

Figure 9-1. Distribution of Mississippian strata at the surface (solid color) and in the subsurface (line pattern) in Pennsylvania (from Pennsylvania Geological Survey, 1990). 1, Anthracite region; 2, Broad Top coal basin; 3, Allegheny Front; 4, Chestnut Ridge; 5, Laurel Hill; 6, Negro Mountain; 7, northwestern Pennsylvania; 8, north-central Pennsylvania.

CHAPTER 9 MISSISSIPPIAN

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INTRODUCTION

Mississippian rocks are distributed at the surface in Pennsylvania in the Anthracite region, the Broad Top coal basin, along the Allegheny Front, along the axes of the Chestnut Ridge, Laurel Hill, and Negro Mountain anticlines, and in the northwestern and north-central parts of the state (Figure 9-1). Generally, Mississippian rocks are thickest in the Middle and Southern Anthracite fields and thin to the west and north (Figure 9-2).

The Mississippian Period of Pennsylvania represents a transition from the prograding deltas of the Middle and Late Devonian Period to the cyclic alluvial and paludal environments of the Pennsylvanian Period. The initial episode of sedimentation occurred as a continuation from the Late Devonian (Oswayo) transgression, which persisted through the Early Mississippian (Kinderhookian and Osagean Stages). This episode is responsible for the deposition of the Devonian-Mississippian marine sequence of northwestern Pennsylvania (Bedford, Berea, and Knapp Formations, and the Cuyahoga Group and Shenango Formation), as well as the Rockwell, Huntley Mountain, and Burgoon Formations of central Pennsylvania, and the Spechty Kopf through Pocono Formations of northeastern Pennsylvania (Figure 9-3). Late Mississippian deposition (Meramecian and Chesterian Stages) is represented by the Loyahanna Limestone and Mauch Chunk Formation, including the coeval Greenbrier Limestone of the southwestern part of the state (Figure 9-3). These two depositional episodes are separated in the western half of the state by a period of widespread nondeposition and/or erosion that may span most of the Meramecian Stage. This unconformity becomes less distinct in central Pennsylvania and is not present in the eastern part of the state.

STRATIGRAPHY

Pocono Formation

The Pocono Formation has traditionally been considered the nonred, coarse-grained detrital strata

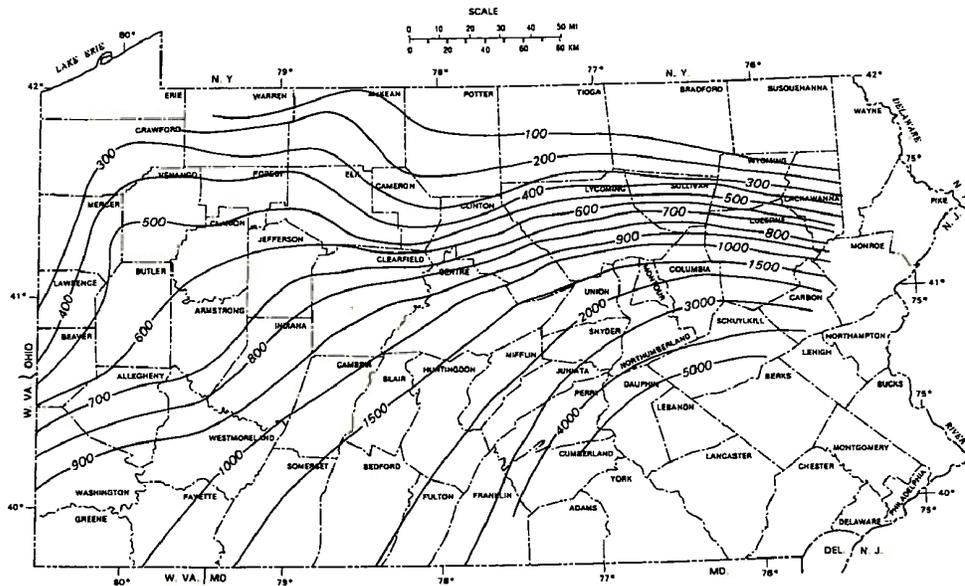


Figure 9-2. Generalized isopach map for Mississippian strata of Pennsylvania (modified from Colton, G. W., *The Appalachian basin—its depositional sequences and their geologic relationships*, in Fisher, G. W., and others, eds., *Studies of Appalachian geology: central and southern*, Figure 24, p. 38, copyright © 1970 by Interscience Publishers, reprinted by permission of John Wiley & Sons, Inc.). Contour intervals are 100, 500, and 1,000 feet.

occupying the interval between the Catskill red beds and the Mauch Chunk red beds, or the Loyahanna Limestone where it is present (Swartz, 1965). In central and western Pennsylvania, marked differences in the lithologic character of the Pocono strata have led workers (Berg and Edmunds, 1979; Edmunds and others, 1979; Berg and others, 1986) to reassign this interval to the Rockwell, Huntley Mountain, and Burgoon Formations. Consequently, the term Pocono Formation is used only in the Anthracite region of northeastern Pennsylvania.

