458

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

Paleogeologic Map of the Sub-Pennsylvanian Chesterian (Upper Mississippian) Surface in the Illinois Basin

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CIRCULAR 458 1971

ILLINOIS STATE GEOLOGICAL SURVEY
URBANA, ILLINOIS 61801
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Illinois State Geological Survey Circular 458
16 p., 2 plates, 7 figs., 2 tables, 3500 cop., 1971
Urbana, Illinois 61801

Printed by Authority of State of Illinois, Ch. 127, IRS, Par. 58.25.

PALEOGEOLOGIC MAP OF THE SUB-PENNSYLVANIAN CHESTERIAN (UPPER MISSISSIPPIAN) SURFACE IN THE ILLINOIS BASIN

H. M. Bristol and R. H. Howard

ABSTRACT

Data from over 53,000 holes were used to construct a paleogeologic map (scale 1 to 500,000) of the sub-Pennsylvanian Chesterian surface within the Illinois Basin. The map shows that a linear drainage system developed on a gently sloping Chesterian surface. One instance of major stream piracy is clearly indicated. Valley widths range from several hundred feet up to 20 miles, depending on which Chesterian unit is considered to constitute the valley walls; valley depths range from a few feet to about 450 feet. Slump blocks of Chesterian limestones commonly occur within basal Pennsylvanian valley fill.

The northeast-southwest orientation of sub-Pennsylvanian valleys in the eastern four fifths of the area mapped was only slightly affected by a rising La Salle Anticlinal Belt. This orientation was apparently unaffected by the Clay City Anticlinal Belt, the Salem Anticline, the Louden Anticline, and most of the Rough Creek Fault Zone, which are therefore assumed not to have been topographically expressed when the erosional pattern was developing.

The erosional pattern of the western fifth of the area mapped differs somewhat from that of the eastern four fifths. The linear erosional pattern of the latter, formed by streams flowing southwest down the paleoslope, across regional strike, ends at about the Third Principal Meridian. Here the paleoslope encountered a rising Western Shelf with the Du Quoin Monocline at its eastern edge. North-south oriented valleys in the vicinity of the Du Quoin Monocline suggest that it was topographically expressed dur-

