

PATTERNS OF DEPOSITION DURING THE EARLY PENNSYLVANIAN (MORROWAN) IN THE ILLINOIS BASIN

Special Report 62



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Patterns of Deposition during the Early Pennsylvanian (Morrowan) in the Illinois Basin

By J. B. Droste, Lloyd C. Furer, and Alan S. Horowitz

INDIANA UNIVERSITY
INDIANA GEOLOGICAL SURVEY SPECIAL REPORT 62



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Front cover: Contour map of tidal area shown on U.S. Geological Survey 1/100,000-scale topographic map of Brunswick Quadrangle, Georgia (1981). Barrier islands shelter extensive tidal flats and a network of tidal channels. Tidal range is normally about 7 feet and tidal currents are rather strong.

Front inset photo: Small tidal pool at north end of Jeekyll Island. Tide is about at midrange. At low tide this area is a mud flat; at high tide the salt-marsh grasses are almost entirely submerged. Except for dredging of the adjacent shipping channel and seawall protection of the outer shore of the barrier islands, ecological and depositional environments in this area are not deeply disturbed.

Along the Atlantic coast, sea level is slowly rising. The sea is transgressing, and coastal environments are slowly progressing inland. Analogs to some of the depositional settings discussed in this publication may be found along these coasts.

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ABSTRACT

The early Pennsylvanian (Morrowan) transgressions in the Illinois Basin can be documented by mapping the depositional limits of the subdivisions of the Mansfield Formation. Initial Morrowan subsidence and/or sea level rises resulted in northeastward onlap in three separate centers of deposition that are associated with paleovalley systems on the sub-Pennsylvanian landscape. In the central and southern parts of the basin most of the sub-Pennsylvanian topography was buried by late Morrowan time. In middle Pennsylvanian (Atokan) time onlap deposition had extended beyond the present outcrop belt of Pennsylvanian rocks in the Illinois Basin.

INTRODUCTION

The Mansfield Formation contains the oldest rocks of the Pennsylvanian System in Indiana and has a maximum thickness of more than 650 feet. The maximum thickness of the Pennsylvanian System in the state is more than 2,000 feet. The younger rocks of the Mansfield—the upper 300 feet—are exposed in the Indiana outcrop belt; however, the older rocks of the formation, about 60 percent of the total Mansfield thickness, are known only from subsurface studies.

The maximum thickness of rocks equivalent to the Mansfield in Illinois and Kentucky is about the same as in Indiana, but generally the Pennsylvanian System in these states is approximately 20 percent thicker than in Indiana. Although the rocks in the lower part of the Mansfield are known only from the subsurface in Indiana, their equivalents are exposed at the surface in southern Illinois and adjacent areas of Kentucky.

The Mansfield has been regarded as Morrowan in age for many years, but the boundary between the Morrowan and the overlying Atokan Series has not met with agreement among numerous investigators. For a summary of Morrowan–Atokan boundary problems, see Shaver (1986, p. 74–75) and Shaver (1984).

A recent study based on palynologic biostratigraphy, which included closely spaced samples from cores in Daviess County, Indiana, facilitates the establishment of a tentative (working) Morrowan–Atokan boundary for subsurface

studies in Indiana and adjacent states. Engelhardt and Furer (1995) identified a very late Morrowan assemblage in shales associated with the Pinnick Coal Member (fig. 1) and an early Atokan assemblage in shales associated with the Blue Creek Coal Member in Indiana. For the subsurface study of this report, we tentatively place the Morrowan–Atokan boundary at the stratigraphic position at the top of the Pinnick Coal Member of the Mansfield Formation. In the following report we present a sequence of maps that show the general pattern of sedimentation that occurred in the Illinois Basin during Morrowan time. The maps document the step-by-step onlap of Morrowan sedimentation that eventually buried most of the topography of the sub-Pennsylvanian erosion surface. Sub-Pennsylvanian topography and major drainage patterns in Indiana have been described by Droste and Keller (1989). The regional drainage patterns on sub-Pennsylvanian rocks for this study area are given by Bristol and Howard (1971).

Subsurface control in this study has come almost entirely from geophysical logs and samples on file in the records of the Indiana Geological Survey. The maps presented have been compiled from study of more than 10,000 well records in Indiana and 3,000 well records from Illinois and Kentucky.

The area of this subsurface study (fig. 2) in Indiana and Illinois lies between the Second (Indiana) and Third (Illinois) Principal Meridians and south of Township 19 North. In Kentucky the study area lies north of the eroded Pennsylvanian outcrop belt and includes a traverse through Hancock, Ohio, Muhlenberg, Hopkins, Webster, and Union Counties.

