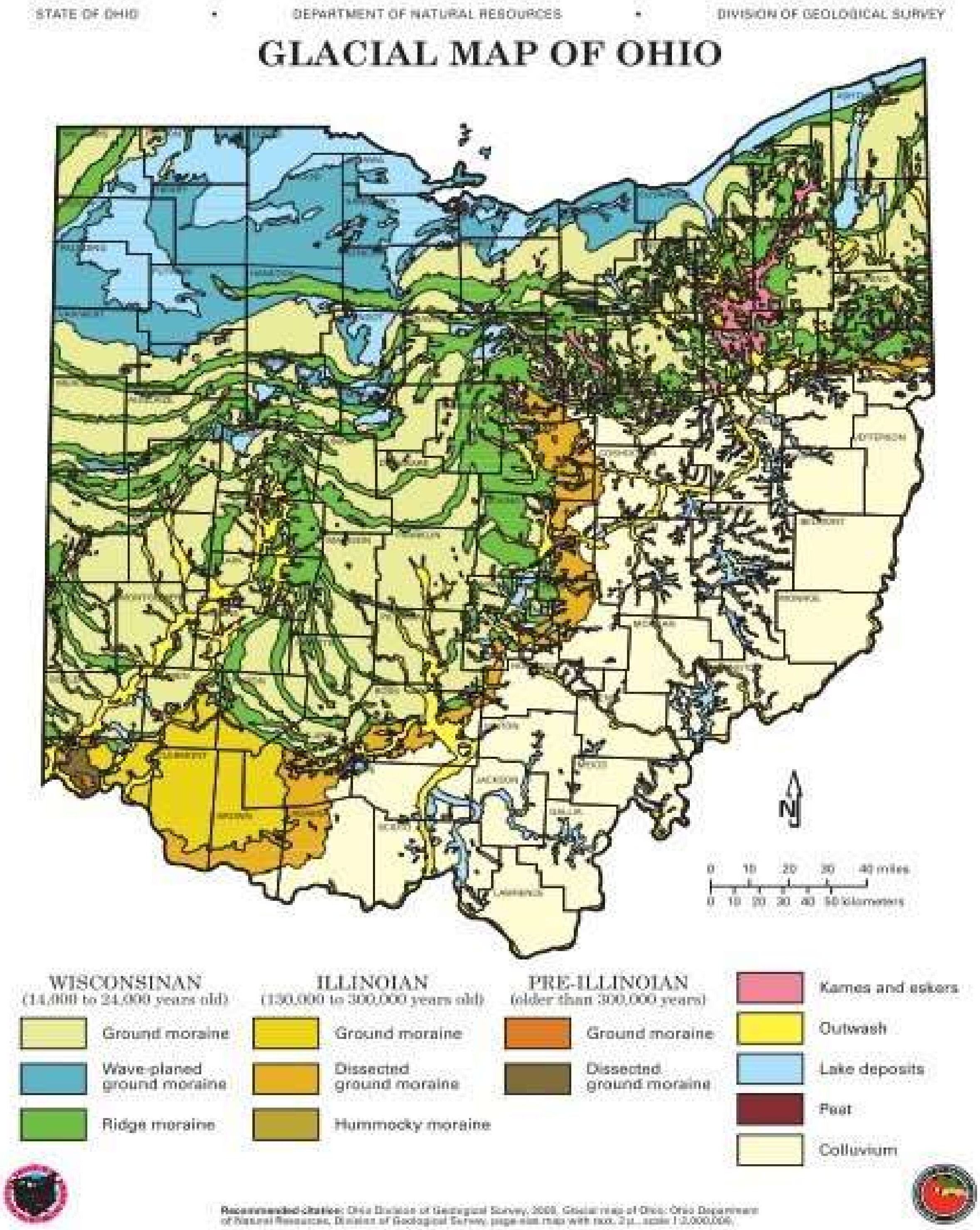

Figure 4: Ohio Division of Geological Survey, 2005, Glacial Map of Ohio: Ohio Department of Natural Resources, Division of Geological Survey, page-size map with text, 2p., scale 1:2,000,000.

ROCK CLASSIFICATIONS

Geologists use three main categories to classify rocks at the most basic level: igneous, metamorphic, sedimentary.