In the Northern Anthracite field, thinning and facies changes preclude subdivision of the Pocono into members (Sevon, 1969b). In the Middle and Southern Anthracite fields, it is subdivided into two members (Trexler and others, 1962). The lower member, the Beckville, consists of interbedded medium- to coarse-grained sandstone, siltstone, and conglomerate that lie unconformably upon diamictites and shaly strata of the Specht Kopf Formation (see Chapter 8).

The upper member of the Pocono is known as the Mount Carbon Member. This member is characterized by crossbedded to massive, coarse-grained sandstone and conglomerate, and very minor silty intervals. Conglomeratic units commonly include large, rounded, white quartz pebbles and cobbles up to 3 inches in diameter (Figure 9-4). Generally, the Mount Carbon Member is much coarser than the underlying Beckville Member.

Pelletier (1958) proposed that the Pocono Formation of eastern Pennsylvania was deposited by high-gradient streams capable of carrying the coarse sand, pebbles, and cobbles present within this unit. These large clast sizes indicate that the Anthracite region

was close to the source area (Pelletier, 1958) (Figure 9-5). Consequently, the Pocono, and especially the Mount Carbon Member, appears to have been deposited on a high-gradient alluvial plain or an alluvial fan.

Huntley Mountain and Rockwell Formations

In central Pennsylvania, two formations are recognized in the stratigraphic interval that has traditionally been termed the lower Pocono. The two formations, the Rockwell Formation in south-central Pennsylvania and the Huntley Mountain Formation in the north-central part of the state, straddle the Devonian-Mississippian boundary (see Chapter 8). The Huntley Mountain Formation consists of interbedded greenish-gray to tan, flaggy sandstone, sandy siltstone, and reddish-brown silty shale. The Rockwell consists of intertonguing marine (Riddlesburg Shale Member) and nonmarine strata in the lower part and interbedded lenticular sandstone and reddish-brown siltstone and mudstone in the upper part. The upper parts of both formations are equivalent to the Beckville Member of the Pocono Formation.

Berg and Edmunds (1979) postulated that the flaggy sandstones of the Huntley Mountain represent channel-phase sands, and the reddish-brown shales represent overbank flood deposits of alluvial-plain origin. This interpretation is similar to that proposed for the upper Rockwell by Bjerstedt and Kammer (1988).

Burgoon Sandstone

Overlying the Rockwell and Huntley Mountain Formations in central Pennsylvania is an interval