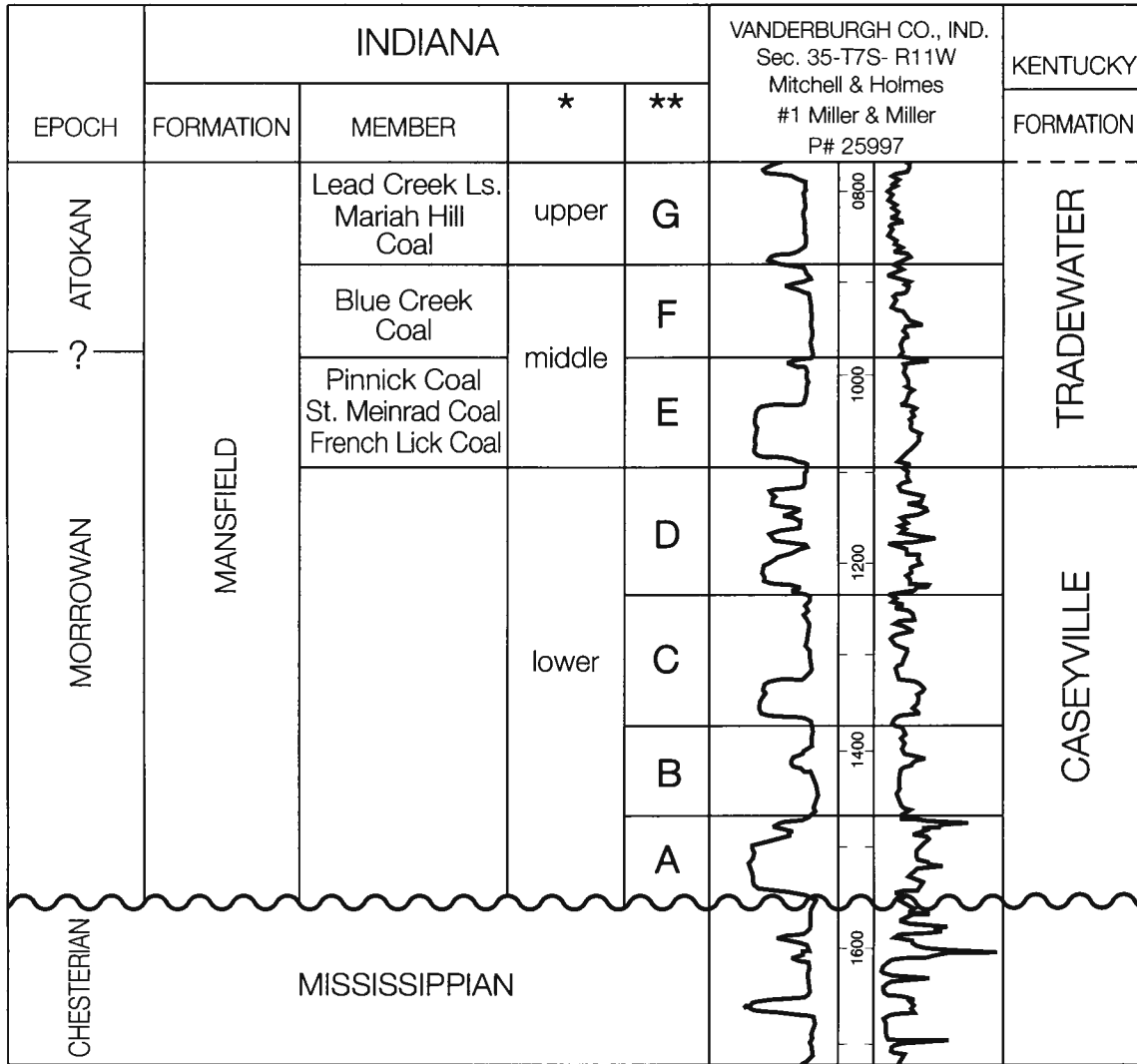


Figure 1. Electric log from a well in Vanderburgh County, Indiana, coordinated with the stratigraphic nomenclature used in this report.
 *From Droste and Furer (1995); ** from Droste and Horowitz (1995, and in press).

STRATIGRAPHY

The Raccoon Creek Group in Indiana consists in descending order of the Staunton, Brazil, and Mansfield Formations. In a subsurface study in Indiana (Droste and Furer, 1995) the Mansfield was divided into three informal units, the upper, middle, and lower divisions. Then Droste and Horowitz (1995) further divided the Mansfield into several informal intervals (fig. 1) using alphabetical designations from base to top.

The Mansfield–G interval is the same unit as the upper Mansfield of Droste and Furer (1995), and the middle Mansfield of Droste and Furer is herein subdivided at the stratigraphic position of the top of the Pinnick Coal Member to separate the Mansfield–F interval from the Mansfield–E interval. The base of Mansfield–E is at the approximate stratigraphic position of the Bell Coal Bed (basal Tradewater Formation) of Kentucky. On numerous logs, particularly in Indiana and Kentucky, the lower shale in Mansfield–E records a significant marine flooding surface. The remaining subjacent Mansfield subdivisions are not associated with any named Indiana outcrop unit because the distribution of these rocks is almost entirely restricted to the subsurface in Indiana.

However, the demarcation of the lower Mansfield subdivisions (A through D) is not arbitrary. The top of the Mansfield–B interval (fig. 1) was correlated on logs during the study by Droste and Furer (1995), but this demarcation was not discussed in their report. This shale break can be correlated on numerous logs from Indiana, Kentucky, and Illinois wells. The shale at the bottom of Mansfield–C includes the stratigraphic position of the Sellers Limestone Member of the Caseyville Formation in Illinois and an unnamed limestone in Kentucky. This shale unit represents a major marine flooding event. The top of the Mansfield–C interval (fig. 1) is selected at the top of a regional shale unit in southwestern Indiana. This stratigraphic position marks the approximate time the highest sub-Pennsylvanian hilltops in Posey County, Indiana, were buried by Pennsylvanian sedimentation.

Trending northeasterly through Vanderburgh and Gibson Counties, Indiana, the Evansville paleovalley is the locus of hundreds of feet of stacked sandstones in the Mansfield. In wells in Vanderburgh County, Indiana, and in central Henderson and Union Counties, Kentucky, the lowest sandstone interval is overlain by a shale unit. The base of this shale (fig. 1) is used to separate the Mansfield–B from Mansfield–A intervals. Further regional subsurface studies may show that the informal subdivisions of the Mansfield that are used herein should be modified and eventually named. At this time, however, mapping of the proposed subdivisions facilitates a step-by-step documentation of early Pennsylvanian onlap in the Illinois Basin.

PATTERNS OF SEDIMENTATION

As noted above, the Morrowan–Atokan boundary of this subsurface study is placed at the stratigraphic position of the top of the Pinnick Coal Member, which marks the top of the Mansfield–E interval (fig. 1). The five maps that follow (figs. 3, 4, 7, 9, 10) show the general areas of sedimentation at the tops of the Mansfield–A through Mansfield–E intervals. Outcrop distribution of units mapped in the subsurface has not been considered in this study, but Greb, Williams, and Williamson (1992) and Nelson (1989) have provided regional information concerning near-surface outcrop geology of rocks, which are equivalent to the Mansfield of Indiana, in the Western Kentucky Coal Field and in southern Illinois.

Deposition of the Mansfield–A interval (fig. 3) was controlled by three areas of maximum regional subsidence. The depocenter in southeastern Illinois appears to have been accessed northeastward from southern Illinois along sub-Pennsylvanian paleovalleys. The locus of deposition from southern Illinois and western Kentucky into Vanderburgh County, Indiana, is along the trend of the Evansville paleovalley. The map pattern shown in the southeastern part of the study area is tentative. The bedrock structure in this area is complex and our well control is scattered. The Mansfield–A rocks are more than 100 feet thick where penetrated in several wells in Union County, Kentucky and in Edwards and Wayne Counties, Illinois. The major sediment sources from early Pennsylvanian rocks were from beyond the study area, but certainly nearby sources added some increment to accumulating deposits. These local sources continued to yield sediments, at least to local deposits, until they were buried by onlap sedimentation.

From zero at its onlapping depositional limit, Mansfield–B (fig. 4) thickens in the three regions of Mansfield–A deposition to a maximum of about 110 feet. Clearly, paleovalleys and upland areas of sub-Pennsylvanian topography exerted some control on the distribution of Mansfield–B. The east–west (fig. 5) and north–south (fig. 6) cross sections illustrate the role played by the initial filling of paleovalleys and subsequent onlap sedimentation that eventually covered the sub-Pennsylvanian topography. Well 1 (fig. 5) and well 5 (fig. 6) are located within the Evansville paleovalley and are the sites of earliest Pennsylvanian deposition (Mansfield–A). Well 3 (figs. 5, 6) is located over a high upland surface on the pre-Pennsylvanian topography and was not the site of Pennsylvanian deposition until late in Mansfield–C time.

