Iowa's NATURE SERIES

LANDFORMS *and* GEOLOGY

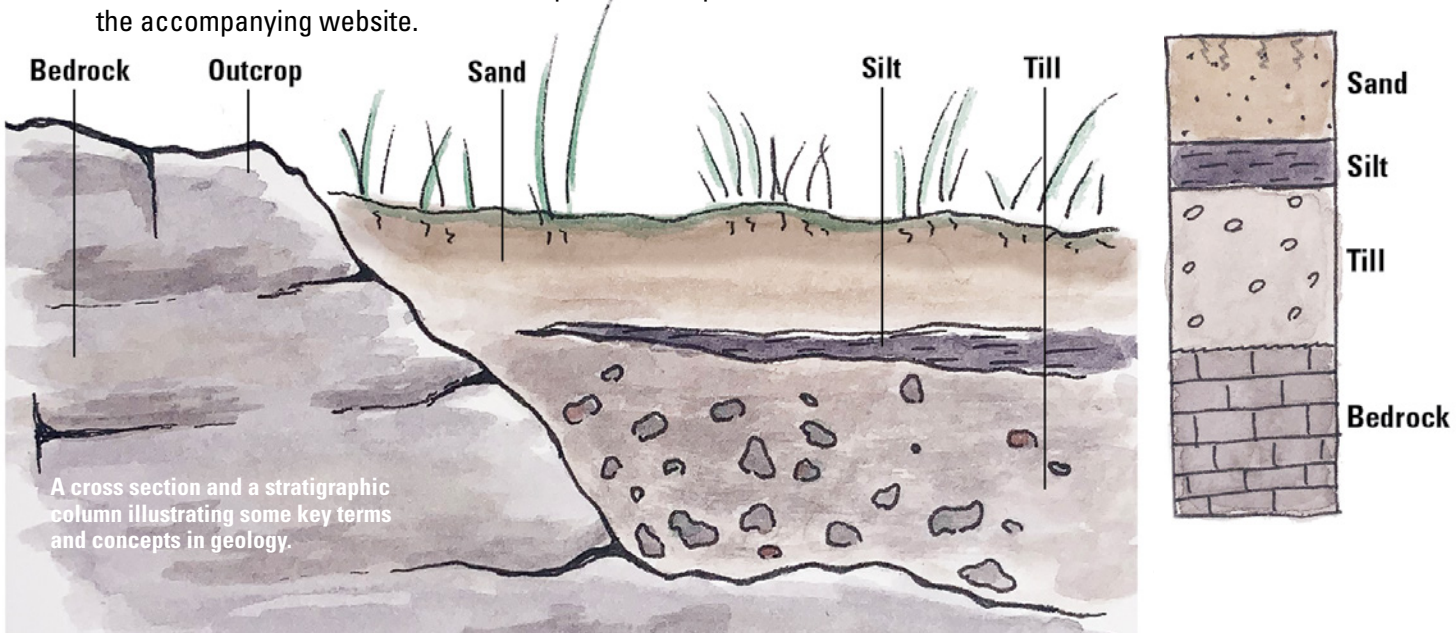
Bailey's Ford Park, Delaware County

When you peer out across a deep river valley from a rocky Iowa bluff, do you wonder why that valley is so deep? Do you wonder what the shells poking out of the rock tell us about ancient oceans? These are the kinds of questions that geologists and geomorphologists ask every day as they unravel the story of how Iowa's geology and landforms came to be. Understanding Earth's past provides valuable insight into Earth's prospects for the future. Recognizing patterns in the distribution of different landforms and rock layers guides exploration for mineral and water resources and determines their sustainability. This guide to Iowa's Landforms and Geology presents an overview of this story.

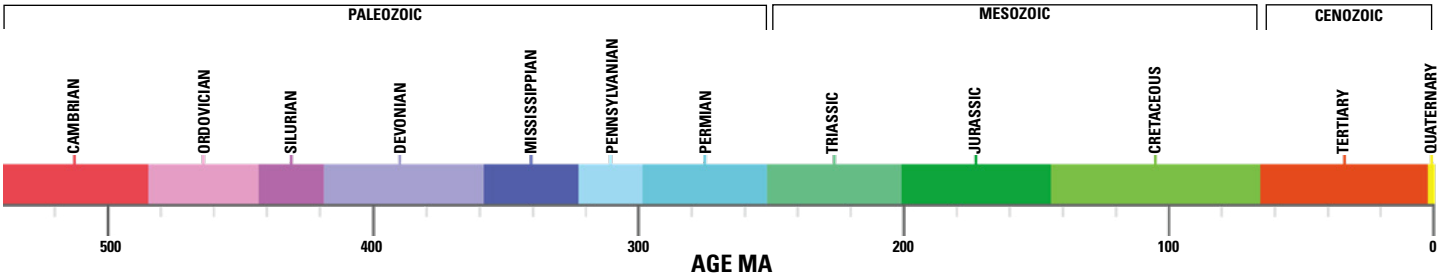
The story is organized roughly by age, beginning with the state's oldest features and rocks and ending with the youngest sediments, landforms, and water resources. Emphasis is placed on the formations and features that you can see directly along the trails in some of our state's public lands. Where possible, specific localities where you can visit rocks or features of interest on public land are mentioned. These localities are all compiled in a map on the accompanying website.

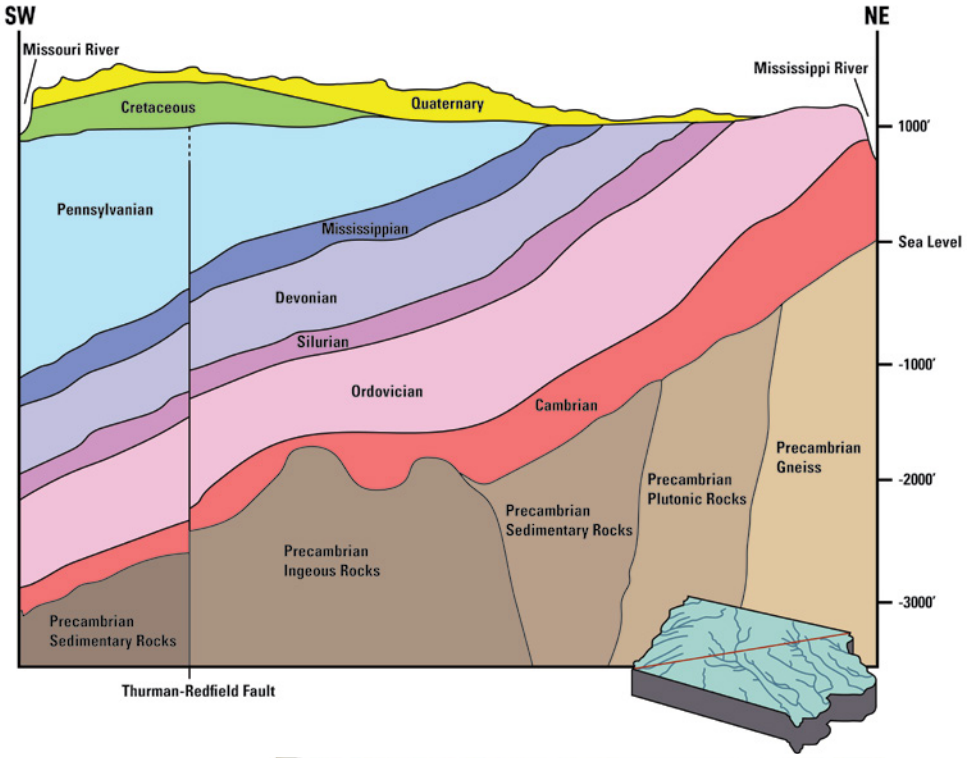
Thinking and Talking Like a Geologist

Before we dig in, let's agree on a few core concepts and terms. Looking at the drawing on this page, we see the ground surface represented on one side by solid rock, while on the other side it is a collection of loose particles. **Bedrock** is the solid rock, firmly attached to the underlying crust on which it formed. Places where bedrock is exposed at the ground surface, like in this drawing, or along a river bluff are **outcrops**. The loose particles on top of the bedrock are no longer referred to as bedrock because they have been detached from the source and transported to where it currently resides. This **unconsolidated sediment** is usually described according to the way it was transported and deposited; by wind, flowing water, or sliding glacier ice. Often, new rocks or sediments are formed on top of older rocks or sediments, leading to a sequence of geological materials that appears in a certain, systematic order. The order of layers stacked on top of one another is referred to as **stratigraphy**, and is often illustrated with a **stratigraphic column**.