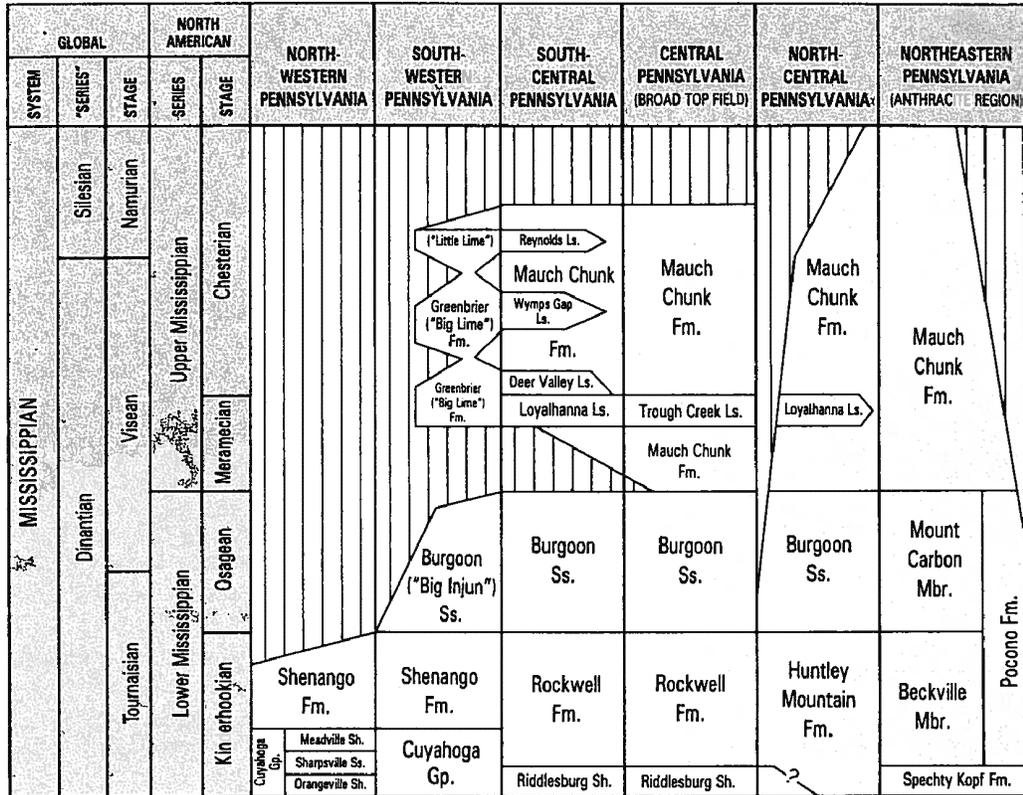


Figure 9-3. Correlation chart for Mississippian units in Pennsylvania (modified from Berg, McInerney, and others, 1986).

comprised predominantly of crossbedded, medium- to coarse-grained sandstone, which Butts (1904) termed the Burgoon Sandstone (Figure 9-6). Although the Burgoon is composed largely of crossbedded sandstone, thin, laterally discontinuous coal beds occur locally (Brezinski and Kertis, 1987).

The Burgoon Sandstone is equivalent to the Mount Carbon Member of the Pocono Formation

but differs from the latter by an overall finer grain size and a lack of thick quartz-pebble conglomerates. Edmunds and others (1979) equated the Burgoon of Pennsylvania with the Logan Sandstone of Ohio and the "Big Injun" sandstone of drillers' terminology.

The only fossils known from the Burgoon Sandstone are plant fragments, which Read (1955) and Scheckler (1986) assigned to the *Triphyllopteris* zone. This zone characterizes the Lower Mississippian (mainly Osagean) of the Appalachian basin.

Cotter (1978) believed that the preponderance of crossbedding, lack of recognizable overbank deposits, and coarse grain size suggested that the Burgoon Sandstone of central Pennsylvania was deposited by high-gradient, braided streams.



Figure 9-4. Quartz-pebble conglomerate within the Mount Carbon Member of the Pocono Formation at Jim Thorpe, Carbon County.

Cuyahoga Group and Shenango Formation

In northwestern Pennsylvania, equivalents to the Rockwell and Huntley Mountain Formations of central Pennsylvania, and the Beckville Member of the Pocono Formation of the Anthracite region, consist of intertonguing sandstone, siltstone,