By the end of Mansfield–C deposition (fig. 7) two aspects of onlapping expansion are clear. Except for sub-Pennsylvanian topographic highs, large areas of southeastern and southern Illinois, western Kentucky, and southwestern Indiana were the loci Pennsylvanian deposition. Rocks of the Mansfield–

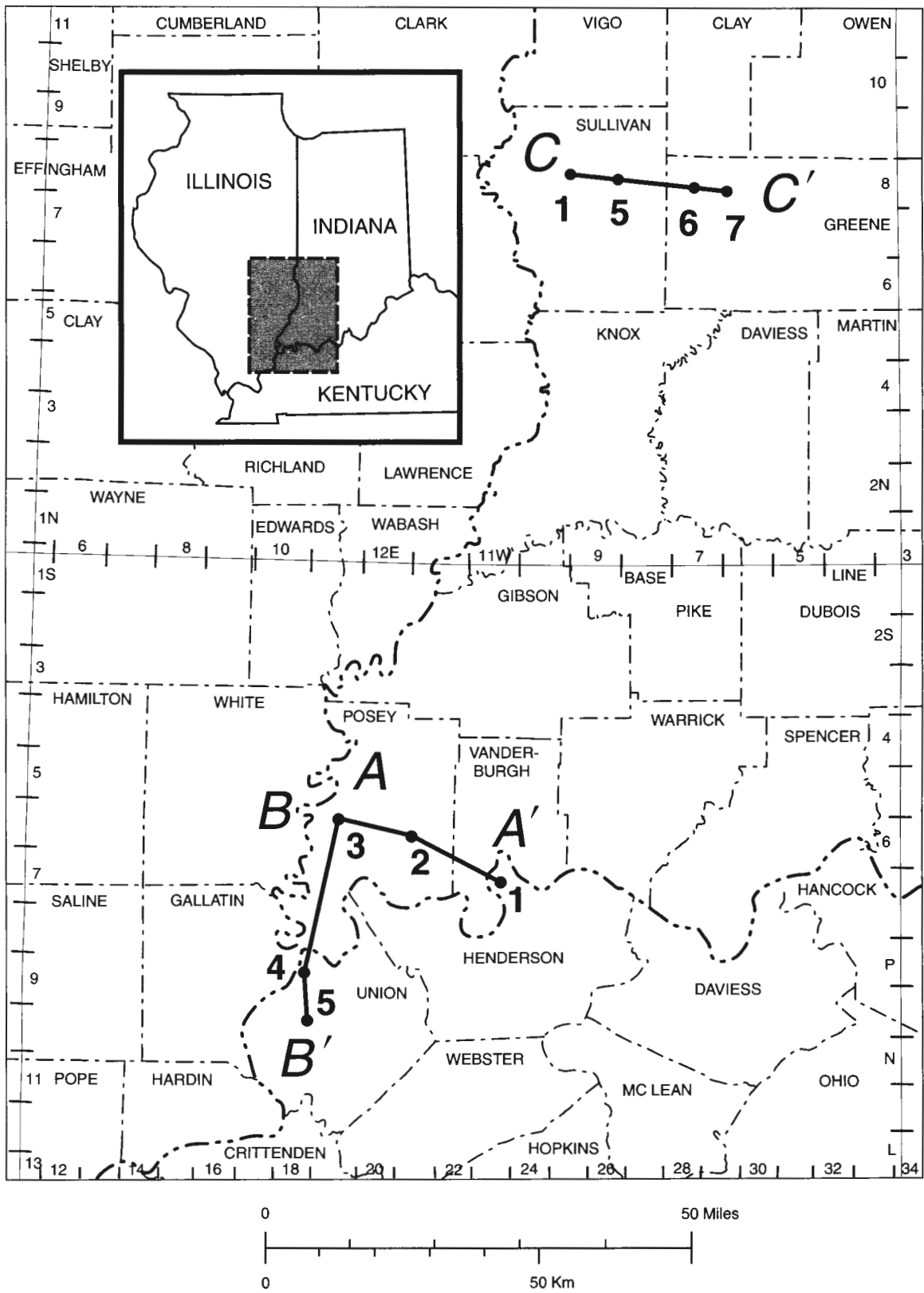


Figure 2. Map showing the study area. Principal Meridians, Base Line, and Township–Range notation shown for Illinois and Indiana. Carter Coordinates notation shown for Kentucky. Cross section locations shown for (A) Figure 5, (B) Figure 6, and (C) Figure 8.

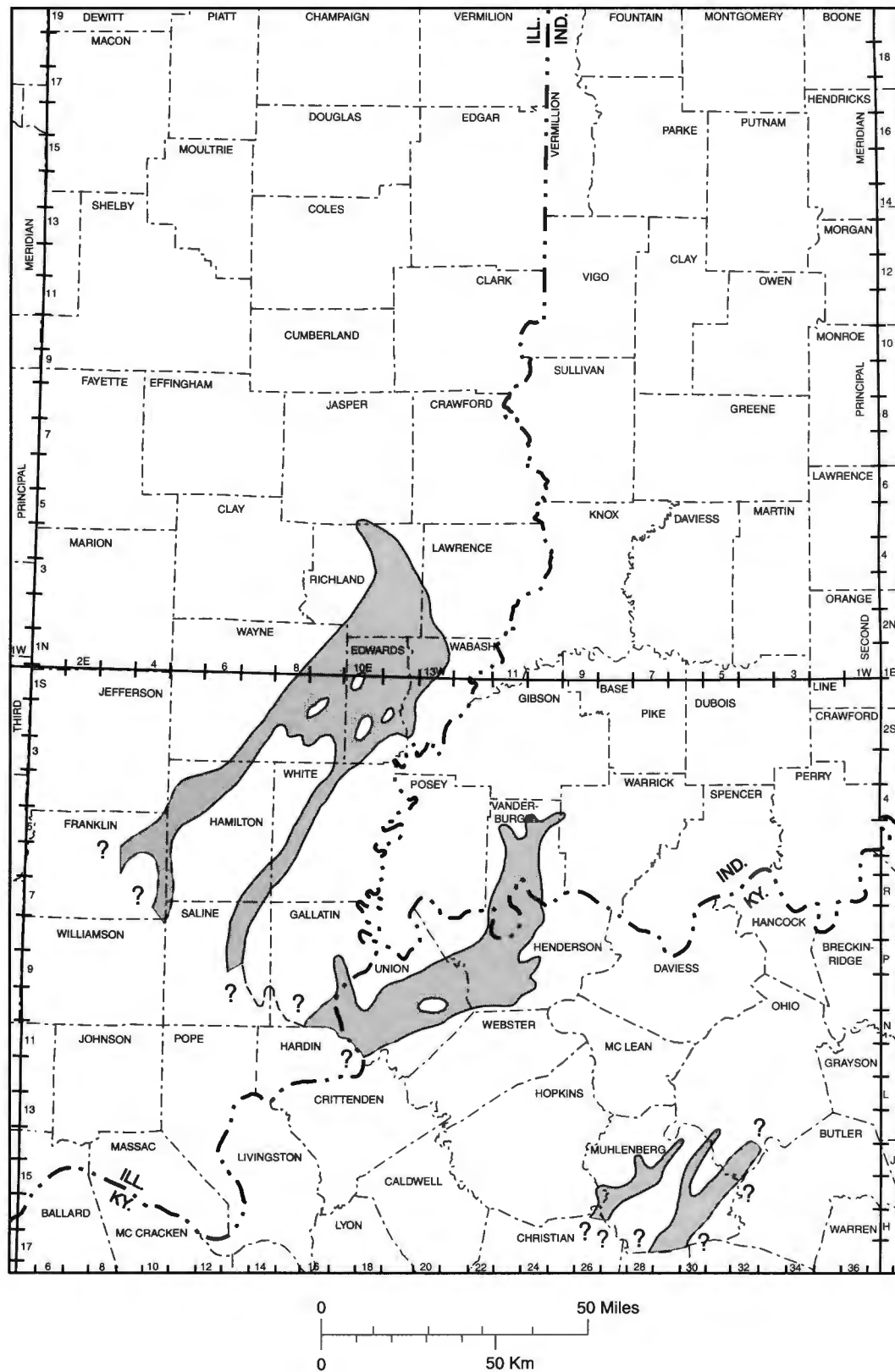


Figure 3. Map of the central Illinois Basin showing areas of sedimentation (shaded) at the end of Mansfield-A deposition.