> *IGNEOUS* rocks are formed as molten material (lava/magma) cools and solidifies. The length of time it takes the material to cool and the chemical composition of the melt determine the composition and properties of the resulting rock.
>
> *SEDIMENTARY* rocks are the eroded and transported fragments of previously existing igneous, sedimentary, and/or metamorphic rock that are deposited as loose sediment and subsequently cemented together (lithified) and hardened. These rocks often contain layering (bedding) and fossils.
>
> *METAMORPHIC* rocks are formed by applying heat and/or pressure to previously existing igneous, sedimentary, and metamorphic rocks.

Ohio bedrock that is exposed at the surface is composed almost entirely of sedimentary rock. Because of glaciers, it is possible to find igneous and metamorphic boulders along Ohio's surface.

As glaciers advanced, they scoured giant chunks of Canada's igneous and metamorphic bedrock. Trapped in ice, boulders were transported hundreds of miles until conditions of the ice flow changed or the ice melted, at which time they were deposited in locations far distant from their origin. Called *erratics*, they are often surrounded by other glacial sediments such as *till* and *outwash*, indicating they were deposited at the same time. When erratics are clustered in a narrow band, it is called a *boulder belt*.

QUATERNARY PERIOD

The Quaternary Period began 2.6 million years ago and continues to this day.

Commonly referred to as the Ice Age, the Pleistocene Epoch of the Quaternary Period, represents most of that period, ending about 11,600 years ago. During much of the Ice Age's interglacial stages, Ohio's environment was like today with sporadic geologic deposition occurring, mostly as a result of rivers flowing out from under the melting glacial ice. However, there were periods of rapid change leading to glaciers partially covering most of Ohio. Subsequent melting of ice during various stages deposited large loads of glacial sediment which altered the landscape. The most dramatic effect was the deposition of finely ground rock which created the rich soil found in much of Ohio. Climate change during the Pleistocene epoch (2.5 million to 11,700 years ago) affected plants and animals, causing extinction of some species while new species appeared.

The last glacial advance, called the Wisconsinan Glaciation, began around 35,000 years ago and ended roughly 12,000 years ago, when ice retreated from the Lake Erie Basin. Ice reached its maximum extent in Ohio around 26,000–24,000 years ago during a time known as the Last Glacial Maximum. The presence of large continental glaciers in Ohio were most likely the result of natural fluctuations in global climate owing to changes in Earth's orbit, variations in how the Earth rotates, tilts, and wobbles. Known as the Milankovitch Cycles, they affected how much of the Sun's energy was absorbed by the planet and changed global average temperatures.

Deposits from two glacial events and four types of glacial deposits have been identified in the park (Fig. 4). There may be additional deposits not currently recognized. When a glacier moves forward, stands still, or retreats, it moves, erodes, or deposits material. Streams flowing out from under a glacier carry rock, soil, and other debris. Ground moraines are identified by their depositional position with respect to a glacier. Types of moraines include end (terminal) moraines, recessional moraines, medial moraines, lateral moraines, and supraglacial moraines.

Ground moraine material found in Two Glaciers Park is near the furthest extent of the glacial advances and is most likely a mixture of end moraine and ground moraine. The ground moraine deposits are often sub-rounded (not round) resultant of transportation by the glacial ice. Finally, large boulders were picked up by ice as far north as Canada and carried in or on the ice as the ice sheet moved south. Once the ice melts, boulders and other rock and mineral debris are left behind. These large rocks are called glacial erratics. They are easily recognized as they tend to be metamorphic or igneous rather than the sedimentary sandstones, limestones, and shales of the basement rock in Ohio. If erratics were carried at the base of the glacier, they could leave behind striation marks or glacial grooves in exposed sedimentary bedrock.

In the northwestern portion of the park, late Wisconsinan age (13,000 to 23,000-year-old) outwash terrace deposits are found. This terrace material consists of mostly boulder- to sand-size rock spread like a blanket over the underlying sedimentary limestone and sandstone (Fig. 5). The southwestern half of the park contains (18,000- to 24,000-year-old) late Wisconsinan to early Woodfordian ground moraine. Glacial deposits in the eastern portion of the park are identified as Illinoian-age outwash that date between 130,000 years ago or older.

The juxtaposition of Illinoian and Wisconsinan glacial material is unique to Two Glaciers Park.