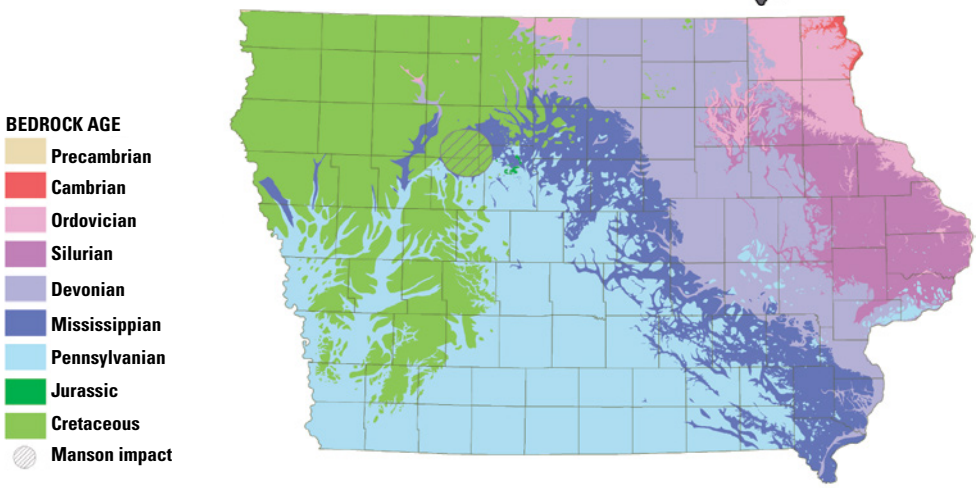


A cross section and a stratigraphic column illustrating some key terms and concepts in geology.





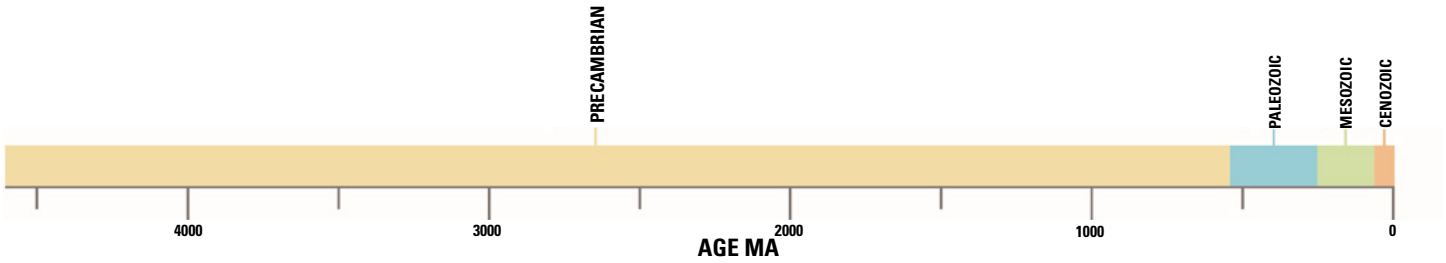
A cross-section through the upper crust of Iowa extending from southwest to northeast.

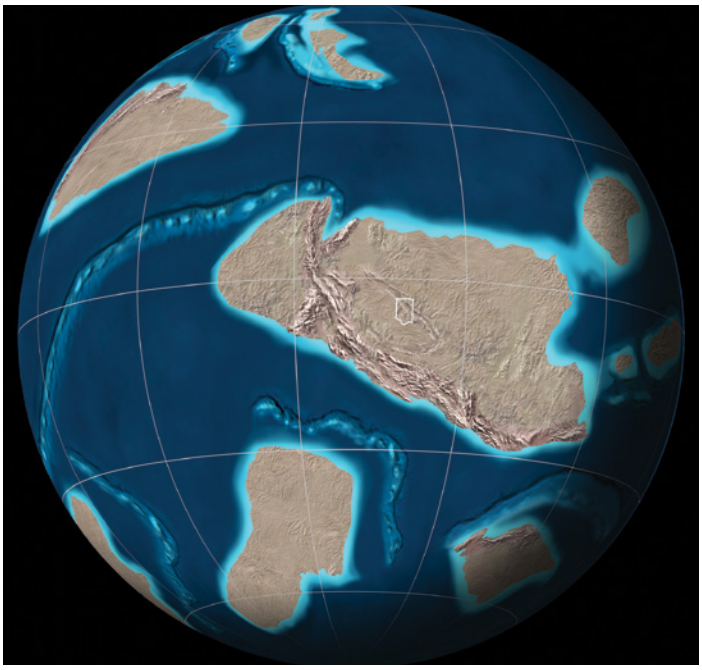


Bedrock geology map showing the age of the bedrock found nearest to the surface across Iowa. The circular feature centered near the Calhoun and Pocahontas County line is the Manson Impact structure, where a meteorite crashed into Iowa near the end of the Cretaceous Period.

Soil can form in either bedrock or unconsolidated sediment as natural physical and chemical processes interact to break down or **weather** these materials at and near the ground surface.

Geoscientists have many terms to describe and categorize geological materials and landforms. Since not all of these terms are familiar to non-geoscientists, we have created a brief glossary of terms and concepts that is included at the end of this document. You can also find a map on the Iowa's Nature companion website, naturalresources.extension.iastate.edu/Iowas-Nature, with the public parks and preserves mentioned in this guide, where you can get up close with the geology and landforms of Iowa. The map on this page shows the distribution of bedrock by age across Iowa. Think of this map as a key to what you would find if you scraped away all the soil and loose sediment from the surface to reveal the bedrock underneath: this map shows the age of the first rocks you would encounter. The timescale shows the relationship between relative age, as denoted by geological periods, and absolute age in number of years. Geologists use the abbreviation Ma to mean millions of years ago. The cross section shows the rock types and ages as if slicing Iowa vertically like a cake, where rock formations are like the cake and frosting layers stacked on top of one another with the oldest layer on the bottom. This cross-section shows rocks tilting toward the west, indicating some of the oldest rocks in Iowa are exposed in the east.





Paleogeographic map showing the position of Iowa and the early North American continent just south of the equator near the end of the Precambrian. The valley extending across the state is the Midcontinent Rift.

Precambrian Sioux Quartzite exposed at Gitchie Manitou State Preserve in the northwest corner of Iowa.

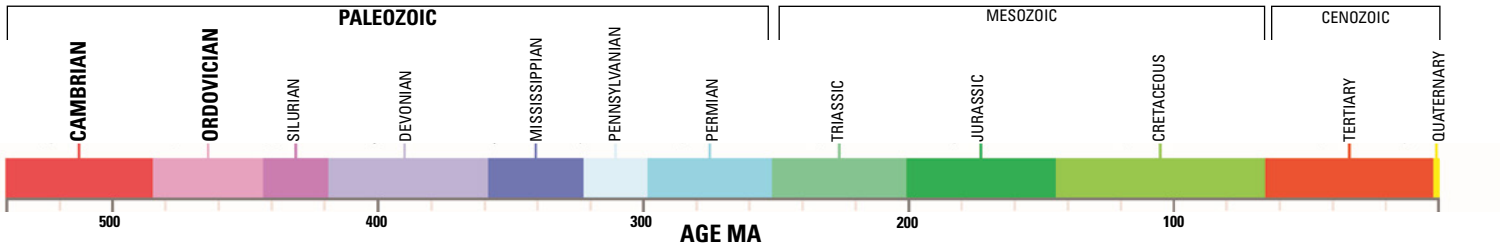
PRECAMBRIAN

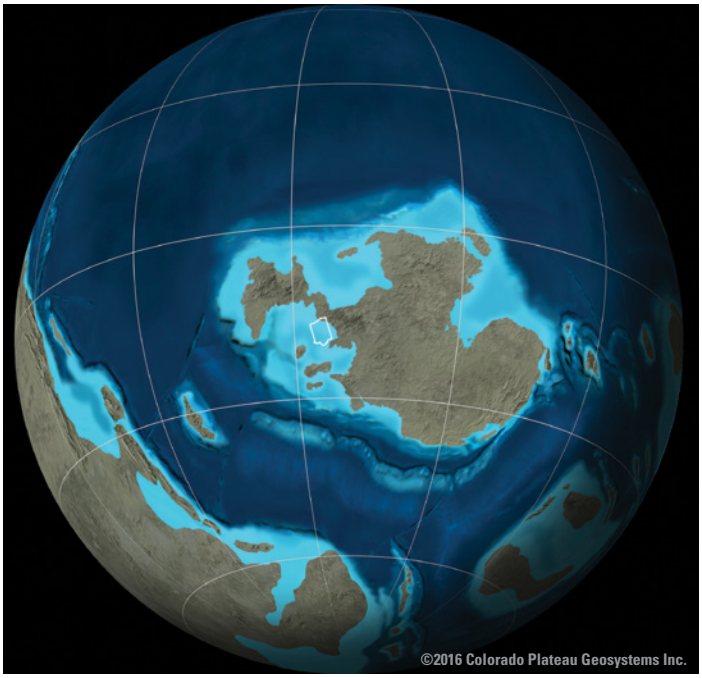
While Iowa has a rich and complex geological history, much of the record of that history is preserved in rock deeply buried and inaccessible to Iowans. Only in the very northwest corner of the state can we view any bedrock at the surface from Earth's earliest and longest period: the Precambrian. These rocks, exposed in Gitchie Manitou State Preserve are part of a formation called the Sioux Quartzite, which is a pink or red **metamorphic rock** that can be found across a large area of southeastern South Dakota and southwestern Minnesota as well.