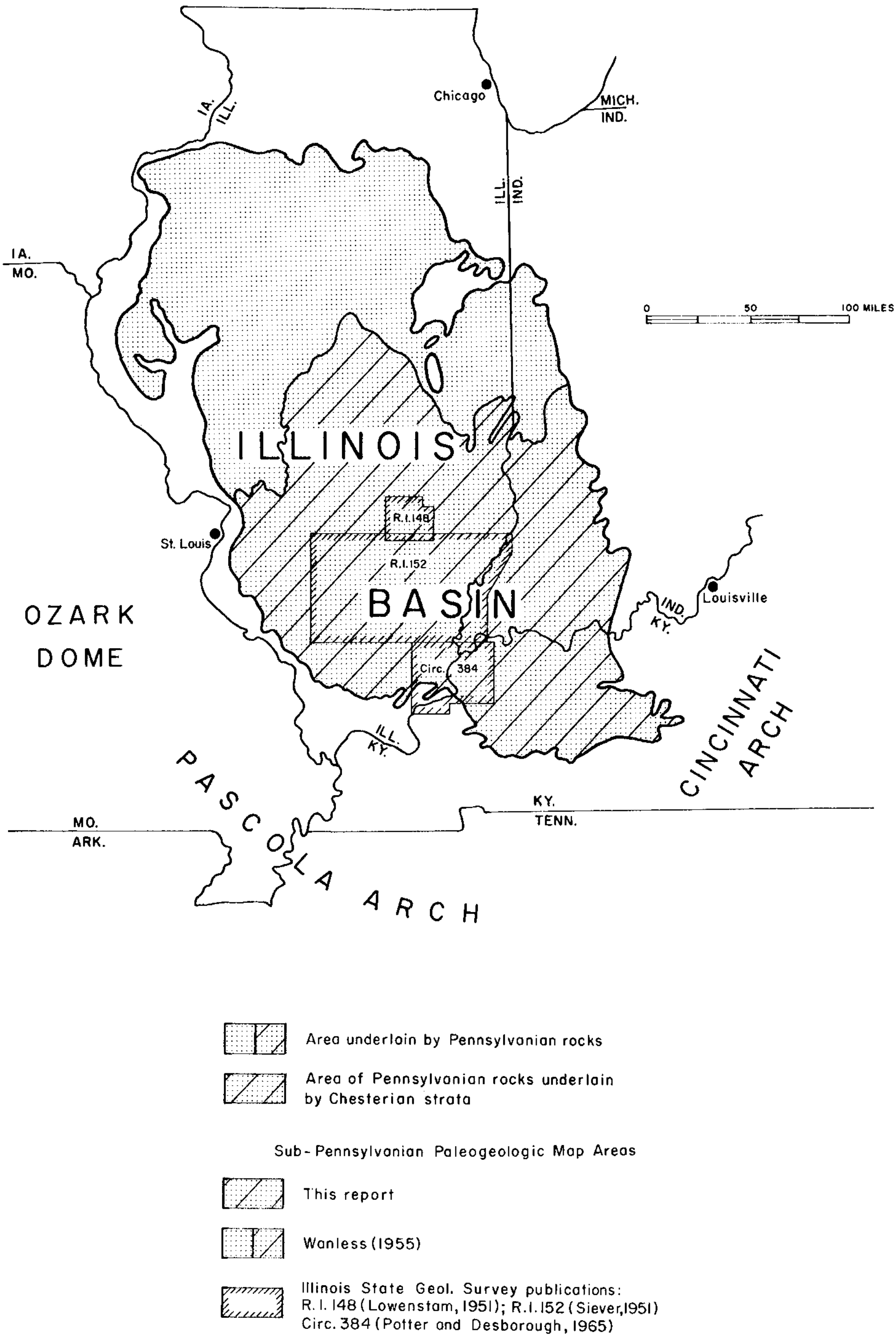


Fig. 1 - Areas of published sub-Pennsylvanian paleogeologic maps.

ing the development of the erosional pattern, deflecting southwestward-flowing streams to the south. In the area north of the Du Quoin Monocline's influence, southwestward-flowing streams crossed the Western Shelf roughly parallel to regional strike; consequently their valleys are poorly delineated on the geologic map.

INTRODUCTION

Chesterian strata are present over some 31, 700 square miles in the Illinois Basin and about 90 percent of them are covered by Pennsylvanian sediments. The erosional nature of the sub-Pennsylvanian surface in the Illinois Basin has long been recognized. The first significant study of this surface was published by Siever (1951). Wanless (1955), enlarging upon Siever's work, published a somewhat generalized pre-Pennsylvanian geologic map of the entire basin. Lowenstam (1951) and Potter and Desborough (1965) published pre-Pennsylvanian geologic maps of smaller areas in the basin. Figure 1 shows the map areas of these reports. Clegg's map (1959) of the pre-Pennsylvanian erosional surface depicts lows in Cumberland County, Illinois, which the present report indicates are in an erosional valley. Etheredge's isopach map (1953) of the basal Pennsylvanian sandstone over Louden oil field, Fayette County, Illinois, clearly shows sub-Pennsylvanian valleys.

These studies showed that the sub-Pennsylvanian surface is characterized by a system of stream valleys that are predominantly northeast-southwest oriented. Other studies (Potter and Siever, 1956; Potter, 1962; and Swann, 1963) have shown that Chesterian and early Pennsylvanian clastics were generally transported south and southwest. Previous workers, therefore, suggested that during Chesterian and early Pennsylvanian times the land sloped generally toward the southwest and that valleys on the Chesterian surface were eroded by southwestward flowing streams.

A comprehensive knowledge of the Chesterian-Pennsylvanian unconformity would require thorough study of early Pennsylvanian sedimentation. Such a study has not been part of this investigation. Our primary objective has been the identification of the Chesterian stratigraphic units immediately below the unconformity. However, by omitting the study of early Pennsylvanian sedimentation, we limit our discussion to the sub-Pennsylvanian (as opposed to pre-Pennsylvanian) surface, which may have been eroded by early Pennsylvanian as well as by pre-Pennsylvanian streams.

Acknowledgments

We are indebted to the following geologists with whom we discussed Pennsylvanian and Chesterian stratigraphy: Indiana Geological Survey members T. A. Dawson, H. H. Gray, D. M. Sullivan, and S. J. Keller; Kentucky Geological Survey members H. R. Schwalb and A. D. Williamson; K. E. Clegg of the Illinois State Geological Survey; P. E. Potter of Indiana University; and J. E. Palmer of Eastern Illinois University. Two unpublished maps were very helpful: T. A. Dawson's sub-Pennsylvanian geologic map (scale 1 to 500, 000) of Indiana and one from D. M. Sullivan's report on the West Baden Group in Vigo and Sullivan

Counties, Indiana. H. H. Gray gave us much data from the area along the outcrop of the Chesterian-Pennsylvanian unconformity, including the detailed delineation of the limit of Pennsylvanian strata in Indiana (plate 1). Most of Potter and Desborough's (1965) pre-Pennsylvanian geologic map (fig. 1) was used in drawing our paleogeologic map (plate 1). Rose's isopach map (1963) of the interval between the base of the Vienna Limestone and the Mississippian-Pennsylvanian unconformity in Muhlenberg County, Kentucky, was also used in constructing plate 1. Shawe and Gildersleeve's contour map (1969) of the Mississippian-Pennsylvanian unconformity in the Brownsville and Reedyville Quadrangles, Kentucky, was similarly used.

