Readings and Notes | An Introduction to Earth Science

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The Mississippian Period

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THE MISSISSIPPIAN PERIOD

Introduction: The first rocks to attract the attention of the early European were those containing the coals, primarily because of their importance in supplying the source of energy for the Industrial Revolution which began in the mid-1700s. As early as 1808, the coal-bearing rocks were referred to on the Continent as the "**bituminous terraine**' while the British geologists called them the "**Coal Measures**" The name **Carboniferous** was introduced in 1822 by Conybeare and Philips when they were attempting to make sense of the rocks of England and Wales. They proposed that all of the rocks from the Coal Measures down to the Old Red Sandstone be included in what they termed the **Carboniferous Order;** at that time, geologists had not yet begun to assign rocks to "systems". In 1839, the Old Red Sandstone was transferred to the Devonian and the remainder of the Carboniferous Order was designated as the **Carboniferous System**. In time, the system was subdivided into the Upper Carboniferous that contained most of the coal beds and the Lower Carboniferous which, being dominated by carbonates, was essentially barren of coal,. North American geologists observed the same difference in the lithology of the system, so much so that they actually separated the Upper and Lower Carboniferous and elevated each to the rank of a system. In 1891, the U.S. Geological Survey recognized the separation and named the Upper Carboniferous the **Pennsylvanian System** after excellent exposures of the coal in western Pennsylvania and the Lower Carboniferous the **Mississippian System** after exposures of the limestones along the Mississippi Valley. Although North American geologists universally recognize the Mississippian and the Pennsylvanian as two separate *systems* of rock accumulated during two *periods* of time, European geologists still consider the Lower and Upper Carboniferous as two *series* of the same *system.*

Late Paleozoic Events: In many respects the combination of the Mississippian and the Pennsylvanian into a single period of time makes some sense in that the Carboniferous represents a continuum of events that progressively changed over time. Except for the Acadian Highlands along the eastern margin, the Mississippian begins with nearly the entire continent of Laurasia covered with a shallow sea in which the sedimentation consisted totally of carbonates (**Figure 1**). By the end of the Mississippian, carbonate sedimentation over most of the craton came to an end as the craton became emergent, not so much due to tectonic activity but rather as sea level dropped in response to the water being withdrawn from the oceans to feed the glaciers that were scouring the surface of Gondwana.

Unlike the Taconic Highlands that had been completely worn down before the onset of the Acadian Orogeny, the Acadian Highlands remained high enough to be a source of clastic sediments largely due to the combined lowering of sea level and to the convergence of South America and Gondwana that by this time had joined together into one massive continent. With the elevation of the Acadian Highland being maintained, clastic sediments were shed into the Appalachian Basin throughout nearly the entire Mississippian with the exception of one brief incursion of the sea that resulted in the accumulation of carbonates (**Figure 2**). By the Pennsylvanian, as the eastern highlands began to respond to the convergence of Gondwana, a vast coastal plain developed from the western base of the Acadian Highlands that would eventually completely fill the foreland basin and spread sediments beyond the Cincinnati Arch into the continental interior (**Figure 3**). This coastal plain would become the site of the most widespread development of coal-forming swamps from which would come the coals that characterize the Pennsylvanian (Upper Carboniferous) world wide.

Major tectonic developments were also occurring elsewhere during this same period of time. While Africa and South America were colliding to complete the formation of Gondwana, what is now Siberia was converging on that easternmost portion of Laurasia that had been created during the Caledonian Orogeny, a collision that would create most of Eurasia and would uplift the Ural Mountains. Simultaneously, a number of micro-continents were converging that would become the present landmass of China. We will see all of these tectonic events culminate at the close of the Paleozoic with the creation of Pangea.