The **quartzite** was once the **sedimentary rock** called **sandstone**, and marked the shore of an ancient ocean nearly 1.7 billion years ago. After younger rocks buried the sandstone and the sand grains were heated and compressed, **metamorphism** turned the sandstone into quartzite. Later, erosion stripped most of the overlying rock away, leaving a ridge of sturdy quartzite exposed. The Sioux Quartzite is excellent quarry stone, and is used for a variety of purposes including architectural stone, asphalt, and railroad ballast. Next time you are on the highway, look for a reddish tint in the pavement and remember the Sioux Quartzite.

Even though we can't see the rest of them, Precambrian rocks are still the foundation of our state. Drillers and **geophysicists** have been able to piece together key parts of Iowa's deep history based on Precambrian rock. Much of the inaccessible Precambrian rock is **gneiss** and **granite** from the early and middle Precambrian as continents were growing through myriad **plate tectonic** events.

A huge gash running northeast to southwest across the state is evident in geophysical surveys. Deep exploration wells show that this geophysical stripe, which cuts through the early continental rocks, coincides with 1.0-1.1 billion-year-old **basalts** and **gabbros**, **igneous rocks** normally associated with ocean crust. The arrangement of these distinctive rock types in the subsurface indicates that around 1.1 billion years ago, the early North American continent began to rift or tear apart, with the beginnings of an ocean basin filling the void. Just as rifting began, however, it ended, leaving what we now recognize as the Midcontinent Rift, extending from central Kansas across Iowa and Minnesota and into Ontario, Canada. These rocks cannot be seen at the surface in Iowa, but rift-related rocks can be seen up close on the Lake Superior shore in Minnesota and Michigan's Upper Peninsula.





Paleogeographic map showing the position of Iowa and the North American continent in the low latitudes of the southern hemisphere during the Cambrian Period. Iowa was mostly covered by a shallow sea.

EARLY PALEOZOIC

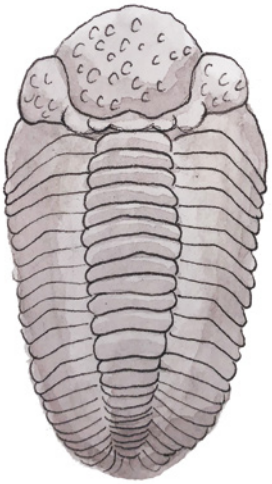
The early part of the Paleozoic Era spans about 100 million years from approximately 540-440 Ma. During much of this time, Iowa was near the equator in a warm, tropical climate. Sandy beaches and shallow reefs dominated the landscape leaving beautiful white sandstone and fossil-laden **limestone, dolomite**, and **shale**. Early Paleozoic rocks in Iowa can exceed 2,000 feet in thickness and are present over nearly the entire state, though only exposed at the surface in the northeast corner known as the Driftless Region. Common fossils include **coral, trilobites, cephalopods, brachiopods**, and **crinoids**.

One of the best places to see early Paleozoic rocks in Iowa is Pike's Peak State Park. Rocks exposed there range from late Cambrian sandstone called the Jordan Formation, upward through nearly the entire sequence of Iowa's Ordovician rocks. This is an excellent opportunity to see the two major marine deposits of the Ordovician Period as well as the sandstone, called St. Peter sandstone, and shale that separate them physically as well as hydrologically. St. Peter sandstone is a mature sandstone that is almost entirely composed of quartz. It's an important resource for glass manufacturing and hydraulic fracturing, also known as fracking, in the oil and gas industry.

Early Paleozoic rocks are an important source of reliable and clean groundwater for public, private, and industrial use in Iowa. Nearly all areas of the state have access to the Cambrian-Ordovician Aquifer, though in some areas wells must be thousands of feet deep to reach the best water. As you will see later, this water is a limited resource and can be easily depleted if not managed properly.

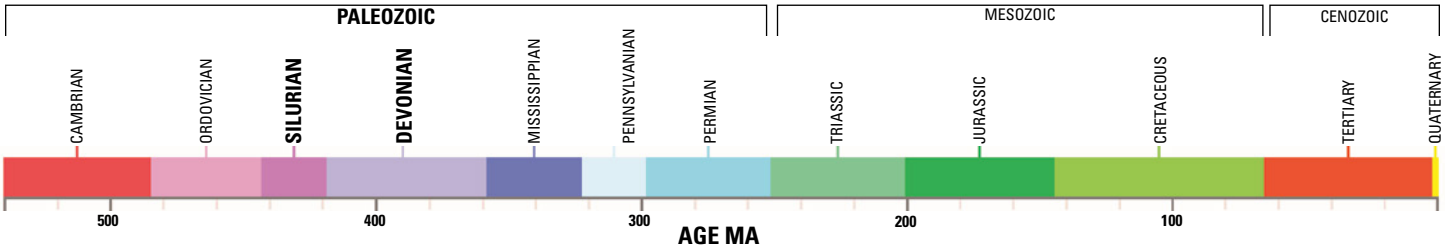
In the Driftless Region of northeast Iowa, thousands of clean cold-water springs feed rivers and streams. Rain falling on this **karst** landscape percolates down through cracks, sinkholes, and caverns in the early Paleozoic limestone and eventually dissolve enough rock to create a vast network of caves and underground rivers. When the water in these features reaches the surface, a spring is formed with water that remains a constant temperature year-round.

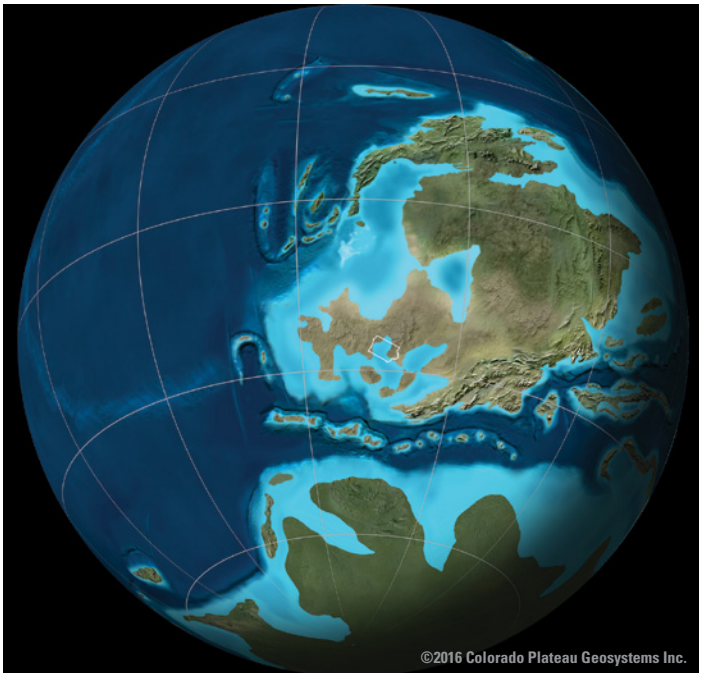
Outcrop of Cambrian sedimentary rocks at a quarry in the Driftless Region, Northeast Iowa.



Trilobites, ancient seafloor creatures somewhat similar to today's horseshoe crabs, can be found in Paleozoic rocks across Iowa.

Outcrop of the Ordovician-age St. Peter Sandstone.





Paleogeographic map showing the position of Iowa and the North American continent in the southern mid-latitudes during the Devonian Period. Note the shallow sea extending across the middle of Iowa and the large continental landmass assembling near the South Pole.

MIDDLE PALEOZOIC

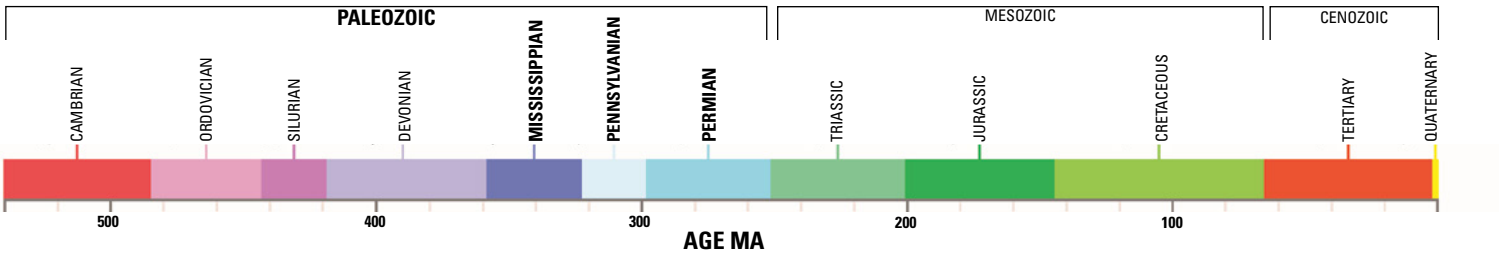
Globally, sea level rose and fell nearly 500 feet during the Middle Paleozoic (440-360 Ma). The extensive limestone and dolomite, or magnesium-rich limestone, deposits of the Silurian and Devonian Periods across central to eastern Iowa tell us that when sea level was high during these time periods, Iowa was a warm, tropical, shallow sea.