A total of seventeen samples were collected at random locations starting from the parking lot on the eastern end of Two Glaciers Park (Fig. 5). The red arrow (Fig. 5) indicates where the *in situ* bedrock sample was collected. A search of the Ohio Geology Interactive Map identified the bedrock geology underlying Two Glaciers Park as Mississippian age, undivided Maxville Limestone, Logan, and Black Hand Sandstone Member of the Cuyahoga Formation.

Sixteen of the samples were collected in the former farm field, taken back to the laboratory, and analyzed for composition and comparison. The *in situ* sample was taken from the outcrop directly south of the parking lot (see red arrow Fig. 5). Laboratory analysis indicated the *in-situ* bedrock sample was comprised of 0.125 to 0.5 millimeter in diameter, angular to sub-rounded grains of quartz, cemented together with hematite and limonite. The exposed surface of the sample (Fig. 7) had weathered a reddish-brown. These properties are consistent with the characteristics of the ridge-forming, Black Hand Sandstone member of the Cuyahoga Formation. Of the sixteen samples collected from the farm field (see circled area in Fig. 5), two samples were identified as Black Hand Sandstone (Fig. 3), seven samples were carbonate (Fig. 9), six samples were granitic (Fig. 10) and one was chert (Fig. 11). Seven samples reacted strongly with Hydrochloric Acid (HCL); they were reddish-purple on a fresh surface and exhibited a hardness of three on Moh's Hardness scale. Six samples contained quartz and feldspar, were sub-angular to well-rounded, indicating considerable distance transport. The chert sample is white/tan, hardness of seven, with conchoidal fracture.