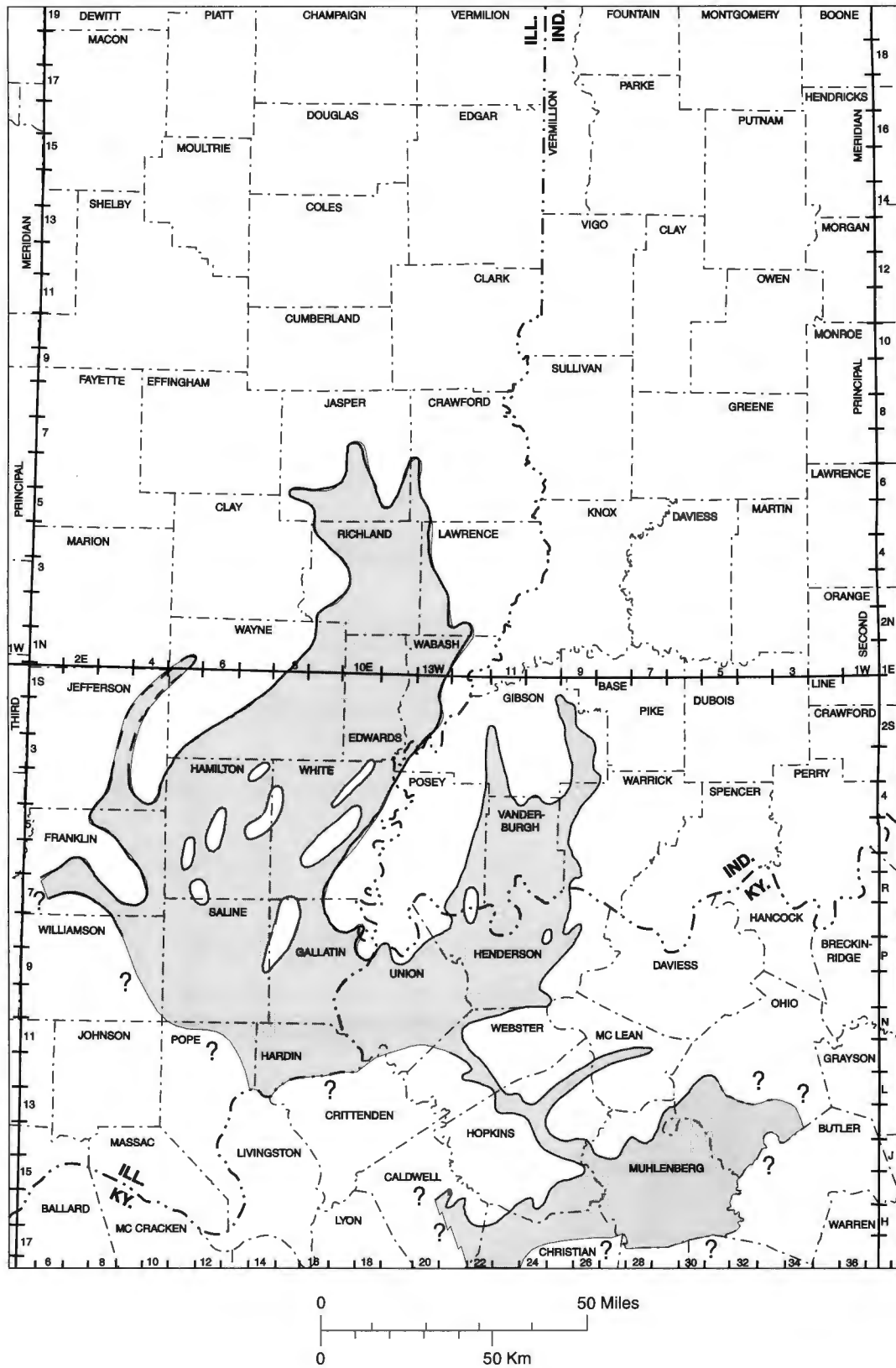


Figure 4. Map of the central Illinois Basin showing areas of sedimentation (shaded) at the end of Mansfield-B deposition.

A'

A

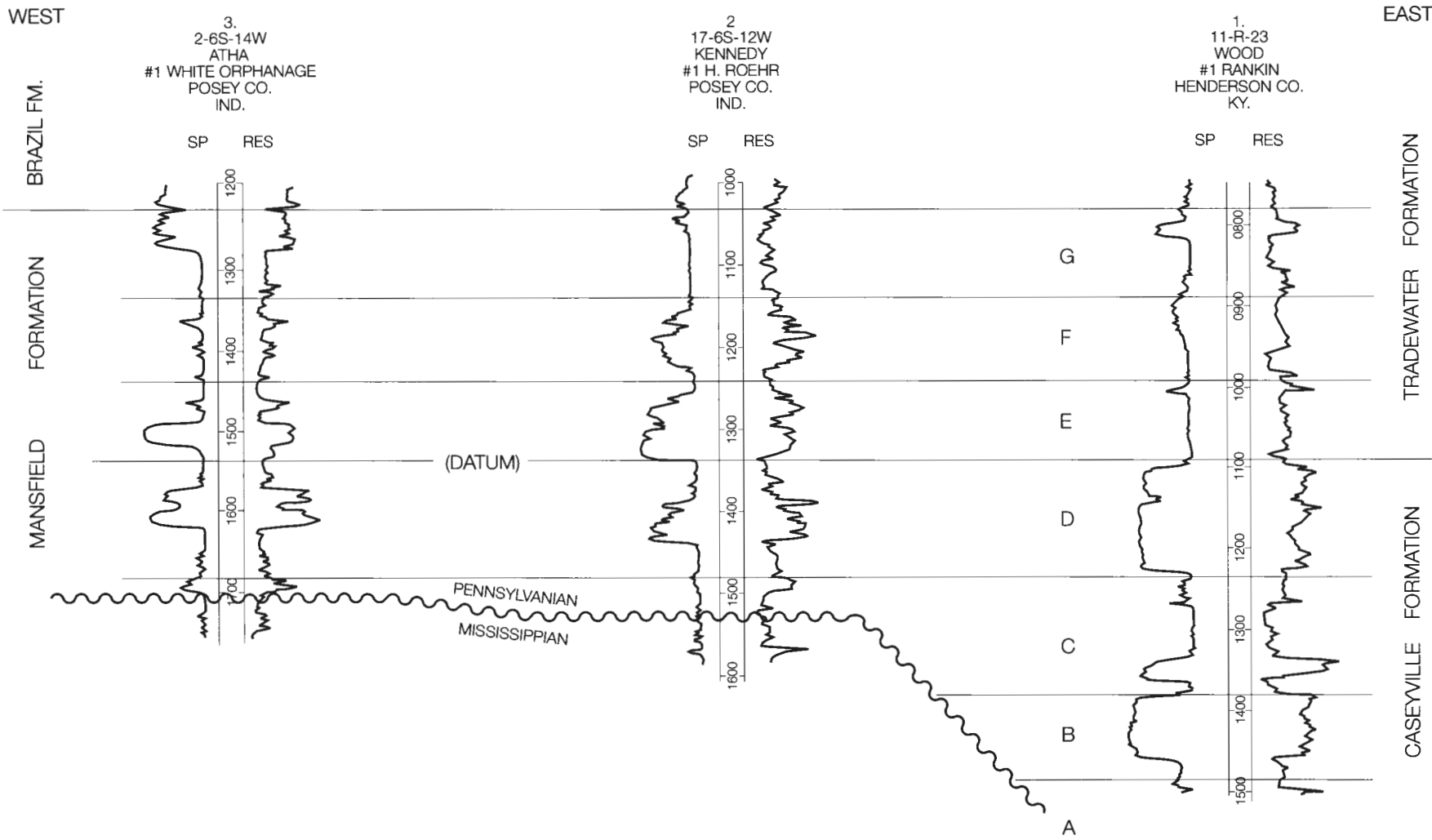


Figure 5. East-west cross section showing correlated electric logs from Henderson County, Kentucky to Posey County, Indiana, illustrating transgressive onlap of Mansfield intervals A through G. For cross section location see Figure 2.