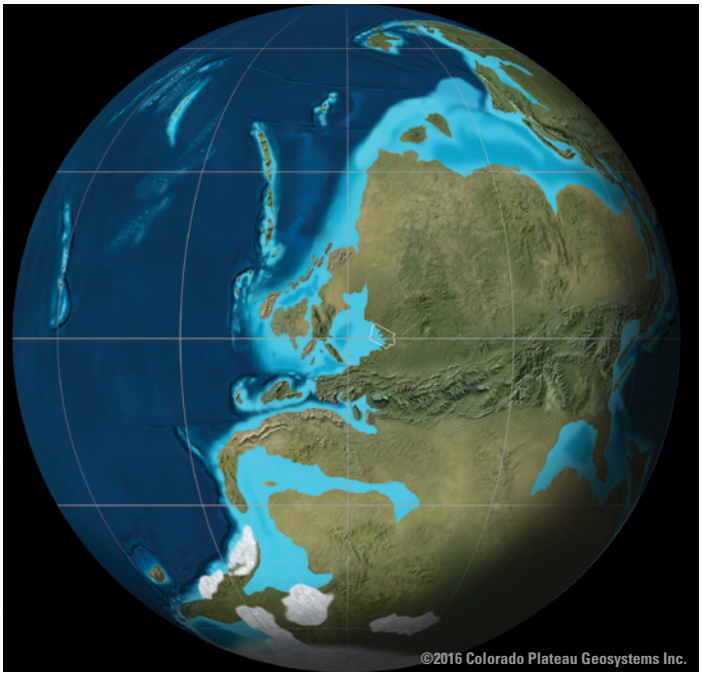
The most striking part of Silurian rocks in Iowa is the Silurian escarpment, a high east or northeast facing bluff that was carved by the ancient Mississippi River and its tributaries. You can explore the Silurian escarpment at Backbone State Park where the gorges and canyons cut through steep layers of Silurian rocks. Like the rest of the Paleozoic rocks in Iowa, the Silurian rocks slope towards the west or southwest and are topped by Devonian limestones, dolomites, and shales as you move westward.

Middle Paleozoic rocks are some of the best Iowa rocks for finding fossils. Paleozoic sea creature fossils are abundant at the Rockford Fossil and Prairie Park. Among the most common are brachiopods, which look similar to clams but were a much more primitive animal with a single organ devoted to both breathing and eating. Also common in rocks of this age are crinoids, which look like a plant but are actually closely related to starfish and sea urchins. These fossils, plus ancient coral, can also be seen at the Coralville Lake and Devonian Fossil Gorge. In fact, Coralville, Iowa is named after the abundant coral fossils found there.

Silurian dolomite exposed within Backbone State Park in eastern Iowa.

Fossils commonly found in rocks of Middle Paleozoic age in Iowa include many types of brachiopods and gastropods. Brachiopods have two shells like modern clams, but are much more primitive animals. They usually attached themselves to the seafloor with a leg called a pedicle. Grastropods, like modern snails, often have spiral or coiled shells.





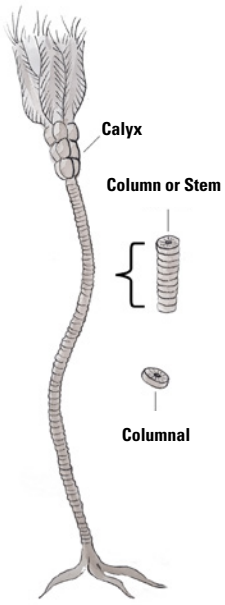
Paleogeographic map showing the position of Iowa and the North American continent straddling the equator during the Pennsylvanian Period, around 300 Ma. At this time, North America was part of the supercontinent Pangaea, the southern portion of which was covered with an ice sheet near the South Pole. The southwestern part of Iowa was covered by a shallow sea, with rivers flowing from the northeast into estuaries across central and southern Iowa.

LATE PALEOZOIC

Rocks of the late Paleozoic (~360-250 Ma) Mississippian and Pennsylvanian Periods cover a significant portion of the state. Virtually all of the southern half of Iowa is covered by rocks of this age.

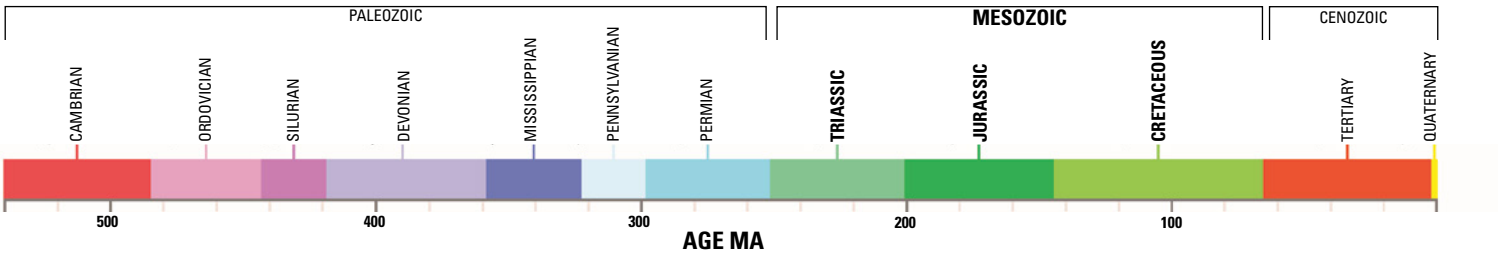
During much of the Mississippian Period (~360-323 Ma), Iowa was beneath warm, shallow seas much like those found today in the Caribbean. Massive reefs and carbonate shelves led to thick accumulation of limestone and dolomite, along with fossils of many varieties of sea life. The Mississippian in Iowa is especially well known for echinoderm fossils, which include crinoids and starfish that are found commonly around Le Grand in Marshall County and Burlington in Des Moines County. Rocks deposited near the end of the Mississippian Period in southern Iowa show that falling sea levels had exposed some land and what remained was an estuary or delta. It was here that some of the first quadrupedal animals walked on land as recorded by **tetrapod** fossils found near the town of Delta in Keokuk County. The Mississippian rocks of Iowa were also important to the native people who lived here before the Europeans because these rocks contain abundant and high quality **chert**; the raw material from which knives, arrowpoints, and other stone tools were made. Chert was obtained in significant quantity from places such as the Iowa River valley in Hardin County, and far southeast Iowa from Burlington to Keokuk.

Throughout the Midwest, rocks of the Pennsylvanian Period (~323-299 Ma) record a time of warmth and rapidly varying sea level. Iowa was poised near the shoreline of the Pennsylvanian inland sea, and rocks deposited here show deposition from river, swamp, estuary, delta, shallow marine, and deep marine settings. Sea level rose and fell dozens of times during the Pennsylvanian Period and each cycle deposited a characteristic sequence of rocks called a **cyclothem**. These cyclothems are present throughout southern and western Iowa. They are crossed by several large sandstone channels that show rivers drained from east to west on the North American continent, the opposite of today. These rivers were draining mountainous regions to the east in Appalachia; the sandstone can be seen at state parks such as Dolliver, Ledges, and near the Lake Red Rock dam. Parts of cyclothems can be seen at state parks such as Wildcat Den and Pammel, and at Saylorville Lake.



Crinoids were bottom-dwelling organisms related to modern day starfish, but were fixed to the seabed with a "holdfast" and a stalk or stem, leading up to a flower-like structure called a calyx. Rarely are complete crinoids found; more frequently, we find individual columnals or column segments.

Pennsylvanian rocks along the shore of Lake Red Rock record rising and falling tides in ancient river estuaries. A ballpoint pen balanced on the rocks in the foreground gives a sense of the scale of this outcrop. This section represents just one fraction of a full cyclothem.



Paleogeographic map showing Iowa and the North American continent in the middle northern latitudes during the late Cretaceous period, around 80 Ma. High sea levels and mountain building along the west coast led to the Western Interior Seaway extending across the continent.

MESOZOIC ERA

The Mesozoic Era, commonly thought of as the age of dinosaurs, spans from 250-65 Ma. In Iowa, Mesozoic rocks include localized Jurassic Period gypsum deposits in Webster County near Fort Dodge, as well as extensive sandstone and mudstone rocks of the Cretaceous Period in western Iowa.

Though small by area, Jurassic gypsum deposits near Fort Dodge are the most economically important Mesozoic rocks in Iowa. They are mined extensively for making dry-wall and other industrial products. They resulted from seawater evaporating in a geographically restricted basin. A similar process leaves behind salt in modern salt flats in western states like Utah. Jurassic gypsum can be seen in just a few places in Iowa, including Snell-Crawford Park in Fort Dodge.