Mississippian Stratigraphy:

The Mississippian of the Cordilleran Region: Across most of the craton, the Lower Mississippian is characterized by carbonate rocks. Throughout the southern Cordilleran region, the Mississippian is represented by thick, in some cases, cliff-forming limestones. One of the most well-known of the Mississippian limestones is the **Red Wall Limestone** that makes up the major cliff in the walls of the Grand Canyon (**Figure 4**). Another Lower Mississippian limestone, the **Madison Limestone**, reaches a thickness of about 1,200 feet in the region of Yellowstone Park and extends northward into the Canadian Rockies. The Oquirrh Range in Utah south of the Great Salt Lake contains approximately 6,000 feet of Mississippian carbonates.

The Mississippian of the Continental Interior: Within the continental interior, the Mississippian System ranges from 2,000 to 2,500 feet thick and consists of limestones, many of which are continuous all the way from Illinois and western Kentucky to Iowa. In Illinois and Indiana, rocks of the basal Mississippian Kinderhookian Series were laid down when the seas were beginning to invade the region and vary lithologically because of the local influences of emergent island landmasses (**Figure 5**). As the waters deepened, carbonate sediments thickened and became much more laterally continuous, creating the limestones of the Osagian Series (refer to Figure 5).

An interesting component of many of these limestones are nodules and lenses of chert within the limestone beds. In the tri-state area of Missouri, Kansas, and Oklahoma, the chert is bedded and is known as the **Boone Chert**. The lead and zinc ores of the Joplin, Missouri mining region are contained within the Boone Chert. Above the Osagian Series is the Meramec Series that contains one of the most famous limestones in the United States (refer to Figure 5). The **Salem Limestone**, known in the building trade as the **Bedford/Indiana Limestone** after the major quarry site at Bedford, Indiana. The stone is relatively soft and very uniform in composition, making it easy to carve. As a result, for many years the Salem limestone has been used as exterior trim throughout the country. In addition for its selection as trim stone, the Salem Limestone has also been used as a major construction stone, an example being the Empire State Building in New York city. In fact, the Salem Limestone is the most widely used single building stone in the country.

The most widespread member of the Meramec Series, and one of the most extensive single sedimentary beds in the country, the **St. Louis Limestone** extends from Iowa to Alabama and forms the bluffs along the Mississippi river near St. Louis, Missouri.

The limestone next youngest to the St. Louis Limestone is the **Ste. Genevieve Limestone**. The limestone is know for being the location of Mammoth Caves and for thousands of other cavern systems in the "Land of Ten Thousand sink holes" in Kentucky.

The youngest Mississippian rocks in the mid-continent, consisting of inter-layered limestones, sandstones, and shales, represent the encroachment of clastic sediments from the Acadian Highlands during the close of the Mississippian.

The Mississippian of the Appalachian Basin: Within the Appalachian Basin, The Mississippian is dominated by the clastic sediments shed from the Acadian Highland that reached its maximum elevation during the culmination of the Acadian Orogeny (**Figure 6**). Throughout most of the region, the rocks are non-marine and represent sediments that were deposited in the Appalachian Basin as a prograding delta complex built a coastal plain westward from the western base of the highland. The basal Mississippian is represented by the **Pocono Formation** that consists of sands that accumulated along the eastern margin of the plain. Finer sediments were carried westward into shallow, oxygenated water where iron precipitated and coated the grains, giving rise to the redbeds of the **Maccrady Formation** (refer to Figure 6). During the Middle Mississippian, a temporary transgression of the sea resulted in the deposition of the carbonates now seen in the **Greenbrier Formation**. The incursion, however, was short-lived. During the Late Mississippian, the sea began to withdraw, not only from the Appalachian Basin but from the entire craton in response to the water removed from the oceans to feed the Gondwana glaciation. With the lowering of sealevel, more of the Acadian Highland became exposed to weathering and erosion, generating sediments now represented by the **Mauch Chunk** redbeds that were deposited in the remaining shallow water. By the end of Mississippian time, the eastern coastal plain had built westward to the Cincinnati Arch that had emerged in the Early Mississippian as a low peninsula. The Cincinnati Arch served as a barrier that prevented clastic sediments being carried further westward. As a result, the craton west of the Cincinnati Arch in Indiana and Illinois was covered by a shallow, warm sea that was ideal for the accumulation of carbonate muds.

