How did Ohio's rocks and soils come to be? For much of its geologic history, Ohio was under water and south of the equator. As time progressed, powerful geologic forces caused Ohio to drift northward, while North America began to rotate. Also during this time, vast seas would advance and retreat, mountains would rise and be worn down, and ice sheets would come and go. That's the story the geologic walk tells with nine very different Ohios along the way. Ancient Ohio is waiting for us...

Let's get started!

WHAT'S BENEATH YOUR FEET

Your tour begins at the information panel. Take a look at the diagram of the geology beneath the Ohio State Fairgrounds (fig. 1, pg 2) and you can see what's under your feet to a depth of a few hundred feet.

The layers of rock beneath you are youngest towards the top and older at deeper levels. These rock layers seem horizontal, like the layers of a cake; but under much of the state, they are tilted down towards the southeast. That tilt combined with long periods of surface erosion causes Ohio's oldest rocks to be exposed in the southwest corner of the state and the youngest towards the southeast. In the northwest corner of the state, the rock tilts to the northwest.

UNCOVERING OHIO'S BURIED PAST

You are standing on a timeline where each foot of the walkway equals one million years of Earth time. At this scale, we would have to walk almost a mile to get to Earth's origin about 4.6 billion years ago (bya). So, we will begin more than 540 million years ago (mya), during what geologists call the **Precambrian Period**.

The Precambrian represents all time prior to the Cambrian, thus from 4.5 bya to 540 mya—almost 90 percent of Earth's history! This period is poorly

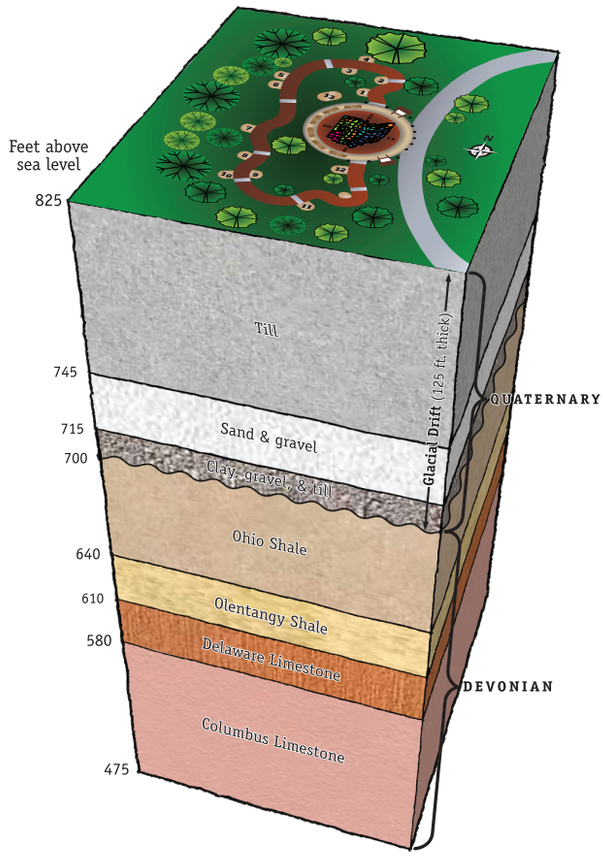


Figure 1. Geology beneath the Ohio State Fairgrounds and Natural Resources Park.

understood because the rocks are extremely deep. However, we learn about them by drilling and by sending sound waves through the ground; these sound waves bounce off the various layers underneath. Nonetheless, only a few drill holes, which are mere inches in diameter, have penetrated these rocks. So, there is little evidence to help us fully understand the geology.

During the Precambrian, granite bedrock covering Ohio was pulled apart by powerful *plate tectonic* forces, creating a huge rift basin in western Ohio. The basin was filled in with deposits of coarse-grained *sandstone* thousands of feet thick. Later, a significant mountain-building event (called an *orogeny*) in the east compressed the basin and left metamorphic rocks in eastern Ohio. The resulting layers are a complex grouping of rock types not resembling those present at the surface of the state. As you enter the walkway, the large, gray *metamorphic* boulder on your left *(Specimen 1)* represents the violent and long-lasting episodes of geologic history.