During much of the Cretaceous Period, the Western Interior Seaway stretched across North America from the Gulf of Mexico to the Arctic Ocean and covered most of western Iowa. Rocks deposited in river, beach, and shallow marine environments are found in Iowa as a result. The most dramatic event in Iowa during the Mesozoic was the impact of a large meteor near Manson in Calhoun County 74 million years ago. The meteor was more than one mile in diameter and left a crater 24 miles wide and thousands of feet deep. The crater is no longer visible because more recent glacial debris covers it. The explosion and shockwave from such an impact would have killed all living things for hundreds of miles in all directions. In fact, at one time this meteor was considered a leading candidate for causing the extinction of the dinosaurs, but careful dating of crater materials indicated that the Manson structure is millions of years too old to have caused the extinction.

Why aren't dinosaur fossils found in Iowa?

Much of the upper bedrock throughout western Iowa is late Cretaceous – an ideal age for finding dinosaurs. Yet only a few small fragments of dinosaur fossils have ever been found in the state, and these were most likely transported to Iowa by glaciers. The Cretaceous rocks of Iowa are remnants of the eastern edge of the Western Interior Seaway. They are mudstone, shale, sandstone, and some limestone formed on deltas, swamps, or in shallow seawater. Though dinosaurs were likely present in Iowa when these rocks were deposited, the rock types that have been preserved to the present day are unlikely to contain or to have preserved large fossils due to the environments in which they formed. Also, these rocks are rarely exposed since loess and till cover the region.

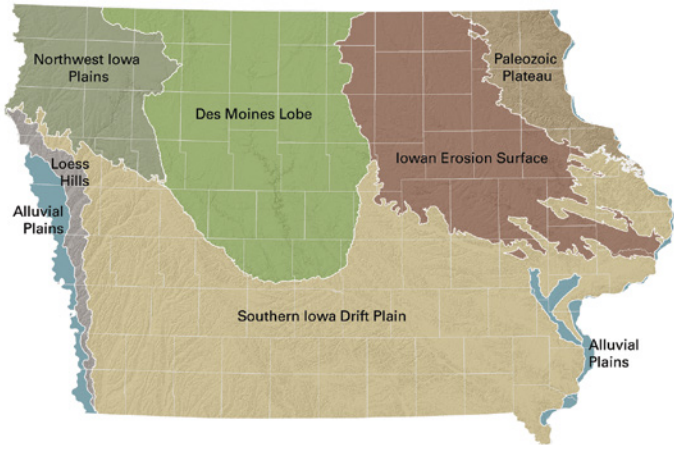
Jurassic gypsum deposits outcropping along Soldier Creek at Snell-Crawford Park in Fort Dodge.

LANDFORMS

Nearly all of Iowa retains some evidence of continent-scale glaciation events during the most recent geological period: the Quaternary. This evidence takes the form of **till**, which covers the bedrock across most of Iowa's landscape. Dig a hole a few feet deep in most parts of Iowa's uplands and you'll find till from one of at least three glacial episodes: the Wisconsinan, the Illinoian, or pre-Illinoian, from youngest to oldest. Exceptions to this rule would likely be for one of two reasons: 1) there is till deeper down, but it is covered in **loess**; or 2) there may have been till present at one time, but it has been eroded away. Indeed, these exceptions allow us to divide the state of Iowa into landform regions, each of which has distinct soils or landscape features evident at the surface.

The Paleozoic Plateau region in northeast Iowa, is the one landscape where direct evidence of Quaternary glaciation is difficult to find. The landscape is dominated by rivers and streams cut deeply into Paleozoic bedrock, creating rock bluffs capped in some places with windblown loess. A hike through Yellow River State Forest or White Pine Hollow State Forest trails develops an appreciation for the steep terrain, rock bluffs, and expansive vistas.

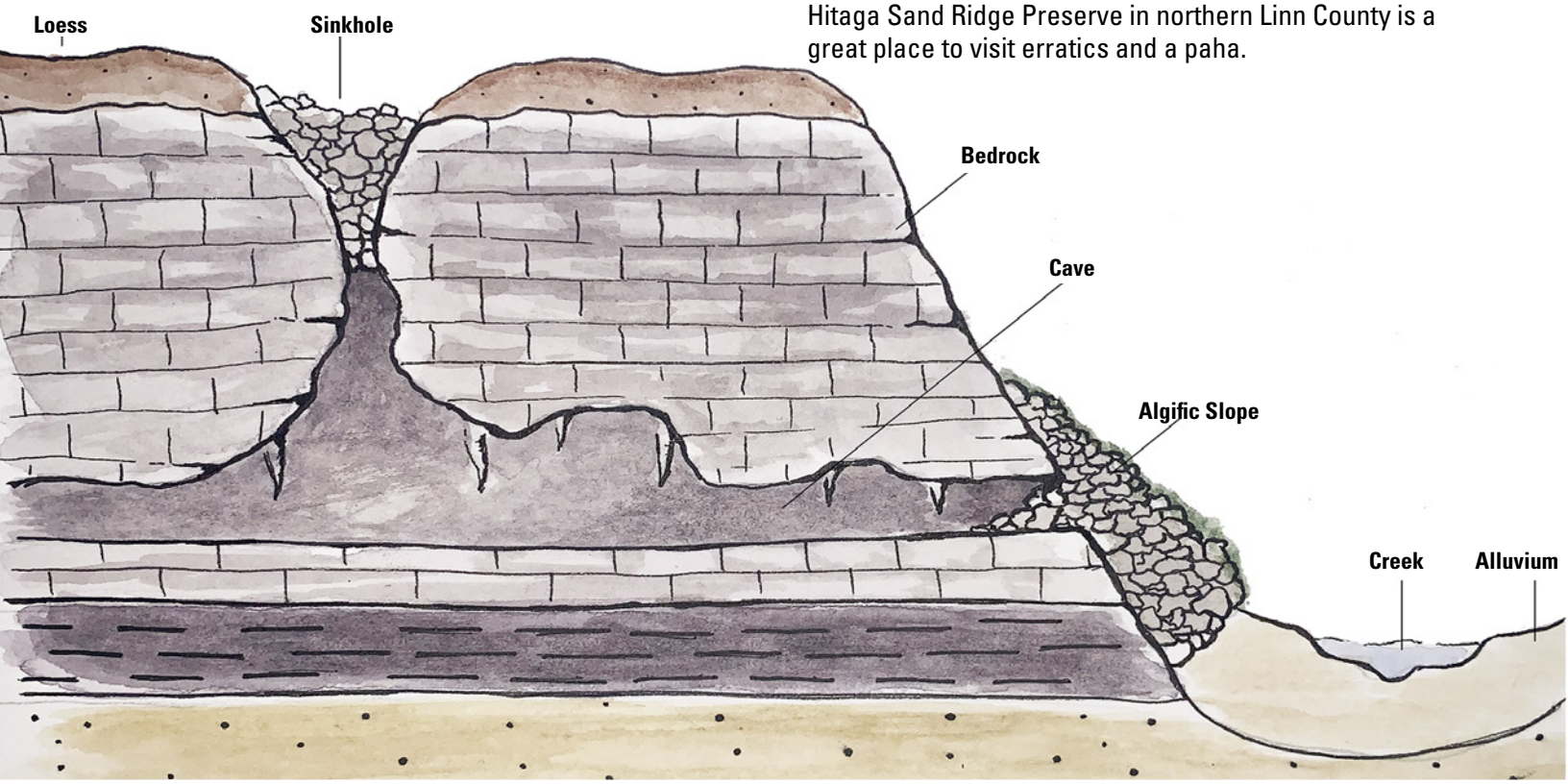
The Southern Iowa Drift Plain is in eastern and southern Iowa, where thick blankets of pre-Illinoian and Illinoian till cover the underlying bedrock. This till is covered with wind-blown sediment called loess from the two most recent glacial episodes. While glaciation tends to leave a flat landscape dotted with wetlands, like those seen today



Landform regions of Iowa.

in the Des Moines Lobe, the glaciations that affected the Southern Iowa Drift Plain were so long ago that extensive erosion by rivers and creeks has reshaped the landscape into rolling hills with rounded hilltops. The Neal Smith National Wildlife Refuge in Jasper County is a great place to see this older glaciated landscape.

The Iowa Erosion Surface, just west of the Paleozoic Plateau in northern Iowa, has a similar history to the Southern Iowa Drift Plain, except that it was likely colder and drier during the more recent Wisconsinan glaciation and most of the loess that probably once capped the till was eroded away. Where the loess remains in this region, it is primarily found in long linear ridges called **pahas**. The topography in the Iowan Erosion Surface region is more subdued than in the drift plain, with long gentle hillsides littered with isolated boulders called **glacial erratics**. The Hitaga Sand Ridge Preserve in northern Linn County is a great place to visit erratics and a paha.