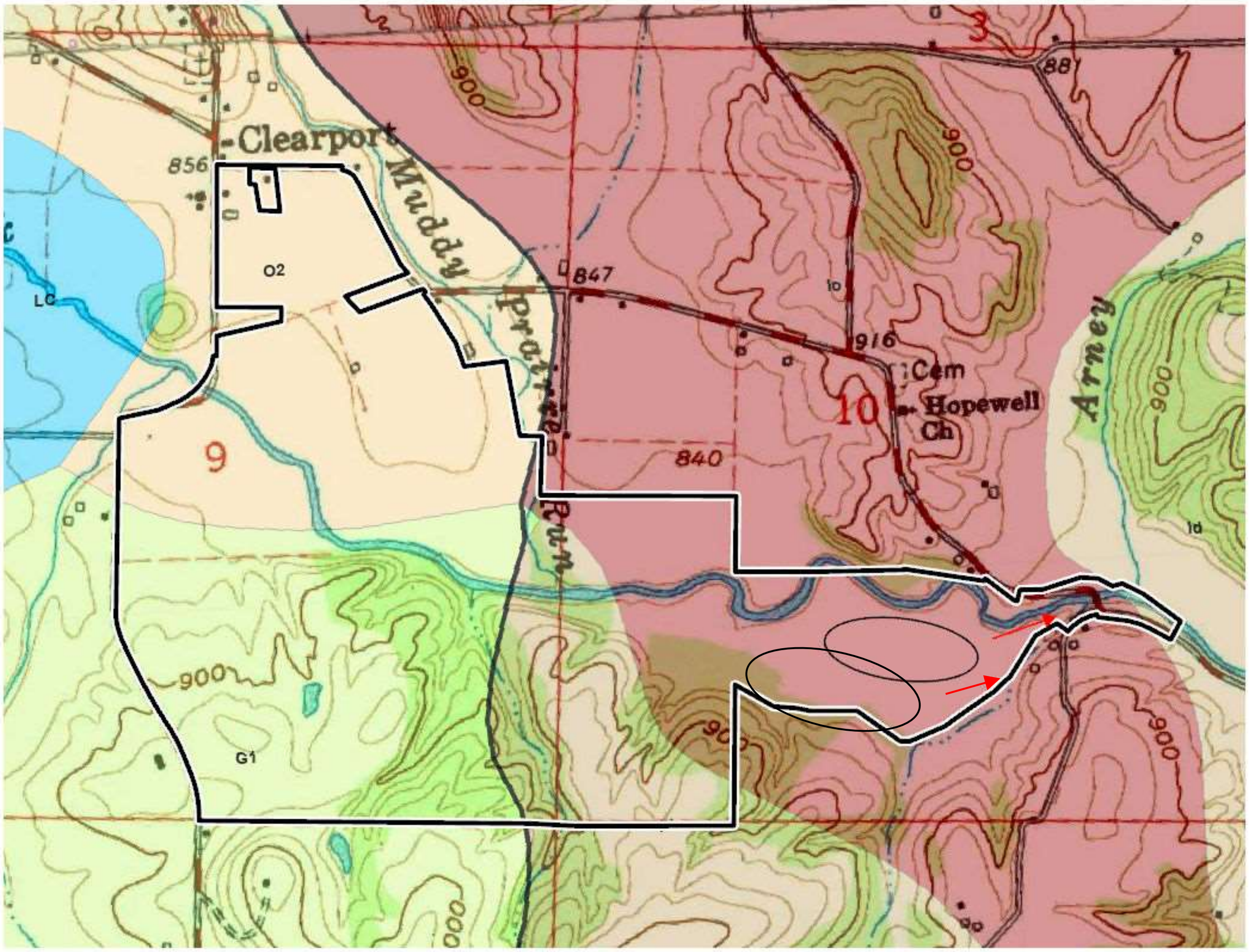

Figure 5: Map modified from Ohio Geology Interactive Map, showing surface glacial geology. Outline of Two Glaciers Park boundaries by Fairfield County GIS/Map Room.

Comparison of Bedrock Sample with Random Field Samples	Count	Hardness
In situ Bedrock (Black Hand member of Cuyahoga formation)	1	3-5
Samples matching the bedrock	2	3-5
Carbonates	7	3
Granitic (Quartz, Feldspar)	6	7-5
Chert	1	7
Total Samples Collected	17	

Figure 6: Samples collected from former farm field in eastern portion of Two Glaciers Park.

Figure 7: Black Hand Sandstone. *Figure 8: Black Hand Sandstone matching in situ sample.*

Figure 9: Carbonates. *Figure 10: Granitic.* *Figure 11: Chert.*

The Ohio Geology Interactive Map identifies bedrock geology for Ohio as sedimentary: limestones, shales, sandstones, conglomerates, claystone, and some marine siliceous chert. Therefore, the seven carbonate rocks and one chert are similar to and most likely originated in Ohio, then were transported via glacial activity, and deposited in Two Glaciers Park. Igneous granitic rocks are not found naturally existing in Ohio. Therefore, the six specimens that exhibited an igneous, granitic composition are not native to Ohio. These specimens were transported to Ohio via glacial activity. The eastern portion of the park property is overlain by Illinoian-age glacial till transported from Canada approximately (180,000 years ago).

The reason soils in Ohio, Indiana, and Illinois are so rich is a result of the ground rock and rock fragments transported from Canada during the previous ice ages. That rock chemistry mixed with local organic materials, plus the right amount of rain, contributed to making the area's soil some of the best in the world to grow crops.

In Two Glaciers Park, one can find the depositional evidence for two entirely unrelated glacial advances, the Illinoian and the Wisconsinan, that occurred approximately 100,000 years apart!

SOURCES

https://www.yumpu.com/es/document/read/30245691/glacial-map-of-ohio-ohio-department-of-natural-resources

https://www.usu.edu/geo/luminlab/whatis.html#:~:text=Optically%2DStimulated%20Luminescence%20is%20a,sediment%20was%20exposed%20to%20light.&text=Through%20geologic%20time%2C%20quartz%20minerals,nuclei%20in%20the%20crystal%20lattice

https://etc.usf.edu/maps/pages/900/973/973.htm

https://ohiodnr.gov/wps/portal/gov/odnr/discover-and-learn/safety-conservation/about-odnr/geologic-survey/glacial-geology/ice-age-in-ohio

https://www.google.com/search?q=Illinoian+glacial+deposits&rlz=1C1CHBF_enUS972US972&source=lnms&tbm=isch&sa=X&ved=2ahUKEwih8eqD4en1AhX5FjQIHcJACTsQ_AUoAXoECAEQAw&biw=1024&bih=657&dpr=1#imgrc=XuUI1u_Oz2p3lM

https://researchmethodsbp835.weebly.com/background.html

https://ohiodnr.gov/business-and-industry/services-to-business-industry/gis-mapping-services/ohio-geology-interactive-map

ACKNOWLEDGEMENTS

Special thanks go to the following National Park College students: Elaine Cox, Evan Grissom, Madellen Harkay, Michael McClure (2024) and Joshua Wacaser (2023) for analyzing the samples collected at Two Glaciers Park, for proofreading, and making comments concerning content and formatting.