The **Cambrian Period** lasted about 55 million years and resulted in significant thicknesses of *sedimentary* rock being deposited throughout Ohio. None of these rock units are exposed at the surface, but they have been penetrated by numerous drill holes. Sandstone dominates the lowest portion of the Cambrian rocks. The deepest unit, called the Mt. Simon Sandstone, covers the Precambrian rocks. Overlying rocks grade upward from sandstone, to siltstone, to shale and eventually are capped with a thick layer of *dolomite*, a type of limestone that is rich in magnesium.

Huge deposits of oil and gas have been extracted from Ohio's Cambrian rocks. The Cambrian Period is unique in geologic history because of a sudden, widespread appearance of multicellular marine life during an event known as the *Cambrian explosion*. But Cambrian fossils are hard to find in Ohio. So, let's move on to a time when many creatures lived in Ohio and left us a fascinating record of their lives.

FOSSIL FEAST

The next stop on our journey is 450 mya, when Ohio's oldest surface rocks were deposited during the **Ordovician Period**. During the Ordovician, Ohio is about 20 degrees south of the equator, about where Australia is today, and lies under a vast, shallow sea. The depth of the water would have been about the height of a ten-story building, and coral gardens abound at the bottom of this tropical sea.

Ordovician rock such as the slab displayed here *(Specimen 2)* is sedimentary, made of seafloor carbonate mud that has been turned to *limestone*. Ohio rocks, especially in the southwestern part of the state, hold some of the finest Ordovician fossils known on the planet. Among the most famous is a trilobite called *Isotelus* (fig. 2), our official state fossil. To grow, they had to periodically shed their skins or *molt* like modern crabs. Many of the trilobite fossils found today are pieces of shed skins.

Figure 2. Isotelus maximus*, a species of trilobite, is Ohio's official state fossil.*

Some of the creatures that shared the sea with *Isotelus* include corals, clams, snails, and brachiopods. Crinoids—nicknamed "sea lilies" because they resemble flowers—often look like fossilized stems, but they are actually animals related to starfish.

Let's move forward in time, into the **Silurian Period** (around 440–410 mya). Ohio is still under a warm, shallow sea about 20 degrees south of the equator. Today, Ohio's Silurian rocks, such as the Brassfield Limestone here *(Specimen 3)*, are mined for aggregates (crushed stone) used in building roads and for salt *(Specimen 4)* for melting ice on roads. In fact, salt is under all or parts of 22 counties in northeastern Ohio.

Step ahead to the **Devonian Period** (410–360 mya). Ohio is still south of the equator by about ten degrees. Ohio also is still under the sea, but the water is shallower. The sea is filled with life. The block on display is a piece of Columbus Limestone *(Specimen 5)*, which was the rock unit used to build the Ohio Statehouse. Look for fossils such as horn corals and brachiopods.

The most terrifying creature of the Devonian seas was *Dunkleosteus*, an armored fish up to 20 feet long (fig. 3). Instead of teeth it had sharp blades of bone on powerful jaws. The best fossils of *Dunkleosteus* come from the Cleveland area, but pieces also have been found around Columbus. Replicas of its skull can be seen in museums around the world. It is certainly Ohio's most famous fossil.

Ohio Shale is a commonly dark rock that breaks into thin sheets. The *shale* formed from layers of mud on the bottom of the sea. Ohio Shale contains a lot of *pyrite*, also called "fool's gold," and it is dark because it contains significant amounts of *carbon*, which comes from the remains of ancient organisms. Both pyrite and carbon indicate the sediments were deposited in water that had little oxygen. If there had been more oxygen, the organic remains would have decayed and the pyrite would not have formed.

Spheres of rock, called *concretions (Specimen 6)*, often are found pressed between the layers of the Ohio Shale. These balls of hard rock typically formed around a fossilized fish bone or fragment of wood found at the core.