Common landscape elements in the Paleozoic Plateau landform region include steep bedrock bluffs overlain with loess, upland sinkholes and caves in the bedrock. One unusual feature in parts of the Paleozoic Plateau is an algific slope, where talus blocks a cave entrance on north-facing bluffs, maintaining cold soil conditions and distinctive plant and animal communities.

The north central and northwestern portions of Iowa were affected by glaciers more recently than the rest of the state, and this gives the landscape a character that is distinct from the southern and eastern regions. The ice sheet that covered much of North America during the Wisconsinan episode advanced into Iowa at least twice in the past 50,000 years. The resulting landscape is referred to as the Northwest Iowa Plains, and is characterized by plains with till covered by a thin layer of loess. The last ice sheet advance sent a tongue of ice known as the Des Moines Lobe all the way to Des Moines. As the Des Moines Lobe ice tongue retreated and ice disappeared from Iowa's landscape, it left behind a vast, open plain with irregular hills or ridges of till, occasional lakes, and extensive wetlands. In contrast to the older glaciated landscapes found elsewhere in Iowa, not enough time has elapsed in this portion of the state for erosion to level the glacial landforms and sculpt smooth, rolling hills. A variety of knobby hills, **kettle holes**, and **moraines** remain as a record of this most recent glacial event, as exemplified by Pilot Knob State Park.

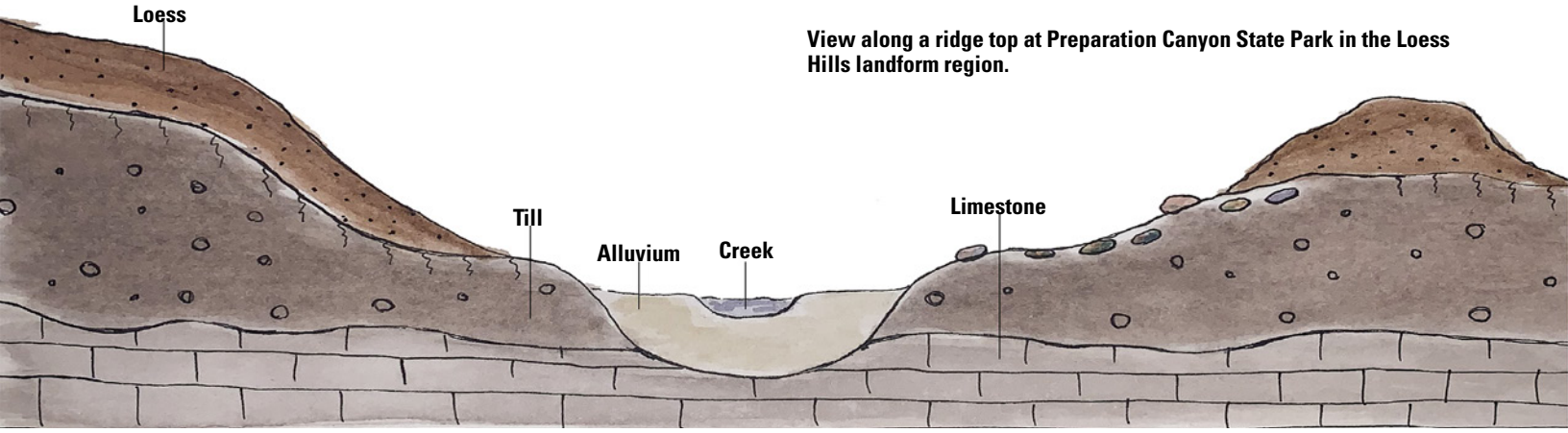
Even though only a fraction of Iowa was directly affected by ice during the Wisconsinan episode, all regions of the state were affected by ice age conditions. The only landform region that escaped loess deposition was the Des Moines Lobe, because it remained occupied by ice at the time. The western edge of Iowa along the Missouri River Alluvial Plain has the deepest and most spectacular loess deposits, piled thickly on top of older glacial deposits or bedrock and later shaped into steep hills and ridges by erosion. Some excellent examples of the Loess Hills landscape can be found in Waubonsie State Park in Fremont County, Preparation Canyon State Park in Monona County, and Broken Kettle Grasslands Preserve in Plymouth County.

Loess

The ice age Missouri and Mississippi Rivers and many other smaller rivers within the state carried meltwater and sediment away from the melting ice sheet margin, depositing enormous quantities of sand and silt in their alluvial plains. With strong westerly winds and little vegetation to anchor these fine sediments, the fine sand and silt were lifted out of the river valleys and spread across the landscape, coating almost every surface in a few inches to more than 100 feet of fine-grained sediments. We call these glacially-derived, wind-blown sediments, loess (pronounced to rhyme with bus).

A typical view across the dissected topography and rounded hilltops of the Southern Iowa Drift Plain.

View along a ridge top at Preparation Canyon State Park in the Loess Hills landform region.



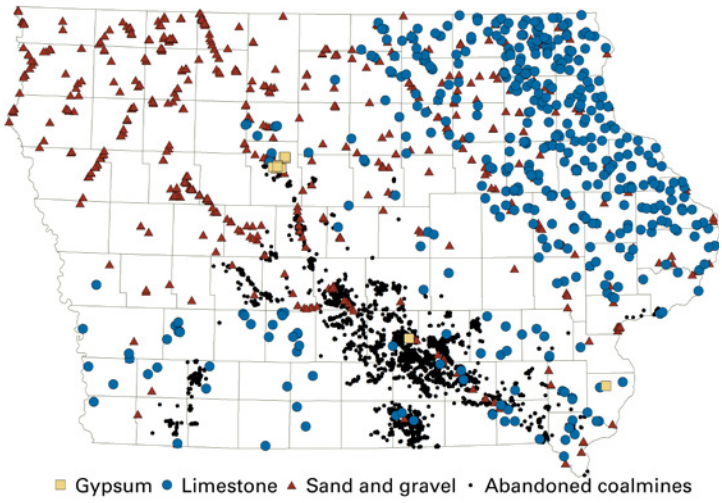
Typical stratigraphy and landscape features of the Southern Iowa Drift Plain (left) and the Iowan Erosion Surface (right). In both landform regions, pre-Illinoian till overlies bedrock. Loess covers most of the landscape in the Southern Iowa Drift Plain, but is limited to a thin veneer or paha ridges in the Iowan Erosion Surface.

MINERAL RESOURCES IN IOWA

As long as people have lived in Iowa, they have been collecting and mining rocks and minerals. Indigenous people in Iowa collected, used, and traded a rock called chert for making stone tools. Chert is extremely durable and is easily flaked to a sharp edge making it ideal for a variety of tools such as arrowheads, knives, and hide processing tools. Several types of chert from Iowa were traded extensively including Burlington chert from southeast Iowa, Maynes Creek chert from central and north central Iowa, and a variety of Pennsylvanian-age cherts from south central and southwest Iowa. Indigenous people of Iowa also made extensive use of high-quality clay deposits for making ceramics and selected igneous erratics such as **diorite** found in glacial gravel and till for making tools such as axe heads.

Iowa has a long history of mining for a variety of mineral resources. In fact, it was the discovery of lead ore in northeast Iowa along the Mississippi River in the late 1700s by Julien Dubuque that led to the first permanent European settlement in Iowa. These lead deposits were relatively easy to recover and the mines were abandoned within a few decades after being depleted of ore.

A typical stone quarry in the Iowa landscape. Nearly every county in Iowa has quarries for stone, sand, and gravel.



Map of the key mines in Iowa producing crushed stone, gypsum, and sand and gravel. Also shown are the areas of historical coal mining, now abandoned or re-purposed.

Later in the 19th century, Iowa became one of the top producers of coal to feed the Industrial Revolution. Coal deposits are still found in abundance over much of the central and south central part of the state, but coal is no longer mined in Iowa. The coal was formed at the same time as the famous coal deposits of Pennsylvania, but Iowa coal contains significant amounts of sulfur and does not burn as cleanly as eastern or western coal. Coal mining in Iowa was largely suspended by the 1960s for environmental reasons.

Also beginning in the late 19th century and continuing today, Iowa has been a major producer of gypsum for industrial uses. Most Iowa gypsum is mined to produce drywall for the construction industry. Gypsum is found near Fort Dodge and also in southeast Iowa.

Before railroads made it feasible to transport ore from the Iron Range in Minnesota, Iowa was briefly a player in mining iron for making steel. Hilltops near Waukon in northeast Iowa were mined using open pits and the ore transported to St. Louis for smelting using Mississippi River barges. These iron mines operated from the late 1800s through the early 1900s.

Extensive clay deposits of various geologic ages were heavily mined in the 1800s through the 1900s for making ceramic products like pipes, tile, and kitchenware. In some locations, these clay sources are still mined to make bricks.