MAPPING PROCEDURE

Data Use

Various approaches can be made to studying a problematical stratigraphic boundary across an entire basin. For example, data use can vary from use of only a few of the available drill-hole records per township to use of every available drill-hole record. Geologic map detail varies with the number of stratigraphic units mapped and the scale of the map.

Our approach was to examine every available electric log; sample studies and drillers' logs were used to supplement the electric log studies. Figure 2 shows the density of subsurface control (over 53,000 datum points) used in constructing plate 1. In densely drilled areas, use of every electric log occasionally revealed topographic features (e. g., narrow, steep-walled valleys) which would not have been discovered if less control had been used.

In Illinois we examined the available records of every hole within the report area. In the densely drilled, central portion of the basin, electric logs were used exclusively, except where local stratigraphic problems required the study of well cuttings. In the outer portion of the basin, where there were fewer electric logs, sample studies were widely used. Drillers' logs were sometimes used when other data were not available.

For Indiana well data we used all available half-scale (1 inch = 40 feet) electric logs on file at the Indiana Geological Survey. Full-scale (1 inch = 20 feet) electric logs and lithology strips were rarely used.

In Kentucky we used primarily half-scale electric logs filed at the Henderson field office of the Kentucky Geological Survey. Where electric logs were scarce, sample studies, drillers' logs and published geologic quadrangle maps were frequently used.

The irregular nature of the limit of Pennsylvanian strata is shown in much more detail along the Indiana portion of the eastern side of the paleogeologic map (plate 1) than elsewhere on the map. However, in this area it would be impossible, from the standpoint of preparing a map, to show the sub-Pennsylvanian Chesterian areal geology in such detail. Therefore, along this area in Indiana we showed Chesterian areal geology without regard to Pennsylvanian cover and indicated by stippling those areas not now covered by Pennsylvanian rocks.

At the southeastern corner of the report area (plate 1) the mapped area ends abruptly at the eastern edge of Cub Run Geologic Quadrangle in J-42. The geologic map of Kentucky (Kentucky Geological Survey, 1954) shows a chain of Pennsylvanian outliers extending some 35 miles farther northeast. However, geologic quadrangle maps are not yet available for the area northeast of Cub Run Quadrangle; therefore, we did not attempt to map this area.