Not only are Ohio's fossils famous, so is one of its Devonian rock layers. A rock unit called Berea Sandstone is famous for three things. First, the small spaces between the sand grains can hold oil. The Berea was one of Ohio's first major oil-producing layers. By 1886, over 2,000 wells had been drilled into the Berea in eastern Ohio. Second, the Berea Sandstone was perfect for making grindstones. In the 1870s, the Berea produced over 75 percent of the entire world's supply. In fact in 1870, 10,000 railroad cars of Berea grindstones were shipped out of the quarries in northern Ohio to places all over the world. Third, the Berea is a wonderful building stone and was used in buildings all over North America, including the Michigan state capitol.

Note that during your time in the Devonian Period, you have gone from limestone to shale to sandstone. This change in rock type shows that ancient Ohio went from being under clear water far from shore to muddier water closer to shore to sandy water near the shore. Thus over millions of years, Ohio was gradually rising from the sea. So, let's move onto land.

UP FROM THE DEPTHS

You have just walked 50 million years closer to the present and are now in a time geologists have named the **Carboniferous Period**. This period is sometimes divided into two shorter intervals, the **Mississippian** and **Pennsylvanian Periods**. During your walk, North America has been moving north through the process of plate tectonics, and Ohio now sits at the equator.

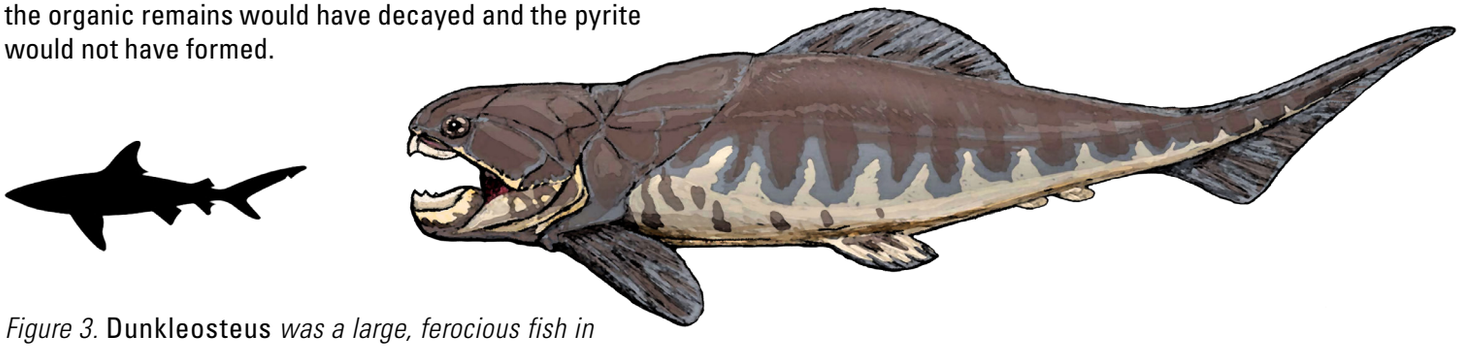


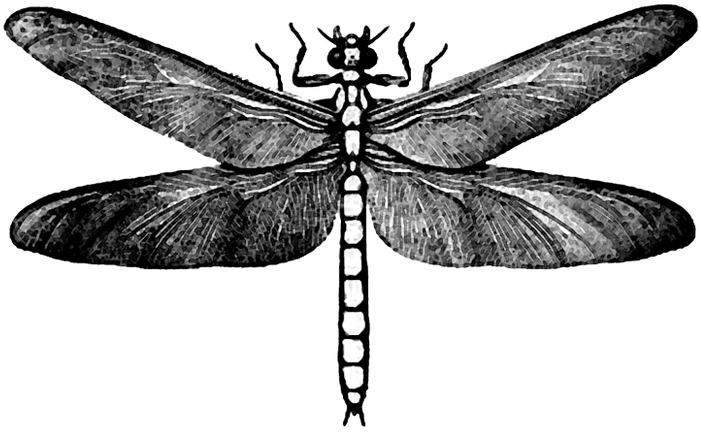
Figure 3. Dunkleosteus *was a large, ferocious fish in Devonian seas of Ohio. At almost 20 feet long, it easily dwarfed modern-day sharks.*

The land is swampy and close to sea level, the climate is warm and humid, and the vegetation is lush. Tremendous amounts of plant material sink into the swamps where, cut off from oxygen and decay, it is compressed into Ohio's most abundant fossil fuel—*coal*. Today, over 80 percent of the electricity Ohioans use is made by burning coal.