Today, most mining in Iowa is related to the construction aggregate industry. Iowa is rich in quality limestone bedrock, sand and gravel, all necessary for producing high-grade concrete products. Limestone from Iowa is used in concrete applications requiring the greatest strength such as interstate highways and airport runways.

The Geode: State Rock of Iowa

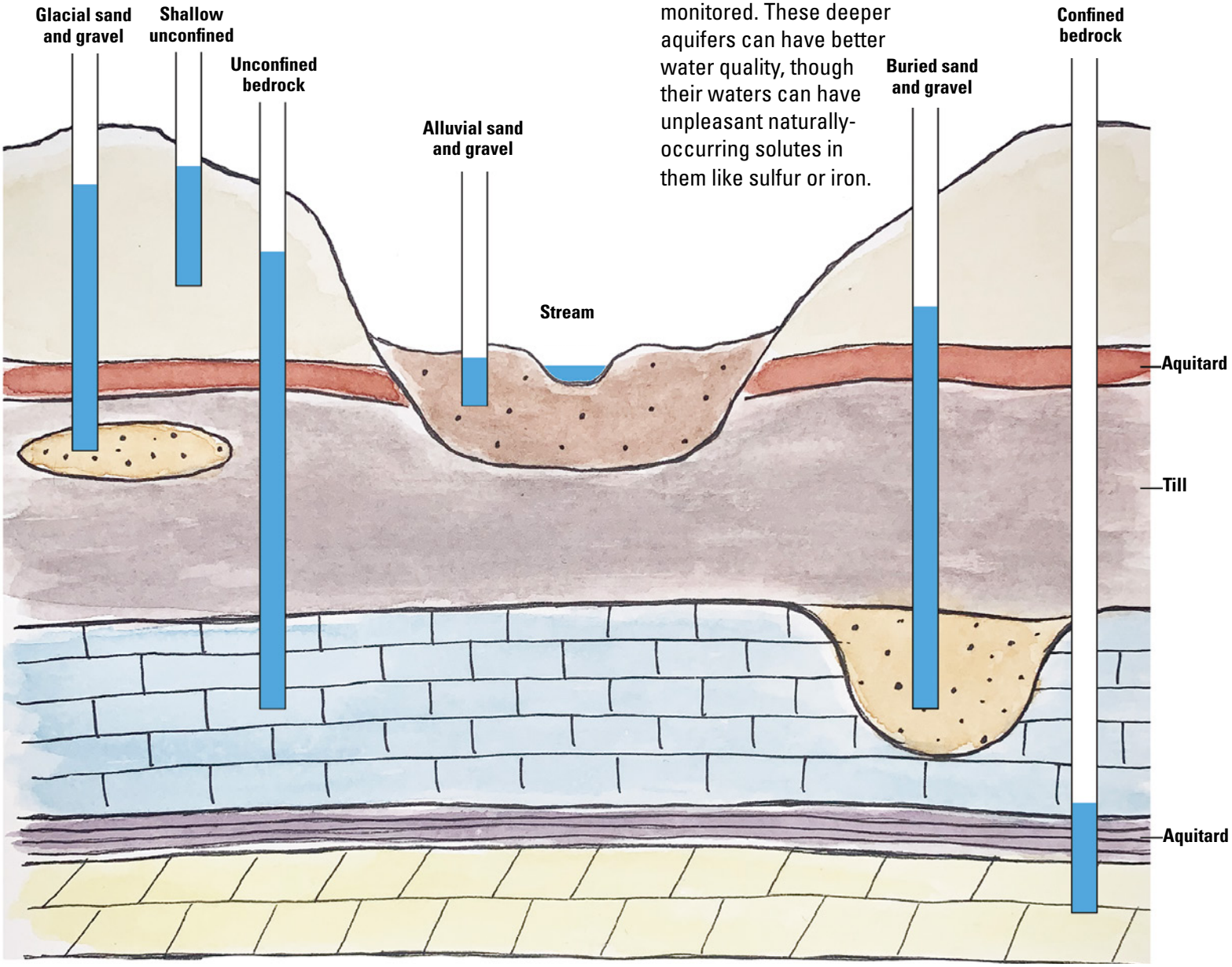
Geodes are typically spherical, hollow rock formations from 2-8 inches across and often contain a wide assortment of beautiful crystals when split. Opening up a geode is always exciting since the contents are unpredictable. More than two dozen different minerals can occur in Iowa geodes, but the most common are quartz, calcite, dolomite, and chalcedony. Southeast Iowa is known worldwide for geodes found in the Mississippian-age Warsaw Formation (340 million years old), which is composed of easily-eroded layers of shale and limestone. The geodes formed in these layers are more resistant to breakdown than the surrounding rock, and so are left behind in creeks and rivers adjacent to or downstream from eroding rock bluffs. Geode State Park near Keokuk,

WATER

The availability and quality of drinking water is also strongly affected by geology. Iowans get their water from three main types of sources: surface water bodies like rivers and reservoirs; shallow **aquifers** that store water in the gravels and sands of river and glacial deposits; and deep aquifers that store water in voids and cracks within bedrock. Each of these water sources has benefits and drawbacks associated with the presence and accessibility of different rock or sediment layers and their proximity to sources of contaminants. Most Iowa homes and communities get their water from a combination of sources.

Surface waters are the easiest to access, requiring little energy to pump into water supplies, but these water bodies can quickly be affected by contaminants and can be susceptible to drought and flood. As a result, many areas in Iowa get drinking water from wells drilled into underground aquifers. Shallow aquifers in unconsolidated sediments can come from one of three different sources. Alluvial aquifers are river valleys filled with enough sand and gravel to store large volumes of water. Buried valleys are similarly made of river sediments, but are covered with deposits that restrict groundwater flow called **aquitards**. Finally, loess aquifers occupy the base of loess layers where the loess sits atop low-permeability tills.

Deep, or bedrock aquifers can either be unconfined or confined, differing in the extent to which surface waters can percolate into the aquifer over large areas. Unconfined bedrock aquifers share many similarities with shallow unconsolidated aquifers, except they may be deeper and recharged with water over longer timescales. Confined bedrock aquifers are recharged over much longer timescales which both effectively isolates them from surface contamination and means they can be depleted if we pump too much water out. The Cambrian-Ordovician aquifer is one of the most important confined aquifers for Iowa and its water levels are closely monitored. These deeper aquifers can have better water quality, though their waters can have unpleasant naturally-occurring solutes in them like sulfur or iron.



Schematic illustration of different types of surface and groundwater resources commonly used in Iowa. The blue represents typical water levels in wells drilled into the aquifer in each stratum.

Fossils and Minerals

Iowa's long geologic history has left behind a diversity of fossils and minerals that modern Iowans can find and enjoy. Here are 9 fossils and minerals that can be found across the state.


Brachiopods


Horn corals


Corals


Cephalopods


Trilobites


Petrified wood


Crinoids (stem segments)


Gastropods


Agates


Lepidodendron (tree-like plant fossil)


Geodes


Fossil teeth

GLOSSARY

Algific Slope: A rare ecosystem found only on steep, rocky, north or east-facing hillsides in the Driftless Region of northeast Iowa (Paleozoic Plateau). These slopes support communities of rare plants, animals, and mosses that are often found nowhere else in the area. Rainwater and meltwater percolate into the subsurface and turn to ice during the winter; supporting the unique biology by continuous cold-air output during the warmer months as the subsurface ice slowly melts.

Alluvium: Unconsolidated, clay, silt, sand, or gravel that has been transported or deposited by water.

Aquifer: An underground layer of permeable rock, sand, gravel, or other material that is capable of holding and transmitting water. Aquifers are capable of releasing their water as springs or seeps, and also are tapped by drilled wells for drinking or other applications. Aquifers can be recharged by rainwater, or by lateral migration of underground water.

Aquitard: A layer of impermeable rock or sediment through which water either cannot pass, or passes extremely slowly. In Iowa, aquitards are often relied on to protect aquifers from surface contamination.

Basalts: A dark, fine-grained igneous rock that is commonly formed by rapid cooling of lava at the surface. More than 90% of the volcanic rocks on earth are basalt. In Iowa, basalt was erupted in large volume as a result of the Mid Continent Rift.

Bedrock: Solid rock underlying unconsolidated or unlithified surface sediments such as soil or glacial till. Bedrock is exposed in Iowa at outcrops. Geologic maps display the uppermost bedrock that one would find in a given location if the soil was stripped away.

Brachiopods: A unique marine animal that is a very common and enormously diverse fossil in many Iowa rocks from the Cambrian to the Pennsylvanian Periods. Brachiopods are often used for assessing the age of unknown rock layers. Though they resemble clams and mollusks in shape, they are not related and were attached to the seabed with a stalk emanating from a small hole or pedicle near where the two halves of the shell are hinged together.

Cephalopods: A mollusk related to squid and octopi that are common fossils in Iowa Paleozoic rocks. The soft parts of the creature are almost never preserved, but the hard, outer shells can be found in both tapered straight and coiled forms. The shell is made up of many chambers used by the animal to control buoyancy.