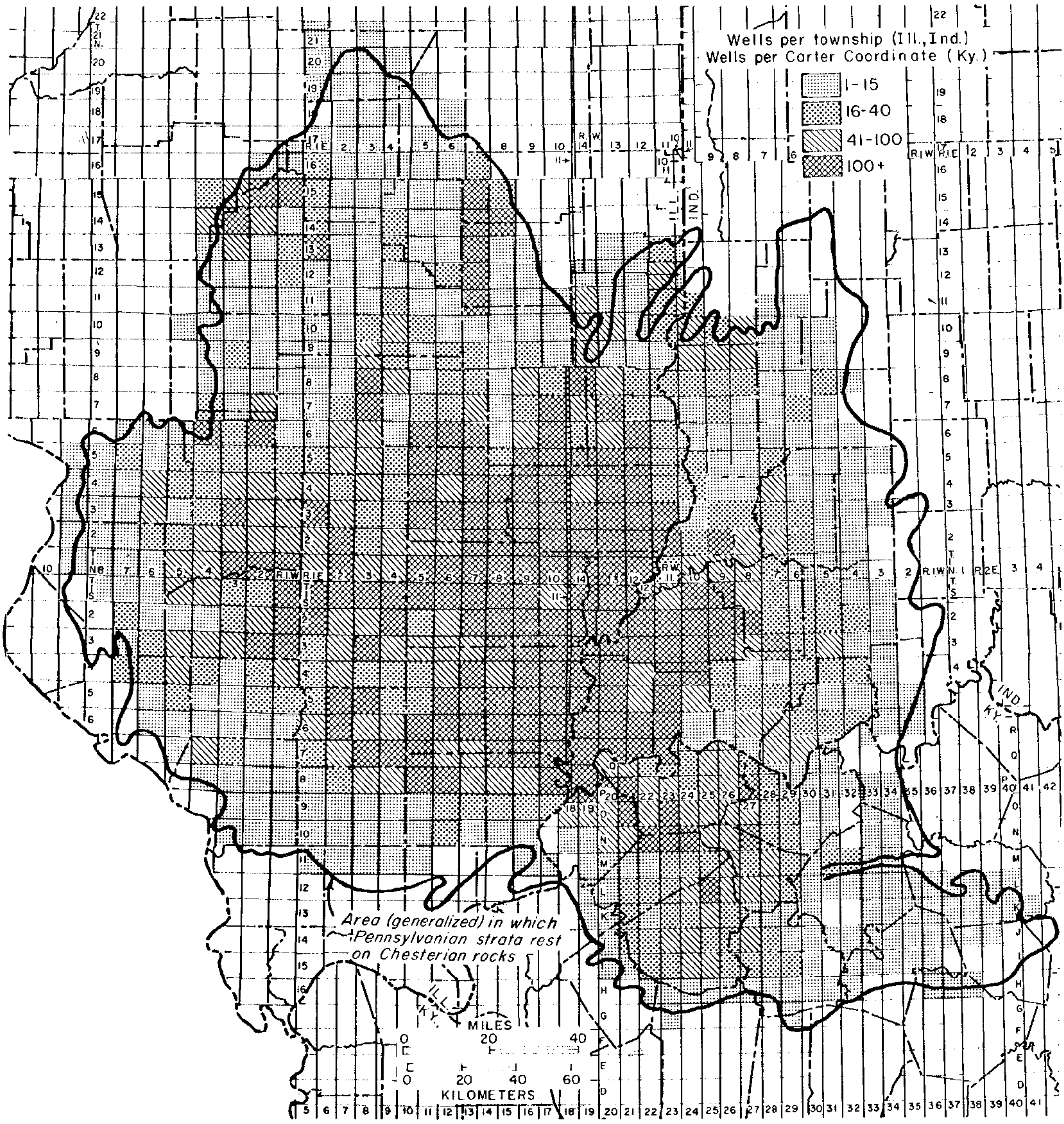


Fig. 2 - Density of subsurface control used in plate 1.

Selection of Map Units

The problems of identifying the Chesterian-Pennsylvanian boundary are described in detail by Atherton et al., (1960). The lower 1000 feet of Pennsylvanian sediments in the Fairfield Basin are nearly all clastics, but the underlying Chesterian sediments are clastics interbedded with widespread marine carbonates which can be identified. Therefore, the main problem in locating the unconformity is to recognize its position in the clastic section between the highest preserved Chesterian limestone and the position that would be occupied by the first missing Chesterian limestone.

In this study, the problem of locating the unconformity within a Chesterian-Pennsylvanian clastic section was circumvented and the mapping was simplified by employing Chesterian clastic-carbonate couplets (table 1 and fig. 3).

The use of clastic-carbonate couplets results in a less detailed geologic map than if each formation were mapped, but it seems justified because it is quicker and more reliable than mapping individual Chesterian clastic units. Seldom are Pennsylvanian rocks easily differentiated in contact with the upper, clastic segments of couplets, although such interpretations are recorded on our work maps (scale 1 inch = 1 mile, on open file at the Illinois Survey). Commonly the exact position of the unconformity is in doubt. Mapping the extrapolated subcrop of clastic units firmly identified in only a few places is of relatively little value if these units cannot be recognized throughout a broad area. It has been considered better to map those clastic-carbonate couplets whose subcrops can be more reliably traced. Furthermore, adequate portrayal of more detailed mapping is precluded by the small scale of the published map.

Some Illinois map units are poorly applicable in Indiana and Kentucky. The Yankeetown and Aux Vases Sandstones of southern Illinois, above and below the Renault Limestone respectively, diminish to insignificance eastward and southeastward into Indiana and Kentucky. Therefore, in Indiana, the lowest two couplet boundaries (plate 1 and fig. 3) are uncertainly drawn. Mapping is difficult at the southeastern corner of the report area because subsurface data are sparse and because post-Glen Dean units break up into a sequence of thin alternating limestones, sandstones, and shales.