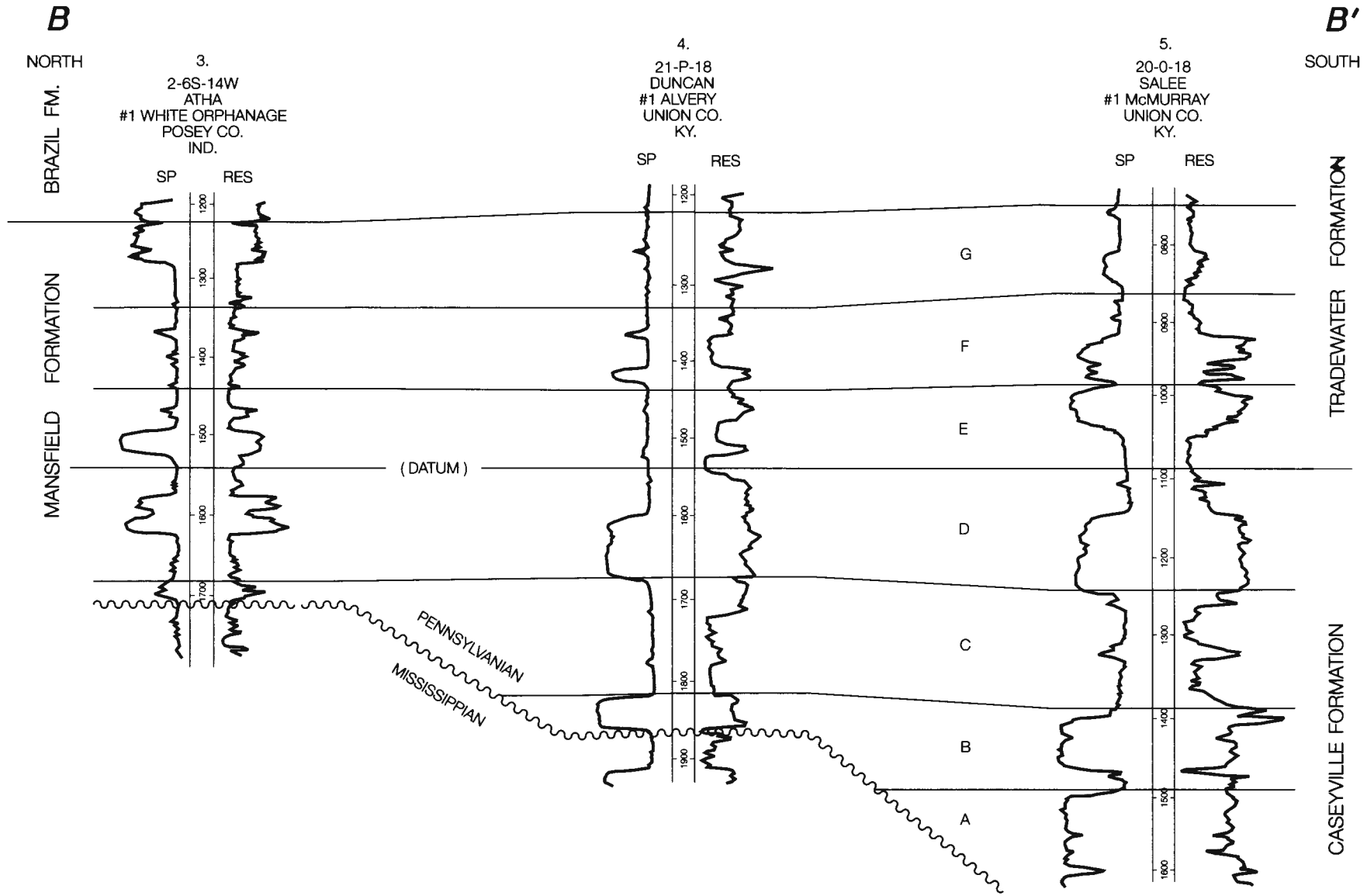


Figure 6. North-south cross section showing correlated electric logs from Posey County, Indiana, to Union County, Kentucky, illustrating transgressive onlap of Mansfield intervals A through G. For cross section location see Figure 2.

C interval are exposed in the outcrop area of eastern Illinois and around the southern part of the Western Kentucky Coal Field. A second interesting pattern of deposition is the extension of Pennsylvanian deposition as much as 50 miles up sub-Pennsylvanian paleovalleys as seen in Indiana (fig. 7) in the backfilled paleovalleys in Knox and Daviess Counties and in Sullivan County. The Mansfield–C interval is as much as 140 to 160 feet thick in Indiana.

An east–west cross section (fig. 8) in northern Sullivan and Greene Counties, Indiana, illustrates the variation in adjacent paleovalley infilling and eastern onlap. The upper rocks of Mansfield–C are present in well 3 (fig. 8) but are absent in well 1 just 1.5 miles farther west. In well 3 the Mansfield–D interval is shale and in well 1 the Mansfield–D interval is sandstone. Note that the location of well 4 (fig. 8) is on a high upland divide on the sub-Pennsylvanian surface that was not the site of Pennsylvanian deposition until Mansfield–F time. Five miles to the east of well 7, where only the upper 50 feet of the Mansfield–F interval lies on Mississippian rocks, further regional eastward onlap is documented.

By the end of Mansfield–D sedimentation (fig. 9) most of the sub-Pennsylvanian topography south of Township 4 North was buried by Pennsylvanian deposition. Rocks of the Mansfield–D interval are exposed on outcrop in southern Illinois, around the rim of the Western Kentucky Coal Field, and almost continuously southward from Greene County, Indiana. The Mansfield–D interval is as much as 140 to 160 feet thick in the subsurface. Data from future drilling in Indiana, particularly in Parke, Vermillion, and Fountain Counties, will undoubtedly require modification of the present map (fig. 9). In addition, the approximate depositional limit of the Mansfield–D interval shown in Illinois (fig. 9) will be altered as more well records are studied.

The limit of Mansfield–E deposition (latest Morrowan) north of Greene County, Indiana (fig. 10) is restricted to the subsurface. In the subsurface the Mansfield–E interval is 80 to 100 feet thick. The Indiana Geological Survey records are insufficient to suggest an approximate depositional limit of this subdivision in Illinois from Fayette to Clark County.