Chert: An impure form of flint found in many limestone and dolomite rocks of Iowa. Composed almost entirely of silica, chert has conchoidal fracture akin to broken glass and was often used and highly valued by indigenous people for tool and weapon manufacture. Chert can be found in many shapes and colors, and often contains fossils.

Coral: Marine invertebrates that occur in both colonial and solitary types living in warm, shallow seas. Corals are extremely important fossils in the Paleozoic rocks of Iowa, where they often form large reefs, now valuable for uses such as building stone and road aggregate due to their strength.

Crinoids: A type of echinoderm related to starfish and sea urchins. Crinoids were shaped like flowers, with a stalk connecting the head or calyx to the roots anchored in the seabed. The calyx was covered in small arms used to filter seawater for drifting food. Pieces of crinoid stalk, called columnals, are likely the most common fossil found in Iowa.

Cyclothem: Rocks are often deposited in a regular, predictable manner as a result of the rising and falling of sea level on both global and local scales. One full sequence of the sea level rising and falling is called a cycle, and the rocks resulting from the cycle are known as a cyclothem. Cyclothems often include shallow water shale, deep water shale, coal, limestone, and ancient soils called paleosols. The pattern of these rock types can be used to reconstruct a record of ancient sea level.

Diorite: A coarse-grained igneous rock resulting from magma cooling slowly beneath the surface. Diorite often has a speckled light and dark appearance resulting from a combination of lighter feldspar and darker mafic minerals.

Dolomite: A common bedrock-forming carbonate mineral in Iowa. It is similar in characteristic to limestone, but includes the cation magnesium and has the chemical formula $CaMg(CO_3)_2$. In Iowa, dolomite is most common in rocks of Ordovician and Silurian age. These rocks were originally deposited in warm, shallow seas.

Gabbros: A coarse-grained igneous rock that contains primarily iron-rich, dark colored minerals. Gabbro is an intrusive rock, meaning that it cooled slowly underground allowing the crystals to reach larger size.

Gastropods: A class of mollusk that includes snails and slugs. Gastropods have been found in the fossil record since the Cambrian Period and are often characterized by a coiled shell.

Geophysicists: Scientists who study the earth's magnetic field, seismicity, and gravitational field.

Glacial Erratic: A rock that was transported by a glacier up to thousands of miles from their origin. They are recognized because they differ from the rocks found in the bedrock where they are deposited.

Gneiss: A metamorphic rock that has been subjected to relatively high levels of heat and pressure such that minerals, generally feldspar, quartz, and micas, arrange themselves into characteristic bands.

Granite: A coarse-grained igneous rock that cooled slowly within the earth. It is commonly made up of quartz, potassium feldspar, and mica.

Igneous Rocks: One of the three major types of rocks, along with metamorphic and sedimentary rocks. A rock formed by cooling magma within the earth's crust or by cooling lava that has been extruded to the surface of the earth.

Karst: A landscape made up of sinkholes and subsurface caves that have been formed by chemically weathering limestone bedrock.

Kettle Hole (or Basin): A depression formed when a block of sediment-covered ice left behind by a retreating glacier melts. Kettle holes are often filled with lakes long after the glacier is gone.

Limestone: A sedimentary rock made up of calcium carbonate. It can either be precipitated directly from fluids or formed by an accumulation of skeletal fragments of marine organisms (shells, corals, foraminifera). It is easy to identify because it fizzes when acid is applied to it.

Loess: Wind-blown, loosely compacted, homogenous deposits of silt and sand.

Metamorphic Rock: One of the three major types of rocks, along with igneous and sedimentary rocks. A rock formed by applying pressure, heat, or hot mineral-rich fluids to igneous or sedimentary rocks. Metamorphic rocks can be either foliated (a process where bands of minerals aligned by shape or type can be seen on the rock) or non-foliated.

Metamorphism: A term that means changed in form that is the process of creating a metamorphic rock by applying heat or pressure to sedimentary or igneous rocks.

Moraine: A deposit of unconsolidated rocks of various sizes and types. It is formed as a glacier scrapes rocks from the underlying bedrock and transports them as it advances. Moraines are one of the features left behind after a glacier melts or retreats.

Outcrops: Bedrock that is visible or exposed at the surface of the earth.

Paha: A long ridge composed of sand or loess, sculpted by wind. These are most frequently found in the Iowan Erosion Surface landform region.

Plate Tectonics: The widely-accepted notion that the earth's crust is composed of discrete plates that move slowly and independently around the surface of the earth, colliding, spreading apart, or grinding alongside one another. Plate tectonics provides a consistent framework for understanding the formation of most of the earth's large-scale structures and phenomena like mountain ranges and volcanoes, the drift of continents from poles to tropics through time, and the assembly and disassembly of supercontinents, among many other things.

Quartzite: A metamorphic rock composed primarily of the common mineral quartz and often formed by metamorphism of sandstone.

Sandstone: A sedimentary rock composed primarily of sand grains, often formed in beach, river, or desert dune environments.

Sedimentary Rock: One of the three major types of rocks, along with igneous and metamorphic rocks. Sedimentary rocks are formed by deposition and burial of solid particles (usually broken rock or mineral fragments, but also shells and organic materials) or by the precipitation of mineral crystals from water at Earth's surface. Common sedimentary rocks in Iowa include sandstone, shale, limestone, dolomite, and gypsum. Common surface materials like alluvium, loess, and till are all composed of unconsolidated sediment derived from pre-existing rocks, but are not yet lithified to become sedimentary rocks.

Shale: A type of sedimentary rock composed mostly of clay that often breaks into thin slabs or flakes. Most shales are deposited in quiet water environments like shallow bays and lakes, and some preserve excellent fossils.

Soil: The mixture of rock and mineral particles and organic matter that develops at the earth's surface through complex physical and chemical weathering processes, as well as biological processes. Rock or unconsolidated sediment serve as the medium within which soil is formed, called parent material by soil scientists.

Stratigraphic Column: A conceptual illustration of the layers (or strata) of rock or unconsolidated sediment in an area, often showing the order, thickness, and rock or sedimentary description of layers.

Stratigraphy: The study of the sequence and geographic distribution of sedimentary rock or unconsolidated sediment layers (or strata) and their interpretation within the context of Earth's history.

Talus: A landform composed of broken rock fragments that have fallen from a bluff or outcrop and collected at the base of the slope. Sometimes called scree.

Tetrapod: A broad group of animals with four limbs, including amphibians, reptiles, mammals, and birds.

Till: Unconsolidated sediment deposited directly by glacier ice. Till often contains disorganized mixtures of particle sizes ranging from clay to boulders and commonly exhibits no internal layering.

Trilobites: An extinct class of marine animals that were widespread in shallow marine environments during the early and middle portions of the Paleozoic Era.

Unconsolidated Sediment: A general term for sedimentary deposits that have not been lithified to become sedimentary rock. Among other things, this term includes alluvium, till, and loess, which cover bedrock across much of Iowa.

Weather (Weathering): The process of physical and chemical breakdown of rock by exposure to air, water, ice, organisms, and other substances and phenomena at or near Earth's surface. Weathering is an essential part of soil formation, but also produces rock fragments that can be eroded and transported to become sedimentary deposits.

ACKNOWLEDGEMENTS

This article was produced through a collaborative project led by members of the Iowa Association of Naturalists (IAN) and Iowa State University Extension and Outreach. Funding for the project was provided by a Resource Enhancement and Protection (REAP) Conservation Education Program grant.

This article was inspired by the booklet titled Iowa Geology and Fossils published by IAN. That booklet, along with others originally produced as part of a larger series by IAN, are digitally archived at lib.dr.iastate.edu/extension_ian.

Authors

Peter L. Moore, Iowa State University

Matthew Allan Graesch, Iowa Department of Natural Resources

Beth Caissie, Iowa State University, US Geological Survey

This article and others in the Iowa's Nature series were reviewed and approved by the Iowa's Nature Editorial Board: Heidi Anderson, Polk County Conservation; Rebekah Beall and Elizabeth Waage, Story County Conservation; Lilly Jensen, Winneshiek County Conservation; Stephanie Shepherd, Iowa Department of Natural Resources; and Adam Janke and Julia Baker, Iowa State University.

Photo Credits

Peter L. Moore—Pennsylvanian Rocks; Southern Iowa Drift Plain

Matthew Allan Graesch—Bailey's Ford Park; Gitchie Manitou State Preserve; Cambrian rocks; St. Peter sandstone; Backbone State Park; Jurassic gypsum; stone quarry; fossils and minerals

Beth Caissie—fossils in hand; Preparation Canyon State Park

Illustrations

Original graphics for this publication were created by Travis James, Iowa State University biological and pre-medical illustration student. All original graphics presented in the article are available to download at high resolution for noncommercial use in educational materials at naturalresources.extension.iastate.edu/Iowas-Nature.

WL17a May 2021

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