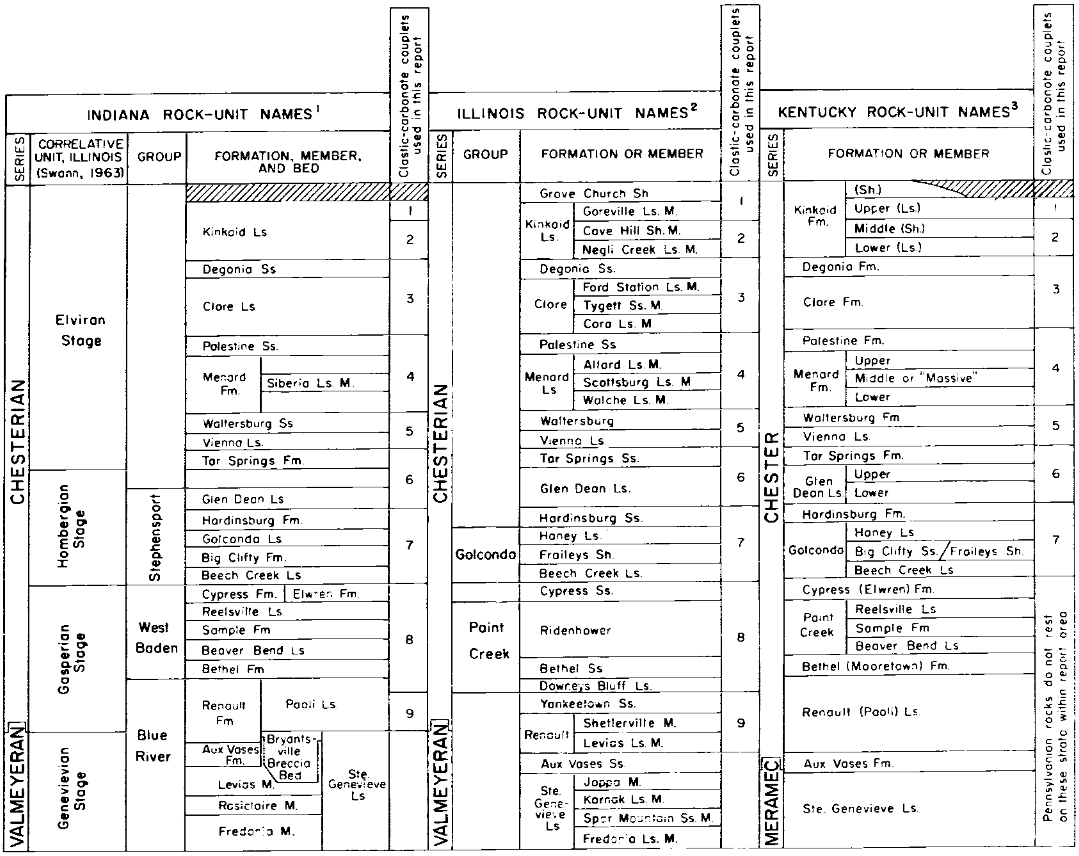
CHARACTERISTICS OF THE CHESTERIAN-PENNSYLVANIAN UNCONFORMITY

Erosional Pattern

The northeast-southwest orientation of major sub-Pennsylvanian valleys in the Illinois Basin is shown in plate 1 and figure 4. (All valley names in figure 4, except Evansville, are new in this report and are listed in table 2). Erosion of Chesterian strata by southwestward-flowing streams formed outcrop-pattern "V's" that point downstream (plate 1); these "V's" suggest that regional structural dip was greater than the paleoslope. A modern analogue is suggested by the geologic

TABLE 1 — CHESTERIAN CLASTIC—CARBONATE COUPLETS USED IN THIS REPORT

1.	Grove Church Shale — Goreville Limestone Member of Kinkaid Formation
2.	Cave Hill Member — Negli Creek Limestone Member of Kinkaid Formation
3.	Degonia Sandstone — Clore Formation
4.	Palestine Sandstone — Menard Limestone
5.	Waltersburg Formation — Vienna Limestone
6.	Tar Springs Sandstone — Glen Dean Limestone
7.	Hardinsburg Sandstone — Golconda Group
8.	Cypress Sandstone — Paint Creek Group
9.	Yankeetown Sandstone — Renault Limestone



[1] Shaver et al. (1970, table 4). [2] Swann (1963). [3] Rose (1963: plate 2, modified).

Fig. 3 - Stratigraphic classification of upper part of Mississippian System in the Illinois Basin.

map of central Georgia and central South Carolina (U. S. Geological Survey, 1932), which shows the development of a linear drainage system on a gently dipping coastal plain.

Although our views on stream-flow direction in sub-Pennsylvanian valleys generally agree with those of previous workers, several exceptions are noteworthy. Siever' s index map (1951, fig. 9) of pre-Pennsylvanian channels in southern Illinois (fig. 5) presents several interpretations which are now significantly altered in the light of data generated from the last 20 years of oil exploration:

(1) Siever indicated (fig. 5) that Inman Valley (plate 1 and fig. 4) drained into Walpole Valley. This probably did take place initially. However, Potter and Desborough, in a modification (1965) of Wanless' paleogeologic map (1955, fig. 2), suggested that Inman Valley probably joined Evansville Valley within a short distance south of the present report area. We agree with this interpretation, which implies that Evansville Valley captured stream flow from Walpole and Grayville-Lawrenceville Valleys via Inman Valley.

