Mississippian Rocks in Illinois

AGE AND DISTRIBUTION

The Mississippian Period is the interval of Earth’s geologic history from about 360 to 320 million years ago (fig. 1). The term Mississippian System refers to the layers of sediment that were deposited during this period. Today, Mississippian-age rocks are present in the southern two-thirds of Illinois, where they are over 3,200 feet thick (fig. 2). These rocks were once more widely distributed over the midcontinent but were removed in places by erosion. Although these layers of rock were originally horizontal, they were warped downward into the shape of a shallow basin because of stresses in the Earth’s crust. This large downwarped depression is called the Illinois Basin. At the deepest part of the basin in southeastern Illinois, the Mississippian rocks are as deep as 5,000 feet beneath the surface. In western and southernmost Illinois, Mississippian rocks are shallow and exposed at the surface around the edge of the basin (see outcrop areas in fig. 2).

ECONOMIC SIGNIFICANCE

Mississippian rock resources have been important to the mineral industries and economy of Illinois since the early 1800s.

- Nearly 80% of the oil produced in Illinois has come from Mississippian rocks (Howard 1991). This crude oil is refined to produce gasoline, fuel oil, asphalt, road oil, lubricants, and other petroleum products, including petrochemicals.
- Fluorite (fluorspar), sphalerite (zinc ore), and galena (lead ore) were mined from major mineral deposits in heavily faulted Mississippian rocks in Hardin and Pope Counties, southernmost Illinois, from the early 1800s until the last mine closed in 1995. Mining ceased because of cheaper sources from other countries, primarily China and Mexico. Additional research on the Mississippian rocks in southernmost Illinois may lead to the discovery of new economically minable fluorspar or other mineral deposits.
- Fluorite (calcium fluoride), Illinois' state mineral, is used in a variety of manufacturing processes, for example, as a flux in refining iron ore to steel. Fluorite is primarily used to make hydrogen fluoride (hydrofluoric acid) and fluorine gas, an ingredient in refrigerants, solvents, lubricants, and toothpaste.
- About one-third of the limestone and dolomite for crushed stone in Illinois is quarried from Mississippian rocks. Crushed stone, also called construction aggregate, is used for road construction, concrete structures, agricultural lime, sulfur dioxide removal from coal-burning power plant flues, and production of Portland cement and various chemicals. Some Mississippian-age limestone was quarried as a building and decorative stone in southern Illinois until the 1960s. It is similar to the “Indiana Limestone,” a building stone used nationwide that is quarried in south-central Indiana.

PALEOGEOGRAPHY

Continental plate movement Paleogeography means “ancient geography.” During the Mississippian, the area now called Illinois was located south of the equator (fig. 3). The equator has not moved during the history of the Earth, but the “plates” that make up Earth’s crust have slowly moved around during Earth’s life of 4.6 billion years. During the 40 million years of the Mississippian Period, what is now Illinois moved slowly northward from near 30° south latitude to just north of 10° south latitude. About 100 million years later, all the continental plates drifted together and formed the supercontinent Pangea. Since then, the continental plates have been slowly drifting apart.
Figure 1 Mississippian rock units in Illinois. Units that have produced oil are shown in bold type. The base of the Fort Payne is approximately equivalent in time to the base of Keokuk (dashed line). DEV = Devonian, UP = Upper Devonian, and K = Kinderhookian.
Figure 2  Distribution and thickness of the Mississippian rocks in Illinois. Thickness contours are shown where upper Chesterian rocks are present (modified from Atherton et al. 1975).
Ancient seas  Illinois and surrounding areas of the midcontinent were covered by a warm, shallow inland sea that extended inland from the deep ocean at the edge of the continental plate (fig. 3). During the early part of the Mississippian, this inland sea covered most of the midcontinent and was up to several hundred feet deep in the southern Illinois area. During the later part of the Mississippian, sea level dropped and exposed more land. As a result, the sea became shallower, just a few tens of feet deep in the Illinois Basin. Geologists can tell relative water depths from the type of sea life preserved as fossils in the rocks (plates A and B) and from sedimentary patterns or structures, such as ripple marks, that were formed in the sediment by currents generated by tides and waves.

COMMON MISSISSIPPIAN ROCKS

Common rocks of Mississippian age found in the Illinois area formed at the bottom of the shallow inland sea. Rivers and streams eroded sand, silt, and clay from the surrounding land area and carried them into the sea where they were deposited on the bottom. Shale forms when mud (a mixture of fine clay and silt) collects at the bottom of the sea and is buried and compacted (lithified, or made rock-like). Sandstone and siltstone form similarly, but from coarser sand and silt particles.

Limestone, the most abundant Mississippian rock type in Illinois, formed differently. Limestone is primarily calcium carbonate (calcite, or CaCO₃) and can form in several different ways. One of the most common ways begins with sea animals (such as crinoids, brachiopods, bryozoans, and mollusks) that secrete calcium carbonate to form their protective shells. When these animals die, their shells collect on the sea floor. Often the shells are broken by strong currents (due to storms and tides) near shore and are carried seaward. When these shells become compacted and cemented on the sea floor (by calcite that precipitates from the sea water), limestone forms. Calcite-secreting animals are most abundant and prolific in clear, warm, relatively shallow water where there is little mud coming into the sea. Because these animals feed by filtering tiny floating plants and animals from the sea water, mud would choke them.
Some limestones (for example, oolitic limestone) are a chemical precipitate from the sea water. Others (for example, micrite) form in part through precipitation caused by microbes, algae, or other organisms. In some cases, limestone is recrystallized to form a magnesium-rich carbonate rock called dolostone (or dolomite).

DEPOSITIONAL HISTORY

Various combinations of the rocks described above were deposited in Illinois during the 40 million years of the Mississippian Period. The oldest rocks were laid down first and are at the bottom of the sequence (fig. 1).