Mansfield–F (early Atokan) extends to the outcrop belt around the entire southern margin of the Illinois Basin, is as much as 100 feet thick, and is present almost everywhere in the subsurface. Absence of Mansfield–F by nondeposition is documented by six wells in the southern third of Township 19 North, Range 8 West in Fountain County, Indiana. In this area, rocks of Mansfield–G directly overlie lower Mississippian rocks. Mansfield–G rocks are present in the Pennsylvanian outcrop belt around the basin, and this subdivision ranges in thickness from about 70 to more than 130 feet.

DISCUSSION AND SUMMARY

The overall Morrowan transgression into the area of study includes two major marine flooding events of regional significance. The onset of the oldest primary marine onlap occurred at the end of Mansfield–B time. The second major flooding event took place at the end of Mansfield–D time. A third major marine flooding event of regional significance began in the early Atokan at the end of Mansfield–F time. The early Atokan marine onlap is especially interesting in that limestone beds are common features of Atokan and younger Pennsylvanian rocks. The rare Pennsylvanian limestones known below the Mansfield–D interval have very limited distribution.

Two additional Morrowan marine flooding events do not have as much basinwide recognition. Some wells in Union and Henderson Counties, Kentucky, and in Vanderburgh County, Indiana, contain a dark gray marine shale unit just above the top of the Mansfield–A interval. A younger secondary marine event is associated with the boundary between the Mansfield–E and the Mansfield–F intervals. This event is particularly important in Indiana because it occurs in association with the Pinnick coal interval of latest Morrowan time.

The Morrowan depositional history in the Illinois Basin may be summarized as follows. Early Morrowan (Mansfield–A and –B) transgression into the Illinois Basin came from the southwest. Initial regional subsidence resulted in onlapping sedimentation restricted principally to three separate depositional centers (fig. 3) that were associated with sub-Pennsylvanian paleovalley systems. Although the areas of deposition expanded significantly during early Morrowan time, sub-Pennsylvanian topography maintained separation of the three depocenters (compare figs. 3 and 7). By middle Morrowan (Mansfield–C) time only the highest uplands on the sub-Pennsylvanian surface were not buried by onlapping deposition (fig. 7) throughout a large area of southern and southeastern Illinois, the Western Kentucky Coal Field, and southwestern Indiana. By the end of Morrowan (Mansfield–E) time the limit of Mansfield deposition extended beyond the present outcrop limits throughout most of the study area (fig. 10). Only in west-central Indiana was deposition of late Morrowan sediments limited to backfilling in sub-Pennsylvanian paleovalleys.

ACKNOWLEDGMENTS

We thank H. H. Gray, N. C. Hester, S. J. Keller, and R. H. Shaver for reviewing the manuscript.

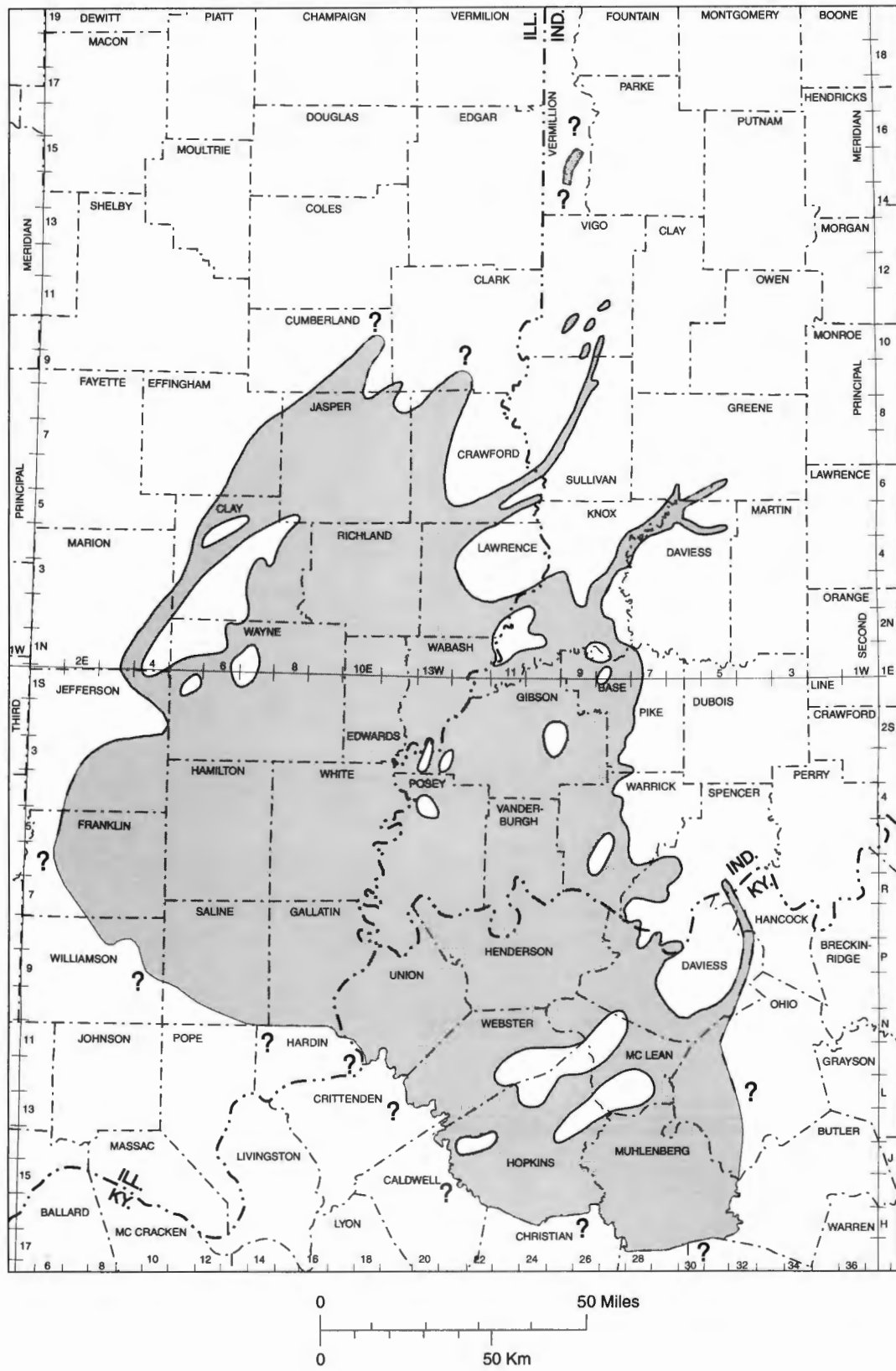


Figure 7. Map of the central Illinois Basin showing areas of sedimentation (shaded) at the end of Mansfield-C deposition.