TABLE 2 — SUB-PENNSYLVANIAN VALLEYS NEWLY NAMED IN THIS REPORT

Valley Names	Location
Benton-Fairfield	Illinois-Indiana
Brownsville	Kentucky
Drakesboro	Kentucky
Enfield	Illinois
Farina	Illinois
Gorham	Illinois
Grayville-Lawrenceville	Illinois-Indiana
Greenville	Kentucky
Harco	Illinois
Inman	Illinois
Iuka	Illinois
Madisonville	Kentucky-Indiana
Marion	Illinois
Mattoon	Illinois
McLeansboro	Illinois
Mt. Vernon-Ste. Marie	Illinois
Taylorville	Illinois
Toledo	Illinois
Vandalia	Illinois
Walpole	Illinois

(2) In his 1951 report, Siever predicted the confluence of Walpole and Benton-Fairfield Valleys (fig. 4) in eastern Franklin County (fig. 5); however, exploratory drilling subsequent to the report has failed to reveal this confluence. Potter and Desborough (1965) indicated that these valleys do not join. In fact, as we show in plate 1, Walpole Valley narrows to the west along the southern border of Hamilton County. Instead of swinging northwest at the Hamilton-Franklin County line to link up with Benton-Fairfield Valley, it veers southwestward into Marion Valley, which parallels Benton-Fairfield Valley.

(3) Siever tentatively suggested that a divide runs southeastward across Marion and Wayne Counties. In part, he made this suggestion in an attempt to explain the presence of the Goreville Limestone Member of the Kinkaid Formation in the floor of Mt. Vernon-Ste. Marie Valley in northwestern Wayne County. We think that instead of a divide, a slight downwarping permitted some of the Goreville Limestone Member to escape erosion. A similar situation exists in McLeansboro Valley in south-central Hamilton County.