At times when Ohio was well above sea level, large rivers flowed from the Appalachian Mountains, which were rising to the east. Those rivers carried sand and gravel that would make layers of sandstone and *conglomerate*, such as the block of Black Hand Sandstone here *(Specimen 7)*. The Black Hand forms the beautiful scenery of the Hocking Hills in southeastern Ohio.

Fossils show us what kind of vegetation existed in Carboniferous Ohio. There were lots of ferns, giant reeds, horsetails, and most of the trees had scaly bark. Many animals lived among the vegetation, including the largest insects in our planet's history. For example, Ohio was home to a dragonfly (fig. 4) with wings over two feet across! Insects and other arthropods could get so big during the Carboniferous Period because high levels of oxygen were created by the plants.

Figure 4. Meganeura *was a large insect that lived in Ohio's lush, tropical climate during the Carboniferous Period.*



Just as today's scientists are worried about global climate change causing ice to melt and sea levels to rise, the level of the Carboniferous sea also was controlled by glaciers forming and melting across Africa, which at that time was at the South Pole. In Ohio, numerous coal beds formed as these sea levels rose and fell multiple times. And although rocks of Pennsylvanian age were deposited in only 18 million years, they provide tremendous economic sources of *clay*, coal *(Specimen 8)* and sandstone *(Specimen 9)* throughout our state.

In addition to bugs and coal, the Carboniferous rocks of Ohio are famous for other things, including deposits of both clay and *flint*—our official state gemstone *(Specimen 10)*. The flint from Flint Ridge in Licking County was used by prehistoric people to make tools and weapons and was traded all over North America. It also was used by Ohio's early settlers to make grindstones. Today, Ohio flint is prized around the world and sought after by artists and lapidarists to make beautiful jewelry (fig. 5).

Figure 5. Ohio flint can be shaped and polished to reveal its beautiful array of colors.

MISSING PIECES

Moving ahead to about 300 mya, we enter a barren zone. By this time Ohio has risen well above sea level. The rocks at the surface are being attacked by strong forces of *erosion* by water and wind. Instead of being preserved, any evidence of ancient conditions is being destroyed. Thus a huge amount of time is missing from the rock record of Ohio. In fact, most of the **Permian Period**, the entire **Mesozoic Era** (the time of dinosaurs), and most of the **Tertiary Period** is absent. Dinosaurs almost certainly lived in Ohio, but all the erosion prevented their bones from being buried so they could turn into fossils. This missing interval was a very long period of nearly 300 million years, so it is not to scale on the geologic walk.

During this time, as Ohio rose even further above sea level, plants evolved in complexity. Plants firmly established on land, away from swamps and seas, now relied on wind rather than water for reproductive success. Once flowering plants appeared, the diversity of plant life exploded.

ICE AGE AND THE THAW

With a few steps forward, we enter the **Quaternary Period** (1.6 mya–Present). Welcome to the Ice Age known as the **Pleistocene Epoch!** About two million years ago, ice began accumulating in northern Canada,

sending *glaciers* across the landscape. The glaciers that covered Ohio were up to a mile thick near Cleveland and 1,000 feet thick in central Ohio. Weight of the thick ice sheet actually depressed Earth's surface. Today, glaciated portions of the United States and Canada are still slowly rebounding.

Such huge sheets of moving ice are powerful agents of erosion. They scrape and gouge the rock underneath them and carry large amounts of sand, gravel, and large rocks. Rocks transported by glaciers are called *erratics*. Many erratics found in Ohio are *igneous* and metamorphic rocks, such as granite and gneiss, respectively. Erratics were brought down from Canada, where such rocks are exposed at the surface. The large rock here *(Specimen 12)* and the gray rock at the beginning of the walkway are metamorphic and are good examples of erratics.