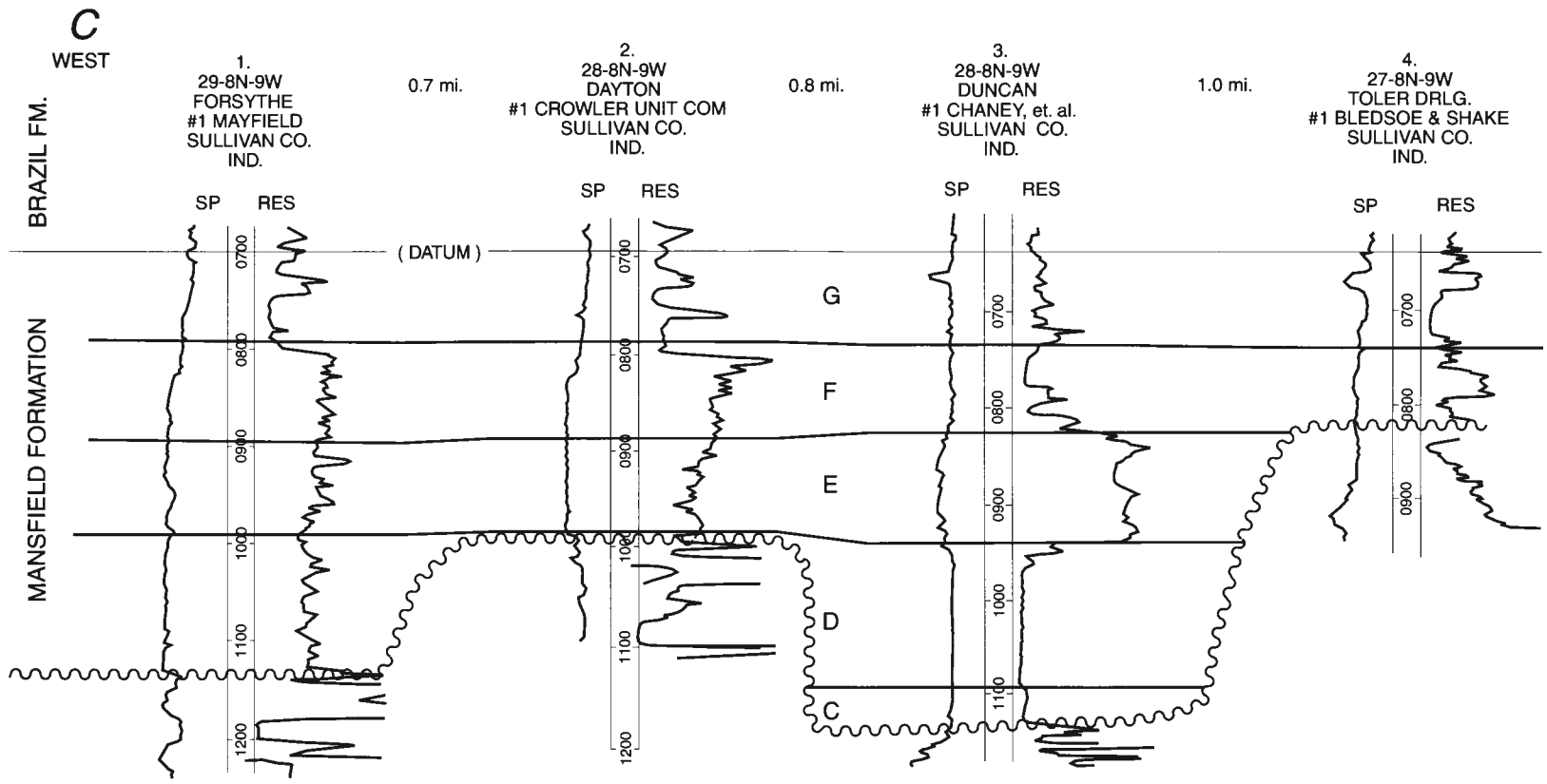


Figure 8a. East-west cross section showing correlated electric logs from Sullivan County, Indiana to Greene County, Indiana, illustrating transgressive onlap of the Mansfield intervals C through G. For cross section location see Figure 2.

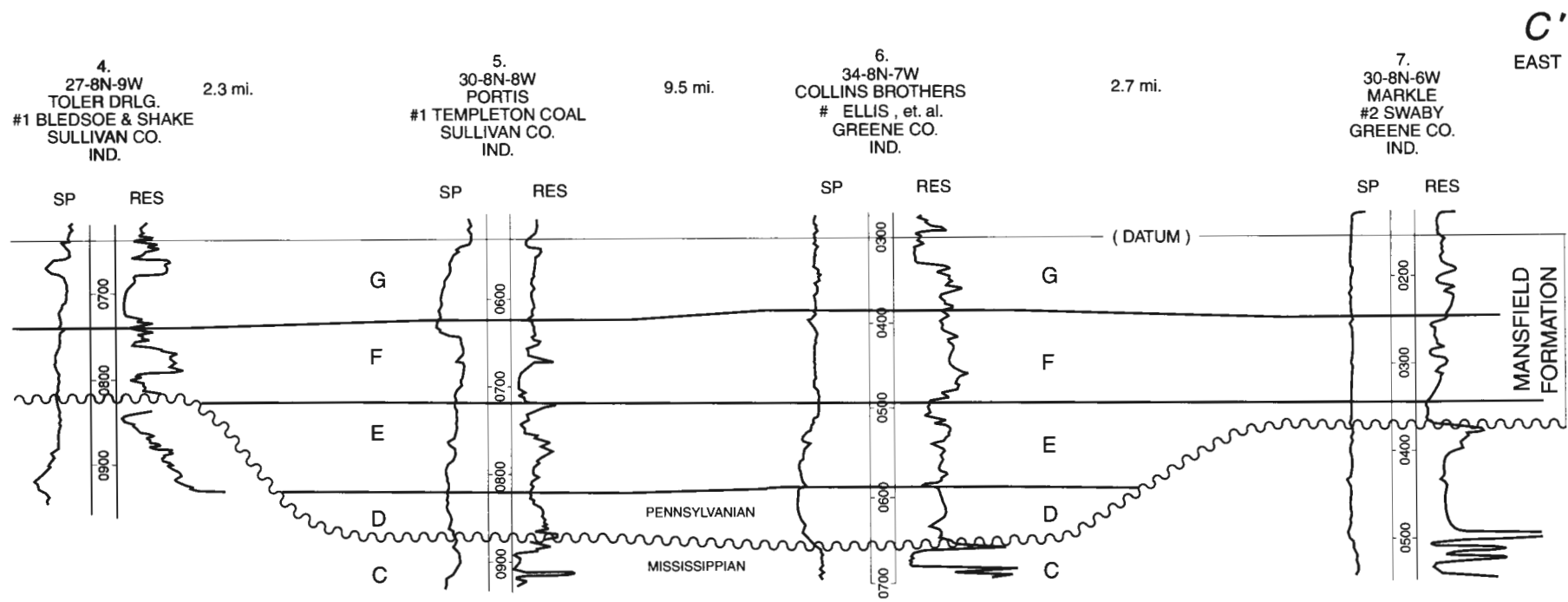


Figure 8b. East-west cross section showing correlated electric logs from Sullivan County, Indiana to Greene County, Indiana, illustrating transgressive onlap of the Mansfield intervals C through G. For cross section location see Figure 2.