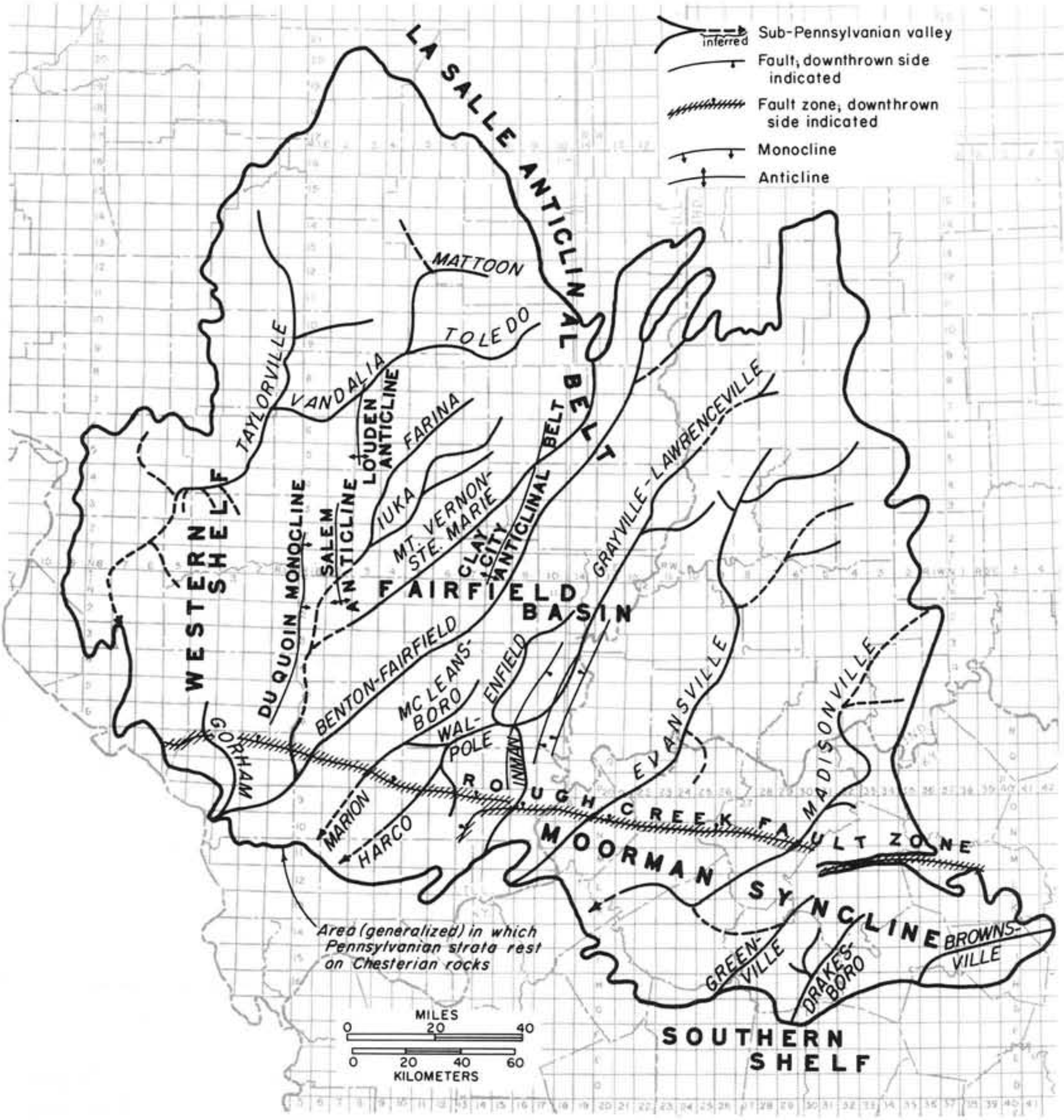


Fig. 4 - Relationship of sub-Pennsylvanian valleys to tectonic features of the Illinois Basin.

Sub-Pennsylvanian Valleys in Cross Section

Valley widths and depths vary, depending on which Chesterian unit is considered to constitute the valley walls (plate 1). Valleys range in width from several hundred feet up to 20 miles. Depths vary from only a few feet to about 450 feet. An example of a sub-Pennsylvanian valley is shown in an electric log cross section of a tributary to Benton-Fairfield Valley (fig. 6). At least 300 feet of Chesterian rocks have been removed in the 1/4-mile wide subsurface valley

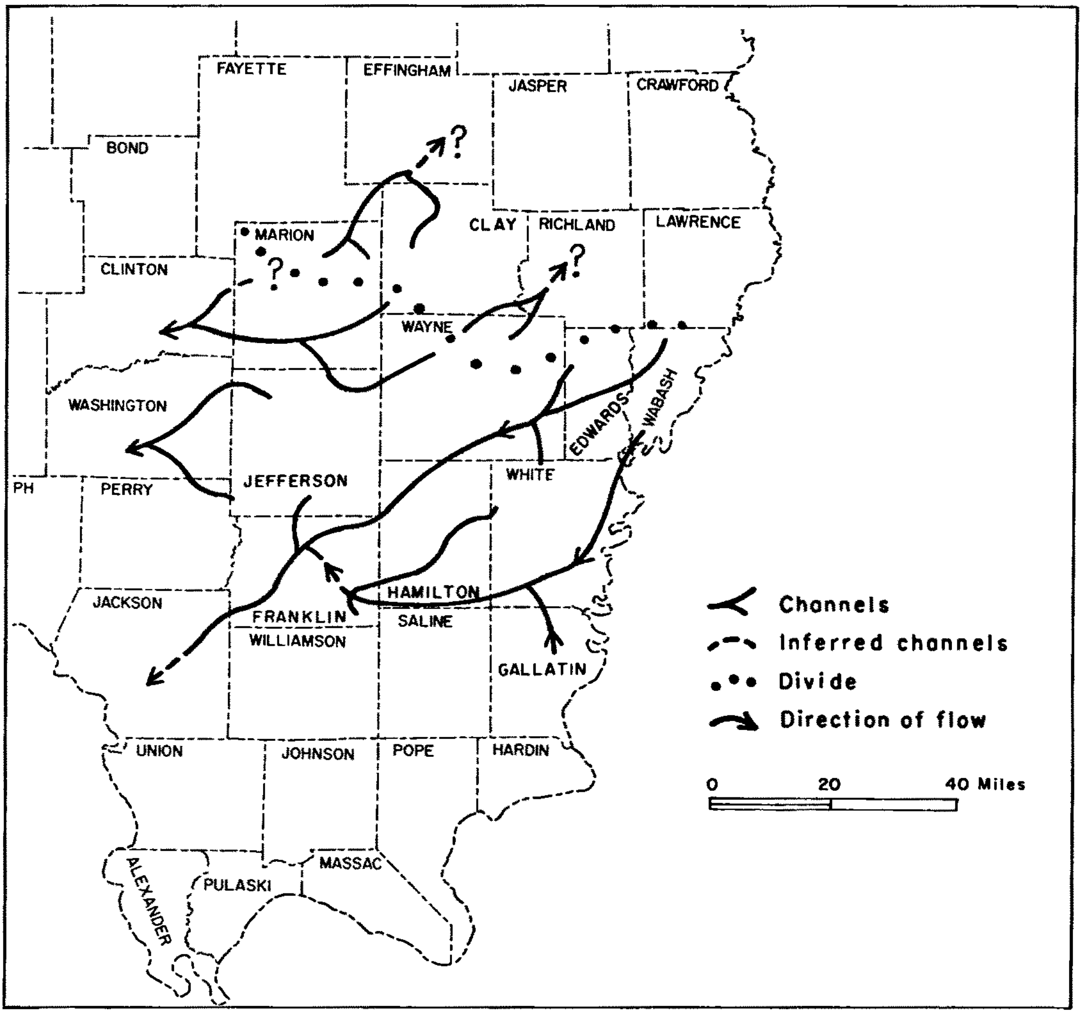


Fig. 5 - Siever's index map (modified) of pre-Pennsylvanian channels (1951, fig. 9).

cut through the Negli Creek Limestone Member of the Kinkaid Formation. Local topographic relief is as much as 220 feet between points not more than 330 feet apart.