The scraping and gouging actions of the glaciers also formed various water features, such as lakes and ponds. In fact, Pleistocene glaciers formed the Great Lakes, including Lake Erie, which is one of Ohio's most important resources and supports wildlife, recreation, and industry. Throughout the state, bedrock surfaces show scratches and grooves cut by pebbles and boulders frozen in the base of the glaciers. These grooves tell geologists about the direction of glacial movement (fig. 6).

Glaciers didn't march across Ohio just once. The ice advanced and then melted back at least a dozen times, with later advances scraping away much of the evidence of earlier ones. With each advance the plant communities were destroyed, only to reestablish as the ice melted. Only a few species could grow on the bare ground left by a glacier. Among them were white

Figure 6. The glacial grooves on Kelleys Island are some of the largest and most famous in the world.

Location Map

Stone Specimen Key†

PRE-CAMBRIAN – GLACIAL ERRATIC

ORDOVICIAN – LIMESTONE

SILURIAN – BRASSFIELD LIMESTONE

SILURIAN – SALT

DEVONIAN – COLUMBUS LIMESTONE

DEVONIAN – SHALE CONCRETION

MISSISSIPPIAN – BLACK HAND SANDSTONE

PENNSYLVANIAN – COAL

PENNSYLVANIAN – MASSILLON SANDSTONE

PENNSYLVANIAN – FLINT

PERMIAN – SANDSTONE

PLEISTOCENE – GLACIAL ERRATIC

LITHIFIED STREAM SANDSTONES

LEGEND

- **INFORMATION PANEL**
- **SANDSTONE BENCH**
- **1 STONE SPECIMENS**
- **TIMELINE MARKER**

† Not to scale.

spruce, speckled alders, and eastern arborvitae. Others, such as hemlock, required deeper soil that took a long time to form. Today, plants that like *acidic* soil, such as rhododendron, sassafras, and various maple trees, do best over sandstone bedrock found mostly in eastern Ohio. Plants that like *alkaline* soils, including various prairie grasses, redbud, and numerous oak trees, prefer a limestone base found in western Ohio.

The alternation of plant communities throughout the Ice Age also created different animal communities, best shown by two animals that lived in Ohio during the Ice Age the mammoth and the mastodon. The more common of the two was the mastodon, an animal about the size of a modern circus elephant. Mastodons lived in forested areas. Their teeth were used like mortars and pestles to grind up leaves and twigs.