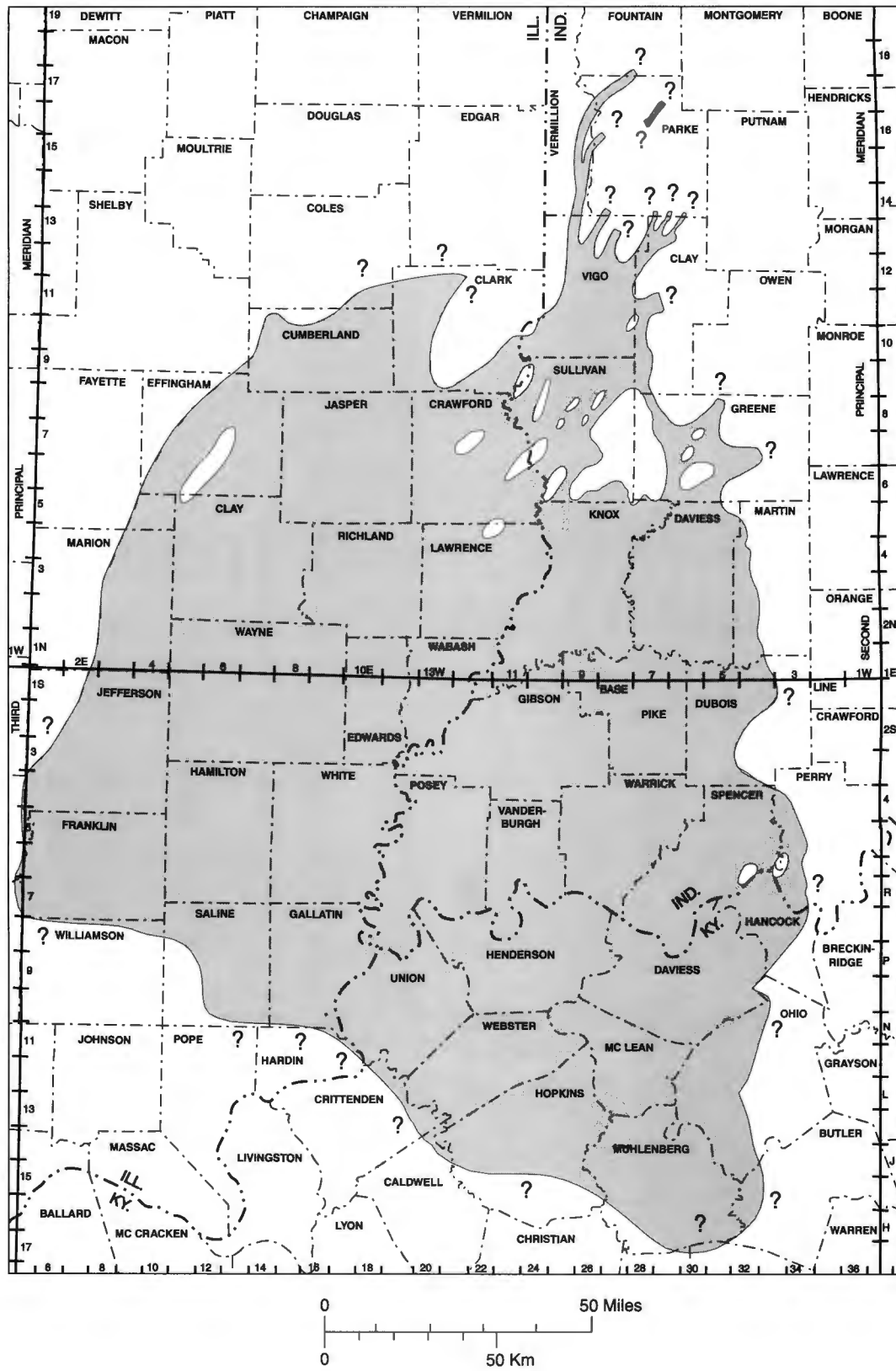


Figure 9. Map of the central Illinois Basin showing areas of sedimentation (shaded) at the end of Mansfield-D deposition.

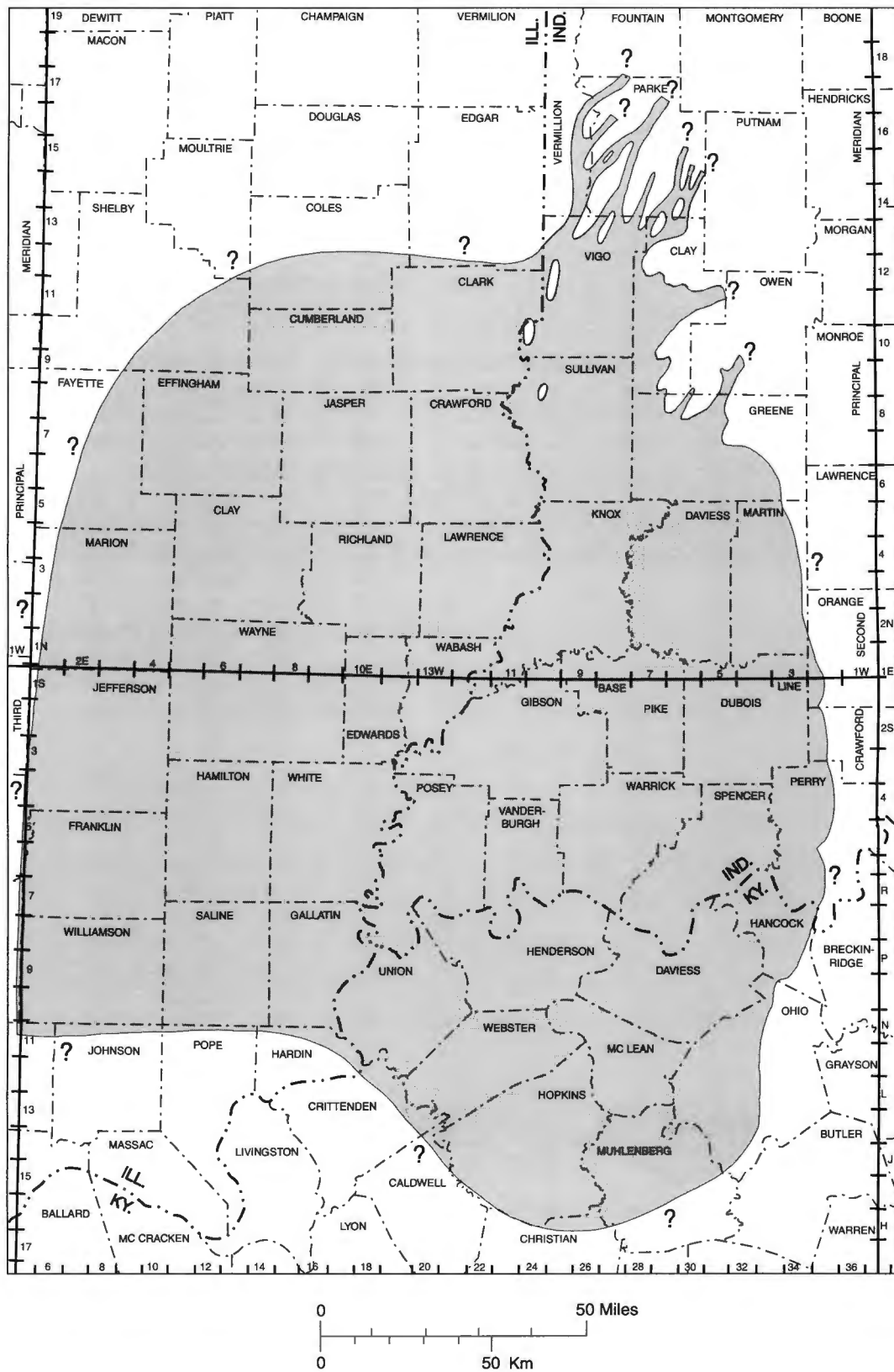


Figure 10. Map of the central Illinois Basin showing areas of sedimentation (shaded) at the end of Mansfield-E deposition.

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