The Ouchita Trough: Beginning in the Early Mississippian, a trough, or basin, began to form across southeastern Oklahoma flanked to the south by a rising highland called **Llanoria,** presumably reflecting compressional forces resulting from the convergence of Gondwana from the southeast (**Figure 7**). With the craton to the north and an emergent landmass to the south, the trough became a deep-water environment that was starved of sediment until the Late Mississippian when turbidity currents began to introduced clastic sediments derived from the Appalachian region to the east (**Figure 8**). By the end of the Mississippian, the basin was full of sediment. During the late Paleozoic, we will see this area uplifted into mountains that are a western continuation of the Appalachians.

Life of the Mississippian: The Mississippian Period saw the last great incursion of shallow seas over the continent of Laurasia during the Paleozoic era. With nearly the entire continent covered by warm, shallow seas, it was the ideal environment for the growth of carbonate-secreting animals and the subsequent production of carbonate sediments. Following the Devonian mass extinction, all of the major phyla recovered. One animal, the **crinoid**, was so abundant that most of the Mississippian limestones are made from their remains (**Figure 9**). The Mississippian has yielded more kinds of crinioid fossils and in greater abundances than any other geologic period. They were so abundant that the shallow Mississippian sea floors have been described as "crinoid meadows". Another type of stalked echinoderm similar in appearance to the crinoid, the **blastoid**, was also very abundant (**Figure 10**). In fact, one of the index fossils for the Mississippian was the blastoid *Pentremites* whose calyx was shaped like a rose bud.

With the stromatoporid and tabulate corals being rare and rugose corals not abundant, the great barrier reefs that were so common in the Silurian and Devonian were all but non-existent in the Mississippian. The bryozoans of the Mississippian were lacy, fan-like structures called **fenestratre bryozoa**. One of the most distinctive Mississippian index fossils .was a fenestrate bryozoan *Archimedes* that had its fan arranged in a corkscrew-like spiral around a central axis.

Below the waving meadows of crinoids, blastoids, and fenestrate bryozoa, the seafloor was dominated by brachiopods. The long-hinged spirifers that characterized the Devonian sea bottom were in decline and were replaced in the Mississippian by the **productids**, a brachiopod that had one deeply-cupped shell equipped with spines that were used to prop the animal up on the sandy seafloor or anchored them to rocky bottoms. The other shell was thin and flat and opened to allow the animal to filter-feed.

In the fish community, most of the fish that had dominated the Devonian seas had either gone to extinction or were on the verge of extinction with the exception of the ray-finned fish that became the dominant predator. The largest predators, however, were sharks, some of which reached lengths of 7 or 8 feet. Goniatite ammonites remained the dominant invertebrate predator while clams and gastropods, though scarce, were still found in the crinoid meadows,

A protozoan that became quite abundant in the Mississippian was the **foraminiferans** that were carbonate-secreting animals that crept along the ocean bottom in great numbers. The famous Bedford-Indiana Limestone is almost totally composed of the shells of the foraminiferan *Endothyra*. Other familiar forms such as the trilobites and graptolites did not fare so well with the both groups of animals nearing extinction.

Figures

Fig. 1: Map showing Laurasia during Middle Mississippian

genera disappeared making the late Devonian extinction one of the most devastating episodes of dying in the Phanerozoic Eon. The tabulate-strome reefs were so reduced that they never recovered. At the very end of the period, planktonic acritarchs and placoderm fish nearly disappeared with only a few placoderms surviving into the Mississippian. Once again, most of the extinctions were of warm-water forms, as exemplified by the demise of the tabulate-strome reefs, with cold-water forms being essentially unaffected. As was the case before, this suggests a general cooling of the oceans as a result of the Gondwana glaciation. The glaciation was also responsible for two episodes of sea level decline that eliminated many of the shallow-water environments in which a great number of animals lived..

Figures