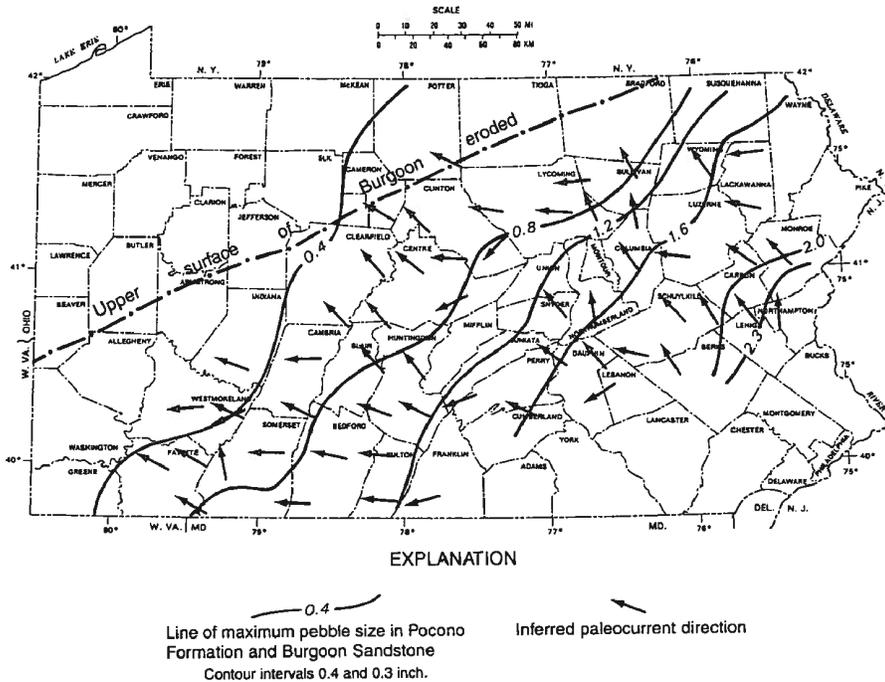


Figure 9-5. Inferred paleocurrent directions and maximum pebble size for the Pocono Formation and Burgoon Sandstone (modified from Pelletier, B. R., 1958, *Pocono paleocurrents in Pennsylvania and Maryland*, Geological Society of America Bulletin, v. 69, Figure 16, p. 1055). Modified with permission of the publisher, the Geological Society of America, Boulder, Colorado USA. Copyright © 1958 Geological Society of America. Limit of erosion based on Pelletier (1958, Figure 3, p. 1038) and Edmunds and others (1979).

and shale. This sequence is composed of the Cuyahoga Group and the Shenango Formation (Schiner and Kimmel, 1972; Edmunds and others, 1979). The Cuyahoga Group ranges in thickness from 200 to 240 feet, and is composed, in ascending order, of the Orangeville Shale, the Sharpsville Sandstone, and the Meadville Shale (Schiner and Kimmel, 1972). The Shenango Formation consists of thinly interbedded sandstone, siltstone, and shale and ranges in thickness from 150 to 180 feet; however, its upper limits have been removed by erosion.

The Cuyahoga Group and the Shenango Formation represent intricately interrelated facies created by the interplay of deltaic progradation and marine transgression.

Sub-Greenbrier Unconformity

During the Meramecian, much of western Pennsylvania appears to have experienced a period of either nondeposition or erosion prior to the deposition of the overlying Upper Mississippian strata (Adams, 1970). This presumed unconformity exhibits little erosional relief to support its existence. However, the sharp contact between the Burgoon and the Loyalhanna, the pervasive presence of a pitted zone in the upper Burgoon where it is overlain by the Loyalhanna, and the remnants of limestone beds not totally removed before Loyalhanna sedimentation began support the existence of an

unconformity. Within the Broad Top coal field and to the east in the Anthracite region, the intertonguing relationship between the Burgoon and Pocono and the overlying Mauch Chunk Formation may indicate that the magnitude of the hiatus diminishes progressively eastward so that no significant break in sedimentation occurred in these areas.

Loyalhanna Limestone

Throughout most of southwestern Pennsylvania, the basal Upper Mississippian unit is the Loyalhanna

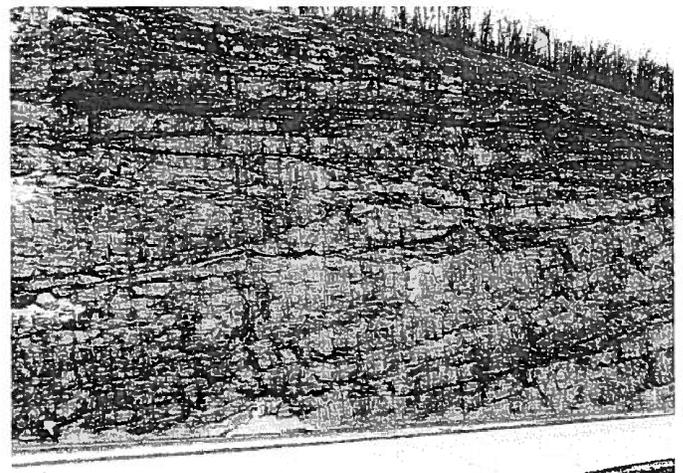


Figure 9-6. Crossbedded braided-stream deposits of the Burgoon Sandstone along U.S. Route 322 west of Port Matilda, Centre County.

Limestone. The Loyalhanna, named for exposures along Loyalhanna Creek in Westmoreland County (Butts, 1904), reaches a thickness of about 85 feet in southwestern Westmoreland and Fayette Counties (Adams, 1970). The Loyalhanna thins and interfingers to the east with clastics of the Mauch Chunk Formation (Brezinski, 1989b). The Loyalhanna is the most areally widespread of the Upper Mississippian marine units, extending from the southwestern corner of the state into Sullivan County (Wells, 1974). As of this writing, no macrofossils have been reported from the Loyalhanna of Pennsylvania, but brachiopods are known from the basal Loyalhanna in Maryland (Brezinski, 1989c). In thin section, fossil fragments, including bryozoans, brachiopods, echinoderms, and forams, are present.