**Pre-Mississippian**  Before Mississippian times, late in the Devonian Period (fig. 1), mud was being deposited in the sea that covered the area. This mud continued to enter the sea during the early Mississippian Period (Kinderhookian Epoch). As the mud was buried and compacted, it became shale. The sea during this time ranged from a few tens of feet deep near the shore to several hundred feet deep in southeastern Illinois, where the shale is thickest. Geologists call this shale unit the New Albany Group (fig. 1). Today this shale is at the surface in western Illinois but is more than 5,000 feet deep in southeastern Illinois, where it is 450 feet thick.

This shale is rich in organic matter that was derived from dead marine plants and animals that accumulated on the ancient sea floor. As the shale was buried progressively deeper in the Earth's crust by overlying sediments, it became warmer. (The Earth is hotter toward the center.) Eventually, about 250 to 150 million years ago, the shale became so hot (at least 125°F) that the organic matter “cooked” and released oil and gas. This oil and gas moved slowly upward along fractures and through pore spaces into and through overlying rock units. Some of this oil and gas became “trapped” in areas where porous rock is overlain by dense, non-porous rock. It is this trapped oil and gas that some geologists look for and that is pumped from the ground for our use.

**Kinderhookian Epoch**  The amount of mud carried into the sea eventually diminished and allowed sea animals to dominate long enough for a thin limestone, the Chouteau Limestone, to be deposited over much of the southern half of Illinois. This limestone marked the end of the Kinderhookian Epoch (fig. 1).

**Valmeyeran Epoch**  During Valmeyeran time (fig. 1), the sea continued to cover much of the midcontinent (fig. 3). In western Illinois, where the sea was now clear and shallow, more than 150 feet of limestone (Fern Glen, Burlington, and Keokuk Limestones, fig. 1) formed a bank with a fairly sharp eastern slope that dropped off into deeper water. Initially, while this limestone was forming in western Illinois, very little sediment (Springville Shale) was being deposited in the southeastern part of the state, where the sea was much deeper.

Later, while the limestone continued to accumulate in the west, silt, clay, and sand again entered the sea from the east and northeast, forming the unit called the Borden Siltstone (fig. 1). This clay and silt eventually spread into western Illinois and choked most of the calcite-secreting organisms, thereby ending limestone production. Where the shales and siltstones that developed from this clay and silt overlaid the limestone in the west, geologists call them the Warsaw Shale (fig 1). The Warsaw, well known for its geodes, is exposed at the surface in parts of western Illinois. The shales and siltstones of the Borden are present in central and southern Illinois and reach a maximum thickness of 700 feet thick in east-central Illinois.

While the Borden Siltstone was still accumulating along the center of what is now Illinois, limestone began to form to the east and south. Initially, the Fort Payne Formation (fig. 1) was deposited in relatively deep water. Then, as the amount of silt and clay entering the area gradually diminished, the Ullin, Salem, St. Louis, and Ste. Genevieve Limestones (fig. 1) formed in the warm, clear, and progressively shallower water.

Today, these Valmeyeran-age limestones are up to 1,800 feet thick in southeastern Illinois, where they are buried as deep as 5,000 feet. These limestones are also present at the surface in western Illinois, most notably in the bluffs along the Mississippi River between Alton and Grafton, and in southern Illinois. Where shallow enough, the limestones are quarried in parts of southern and western Illinois. Oil is produced from some of the limestones in southeastern Illinois; about 18% of all Illinois oil production comes from porous zones in the Ste. Genevieve Limestone (Howard 1991). The deeper limestones can be as productive as the Ste. Genevieve, but they have not been fully explored.
Chesterian Epoch  Near the end of Valmeyeran time, as relative sea level gradually dropped, the northern shoreline moved southward and exposed more land. This transition marked the end of the Valmeyeran Epoch and the beginning of the Chesterian Epoch (fig. 1). As sea level lowered, more mud and sand were carried by ancient rivers and streams from land areas to the north, northeast, and northwest into the sea in the Illinois area. The mud and sand carried into the sea were reworked by tidal currents and distributed over large areas of the sea floor, where they were buried and eventually formed shale and sandstone. Shell-forming organisms were relatively less common during Chesterian time because they were repeatedly choked by the mud and sand in the water. Periodically during the Chesterian, the sea withdrew entirely from the area of Illinois for a time and then returned. Paleosols (ancient soils) and deeply eroded valleys that were later filled with sediment are evidence of these periods of dry or exposed land.

Periodically, sea level rose, and the quantities of mud and sand flowing into the sea were reduced. During these times, the shell-forming organisms prospered once again, and thin limestones formed in this inland sea. These limestones are commonly only 10 to 30 feet thick, unlike the thicker ones of Valmeyeran age. These fluctuations in sea level during the Chesterian resulted in deposition of alternating units of shale, sandstone, and limestone, which geologists refer to as cyclic sedimentation.

Chesterian rocks are present in the southern half of Illinois. Although the rocks are at the land surface in parts of southwestern and southernmost Illinois, in southeastern Illinois they are as deep as 3,000 feet. The rocks of the Chesterian Series are as thick as 1,400 feet in southernmost Illinois. Sandstones of Chesterian age have produced about 60% of the oil found in Illinois (Howard 1991).

The Chesterian, the last epoch of the Mississippian Period, was a time of transition from the Valmeyeran Epoch, when the seas were clear and thick limestones formed, to the subsequent Pennsylvanian Period, when seas shallowed and disappeared for long periods of time and shale, siltstone, sandstone, and coal were the major deposits formed.

REFERENCES


Contributed by Janis D. Treworgy
PLATE A  Typical Mississippian fossils.
PLATE B  Typical Mississippian fossils.