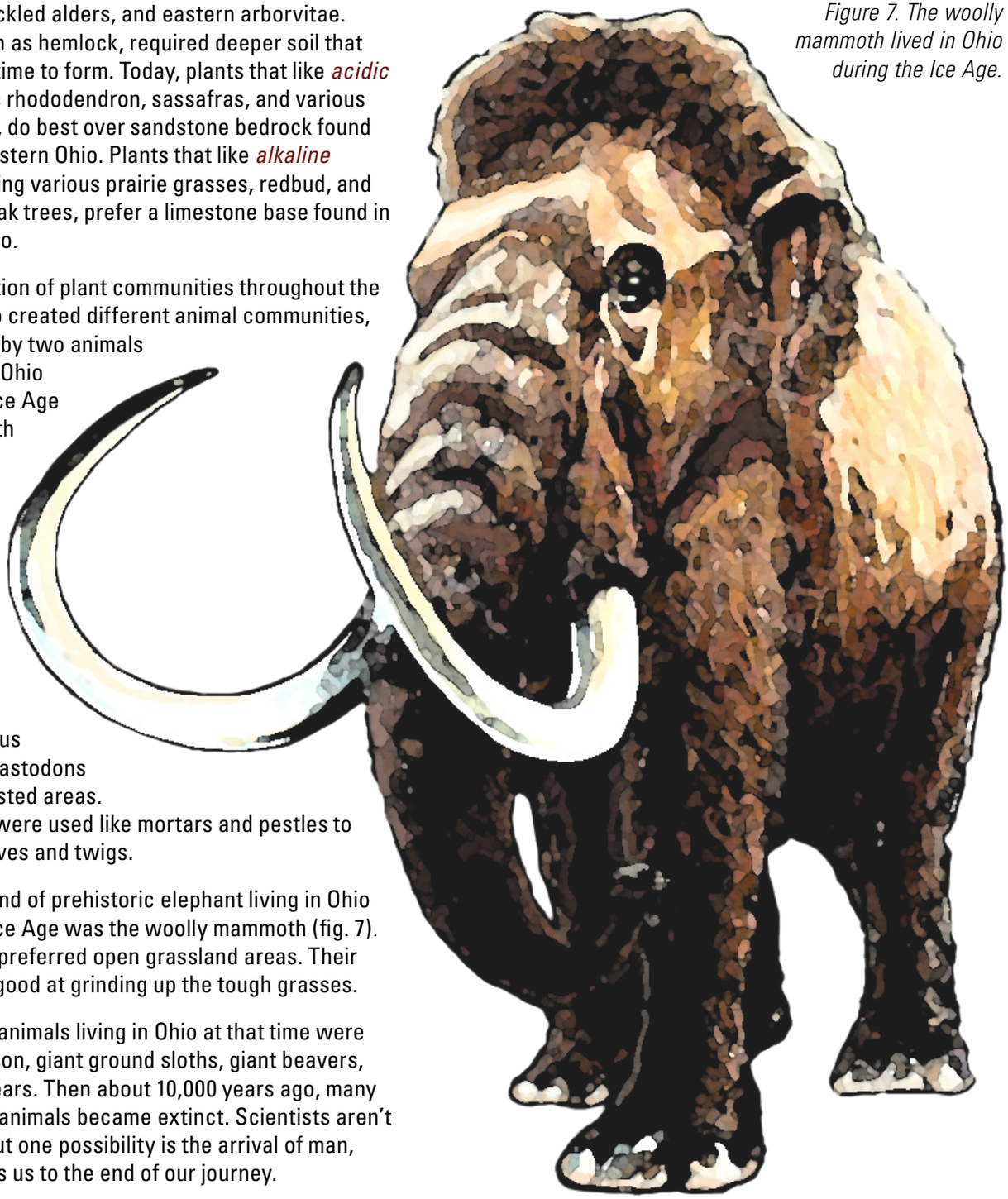


Figure 7. The woolly mammoth lived in Ohio during the Ice Age.

The other kind of prehistoric elephant living in Ohio during the Ice Age was the woolly mammoth (fig. 7). Mammoths preferred open grassland areas. Their teeth were good at grinding up the tough grasses.

Other large animals living in Ohio at that time were musk ox, bison, giant ground sloths, giant beavers, and large bears. Then about 10,000 years ago, many of the large animals became extinct. Scientists aren't sure why, but one possibility is the arrival of man, which brings us to the end of our journey.

As we return to present day, we encourage you to reflect on Ohio's fascinating geologic heritage and how it has shaped the land and has played such an important role in our state's development. We hope you enjoyed your trip!

ACKNOWLEDGMENTS

The ODNR is grateful for the hard work and leadership provided by the Friends of the Ohio Governor's Residence and Heritage Garden (FOGRHG) during the evolution of the Geological Walk Through Time. Founded in 2006, the FOGRHG is a nonpartisan, privately funded nonprofit 501c(3) organization dedicated to preserving and promoting the Governor's residence, a significant Ohio landmark.

We are also thankful for the many volunteers and donors who provided financial support and materials and gave countless hours of their time to make this project happen. For a complete listing of these volunteers and donors, see the information panel just south of the state bedrock map in the center of the pavilion.

FURTHER INFORMATION

ODNR Division of Geological Survey

ohiogeology.com

Get free downloads and educational materials and learn more about Ohio's geology.

Ohio Historical Society

ohiohistory.org

Explore Ohio's ancient past, including native inhabitants and animals, as well as its cultural and economic development as a state.

Ohio Governor's Residence and Heritage Garden

fogrhg.org

Schedule a tour of the Governor's residence and gardens, make a donation, and become a member.

For more information or to schedule a tour of the *Geological Walk Through Time,* contact:

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