Throughout the Allegheny Mountain section of the Appalachian Plateaus province of southwestern Pennsylvania, the Loyalhanna is present as a light-gray to grayish-green sandy limestone to calcareous sandstone containing large- to medium-scale crossbeds. It contains, on the average, 50 percent detrital quartz, but can contain from 11 to 82 percent detrital quartz. Carbonate sands are predominantly coated carbonate grains, but rounded endothyrid foraminifera and echinoderm fragments are also present. Adams (1970) has shown that the terrigenous component of the Loyalhanna generally increases to the north, indicating a northern (presumably eroded Burgoon) source area (Edmunds and others, 1979). A second, more subdued, source is suggested by the local presence of red clays and metamorphic rock fragments in the east. In these areas, the Loyalhanna takes on a reddish tint. The most diagnostic feature of the Loyalhanna in the Allegheny Mountain section is the pervasive, large-scale (up to 10 feet) crossbedding in which quartz-rich layers weather out in relief (Figure 9-7). Paleocurrent studies have shown that the major transport direction was from the southwest to the northeast (Adams, 1970; Hoque, 1975) (Figure 9-8).

In the Broad Top basin and in north-central Pennsylvania, the Loyalhanna is represented by interbedded crossbedded sandy limestone and red, mud-cracked, calcareous siltstone and mudstone (Gallagher and Parks, 1983; Brezinski, 1984, 1989b).

Mauch Chunk Formation

The most pervasive, and possibly most easily recognized, Mississippian formation in Pennsylvania is the Mauch Chunk Formation. Throughout most of its extent in the state, the

Mauch Chunk consists of red to reddish-brown mudstone and siltstone, and chocolate-brown, reddish-brown, and greenish-gray sandstone and conglomerate. The Mauch Chunk was named by Lesley (1876b) for exposures in the vicinity of the city formerly named Mauch Chunk, now called Jim Thorpe, in Carbon County. In the Southern Anthracite field, the Mauch Chunk has been estimated to be 3,000 to 4,000 feet thick, but it may reach a thickness of 6,000 to 7,000 feet. It can be subdivided into three informal members (Wood and others, 1969). The lower member displays an intertonguing of red siltstone and sandstone, typical of the Mauch Chunk, and tan to brown sandstone and conglomerate, similar to the Pocono. Reddish-brown to olive-gray lenticular sandstone and reddish-brown siltstone and mudstone characterize the middle member. The upper member consists of interbedded red sandstone and mudstone, and gray conglomerate more characteristic of the overlying Pennsylvanian Pottsville Formation (Figure 9-9).

The Mauch Chunk thins to the north and west from the Southern Anthracite field. To the north, the thinning appears to reflect not only a thinner original accumulation but also Late Mississippian erosion. The thinning of the Mauch Chunk into southwestern Pennsylvania is reflective of the more distal nature of these areas from the detrital source as well as a slower subsidence rate in the western part of the state. At maximum lateral extent, the Mauch Chunk extends to the southwestern corner of the state (Figure 9-10).

In southwestern Pennsylvania, the lower part of the Mauch Chunk exhibits numerous interbedded

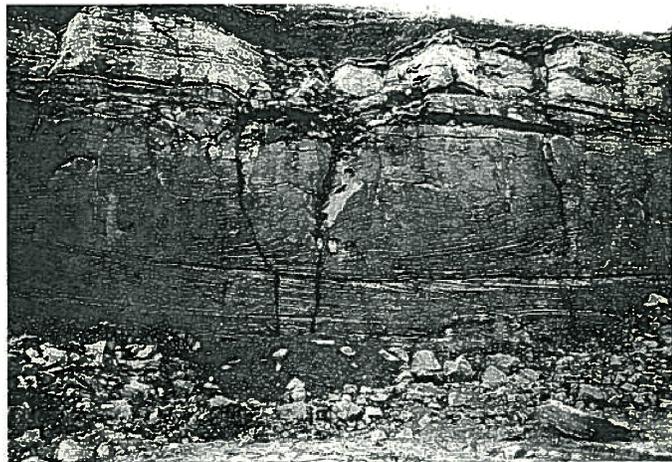


Figure 9-7. Joint face exhibiting typical weathering character of the Loyalhanna Limestone in a quarry near Mount Davis, Somerset County. The Deer Valley Limestone (white unit at the top of the photograph) is approximately 10 feet thick.

Basal Pennsylvanian Unconformity

Within the Northern Anthracite field, the Mauch Chunk and Pocono Formations thin to the north so that the overlying Pennsylvanian Pottsville strata lie disconformably upon progressively older strata. In northeastern Lackawanna, and in Susquehanna and Wayne Counties, Pottsville strata unconformably overlie Devonian strata of the Catskill Formation, and no Mississippian rocks are present. The magnitude of the hiatus diminishes to the south so that, within the Middle and Southern Anthracite fields, an inter-tonguing conformable relationship exists between the Mauch Chunk and Pottsville Formations. A regional discordance is present in northern Clearfield, Clinton, Lycoming, Tioga, and Bradford Counties, where Pottsville strata overlie sandstone of the Burgoon Formation. In much of northwestern and north-central

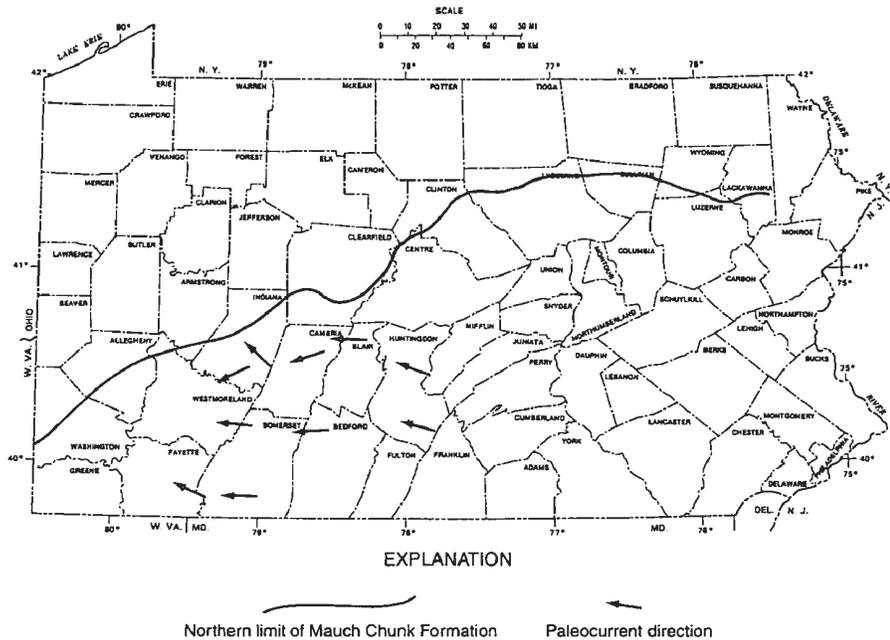


Figure 9-10. Areal extent of the Mauch Chunk Formation in Pennsylvania (from Berg and Edmunds, 1979, p. 45). Paleocurrent data are modified from Hoque (© 1968, Figure 1, p. 247, reprinted by permission of the American Association of Petroleum Geologists).

Pennsylvania, Pottsville strata overlie Lower Mississippian units of the Shenango or Huntley Mountain Formations. In southwestern and south-central Pennsylvania, evidence for a pre-Pennsylvanian unconformity is less distinct. Meckel (1970) postulated that

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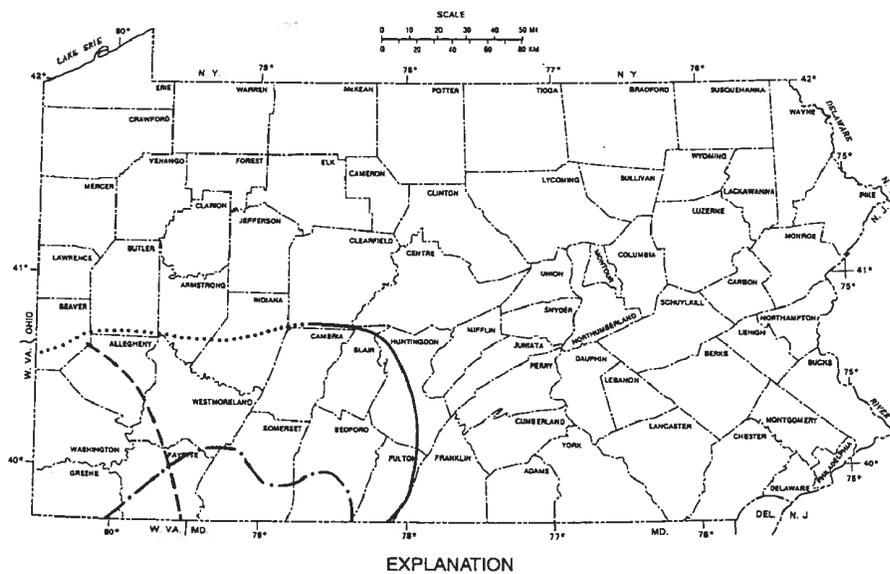


Figure 9-11. Relative maximum shoreline positions of the limestone members of the Mauch Chunk Formation in southwestern Pennsylvania (from Brezinski, 1984).

- Maximum shoreline position during deposition of Reynolds Limestone
- Maximum shoreline position during deposition of Wymps Gap Limestone
- Maximum shoreline position during deposition of Deer Valley Limestone
- Erosional limit of Wymps Gap and Reynolds Limestones

the pre-Pottsville surface was unconformable in most of Pennsylvania, with the exception of the Middle and Southern Anthracite fields. The dramatic lithologic change from the predominantly red, fine-grained deposits of the Mauch Chunk to the coarse-grained conglomerate of the Pottsville indicates that a major change in depositional environment occurred during this time interval.

PALEOGEOGRAPHY AND DEPOSITIONAL HISTORY

During the earliest Mississippian (Kinderhookian), marine waters extended into Pennsylvania from an extensive inland sea that covered much of the mid-continent. The marine embayment submerged most of eastern Ohio and inundated much of western Penn-

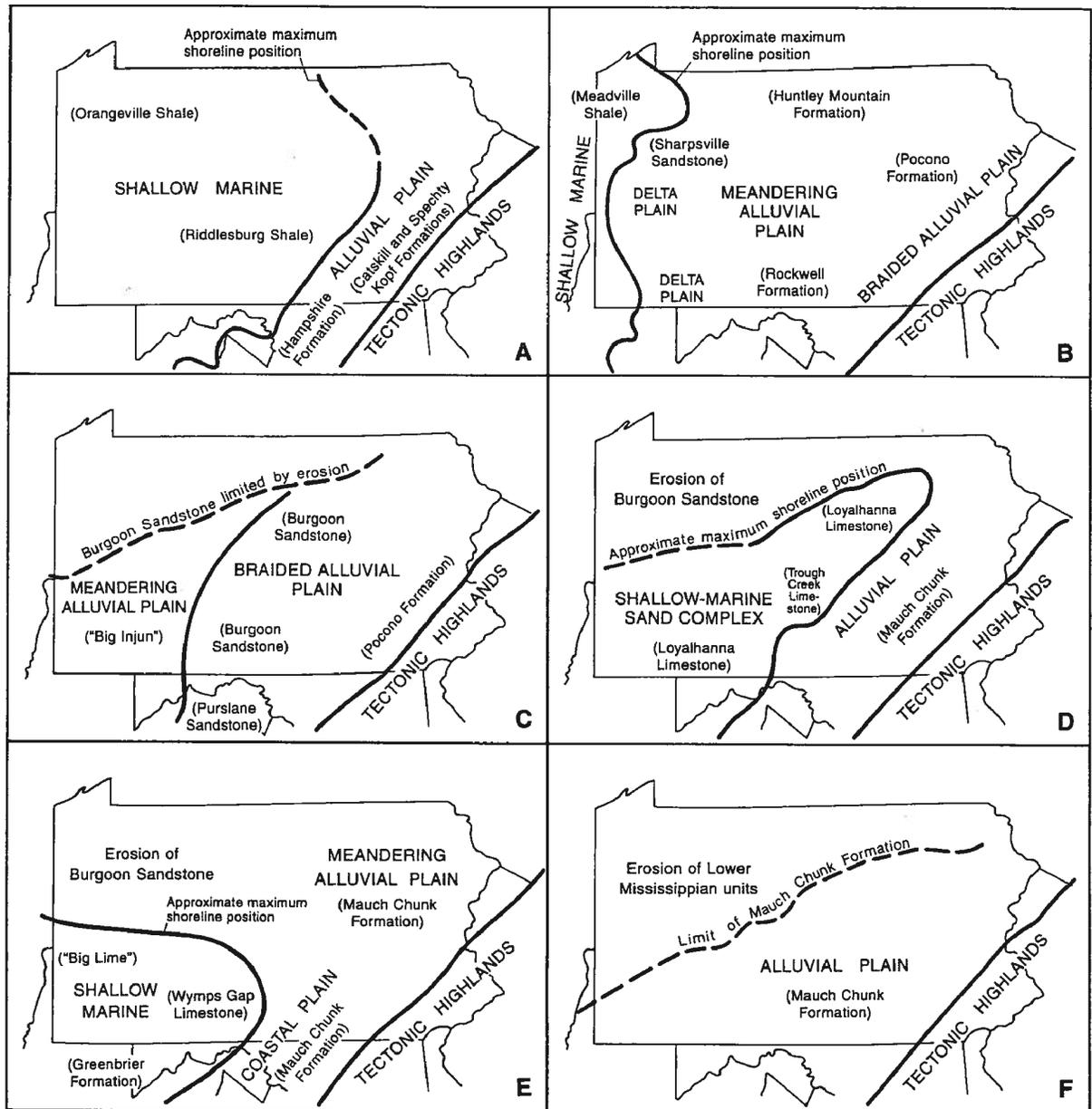


Figure 9-12. Generalized Mississippian paleogeography. A, Early Kinderhookian; B, Late Kinderhookian; C, Osagean; D, Late Meramecian; E, Early Chesterian; and F, Late Chesterian. See text for discussion.

sylvania as well. While this submergence resulted in the deposition of the Riddlesburg Member of the Rockwell Formation (Figure 9-12A) (Bjerstedt and Kammer, 1988), eroding tectonic highlands in eastern Pennsylvania continuously supplied clastic sediments. As marine regression occurred, deltas prograded westward into the marine embayment, and meandering streams deposited sediments to form what are now the upper Rockwell and Huntley Mountain Formations (Figure 9-12B). Pebbles and cobbles supplied from the tectonic highlands were transported westward by high-gradient, braided streams (Pocono Formation). As the gradients of the westward-flowing streams decreased, so did stream competency, and increasingly finer materials were deposited on an aggrading alluvial plain (Burgoon Sandstone) (Figure 9-12C). Alluvial-plain aggradation and progradation continued through much of the Early Mississippian, and by the Meramecian, a broad, low-lying alluvial plain lay across most of Pennsylvania (Berg and Edmunds, 1979).

During latest Meramecian, Pennsylvania once again marked the northern edge of a marine seaway that was oriented northeast-southwest and opened into the midcontinent in eastern Kentucky (Figure 9-12D). This seaway covered areas in West Virginia (producing the Greenbrier Formation) but only intermittently inundated the northern part of the depositional basin in Pennsylvania. Along its eastern extent, the sea was bordered by a broad alluvial plain on which red clastics (Mauch Chunk Formation) were deposited. Sediments were contributed to the northern end of the marine embayment from two sources. Large amounts of red clastics and metamorphic rock fragments were derived from an eastern source, presumably the tectonic highlands (Hoque, 1968; Adams, 1970). A more subdued source to the north contributed recycled quartz sand from the eroding Burgoon (Edmunds and others, 1979).

At the northern end of the marine embayment, in Pennsylvania, shallow estuarine conditions initially existed. This estuary was the site of a mixed transgressive carbonate and quartz sand-wave complex (Loyalhanna Limestone) that extended well into the north-central part of the state (Figure 9-12D). Although deepening of the marine waters continued into the Chesterian (Wymps Gap Limestone), the shoreline actually prograded westward as red Mauch Chunk sediments overwhelmed the marine conditions (Brezinski, 1989b) (Figure 9-12E). By latest Mississippian, red sediments of the Mauch Chunk had extended

into the southwestern corner of the state, and all but the most rapidly subsiding areas were undergoing erosion (Figure 9-12F).

PROBLEMS AND FUTURE RESEARCH

One of the most neglected Mississippian intervals is the one containing the Cuyahoga through Shenango marine units distributed throughout northwestern and north-central Pennsylvania. Future lithostratigraphic, as well as biostratigraphic, study of these units is needed. For the Upper Mississippian sequence, the most pressing need is for biostratigraphic study. Forams, which are common in many of the marine units, may prove useful in helping to unravel stratigraphic problems in this part of the Mississippian section.

RECOMMENDED FOR FURTHER READING

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