Chesterian Limestone Slump Blocks Within Basal Pennsylvanian Sediments

Chesterian limestone slump blocks noted within basal Pennsylvanian sediments are shown on plate 1. Many more slump blocks undoubtedly exist but were not detected. For example, we did not re-examine drill-hole records for evidence of slump blocks in that portion of southeastern Illinois mapped by Potter and Desborough (1965), (fig. 1). Most of those noted are limestone blocks of Negli Creek; limestone blocks from the Goreville Member or from the Clore, Menard, Glen Dean, and Beech Creek Formations are rare. Swann (1945) described

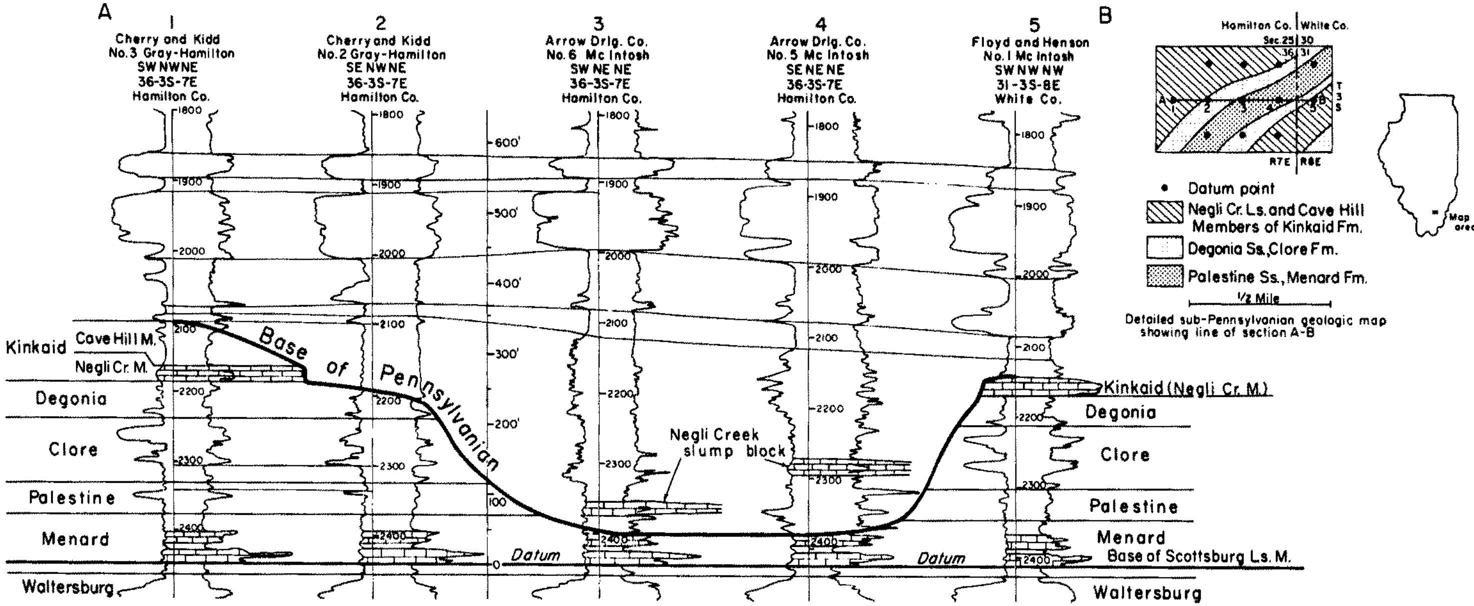


Fig. 6 - Cross section of tributary of sub-Pennsylvanian Benton-Fairfield Valley, Hamilton and White Counties, Illinois.

blocks of the Negli Creek and the underlying Degonia Sandstone occurring within basal Pennsylvanian sediments in the subsurface of northwestern Clay County. Logs 3 and 4 in figure 6 show Negli Creek blocks 25 feet and 85 feet, respectively, above the base of Pennsylvanian.

Karst Topography Problem

The presence of numerous small Cave Hill-Negli Creek inliers, surrounded by Goreville limestone, suggests possible development of karst topography on the

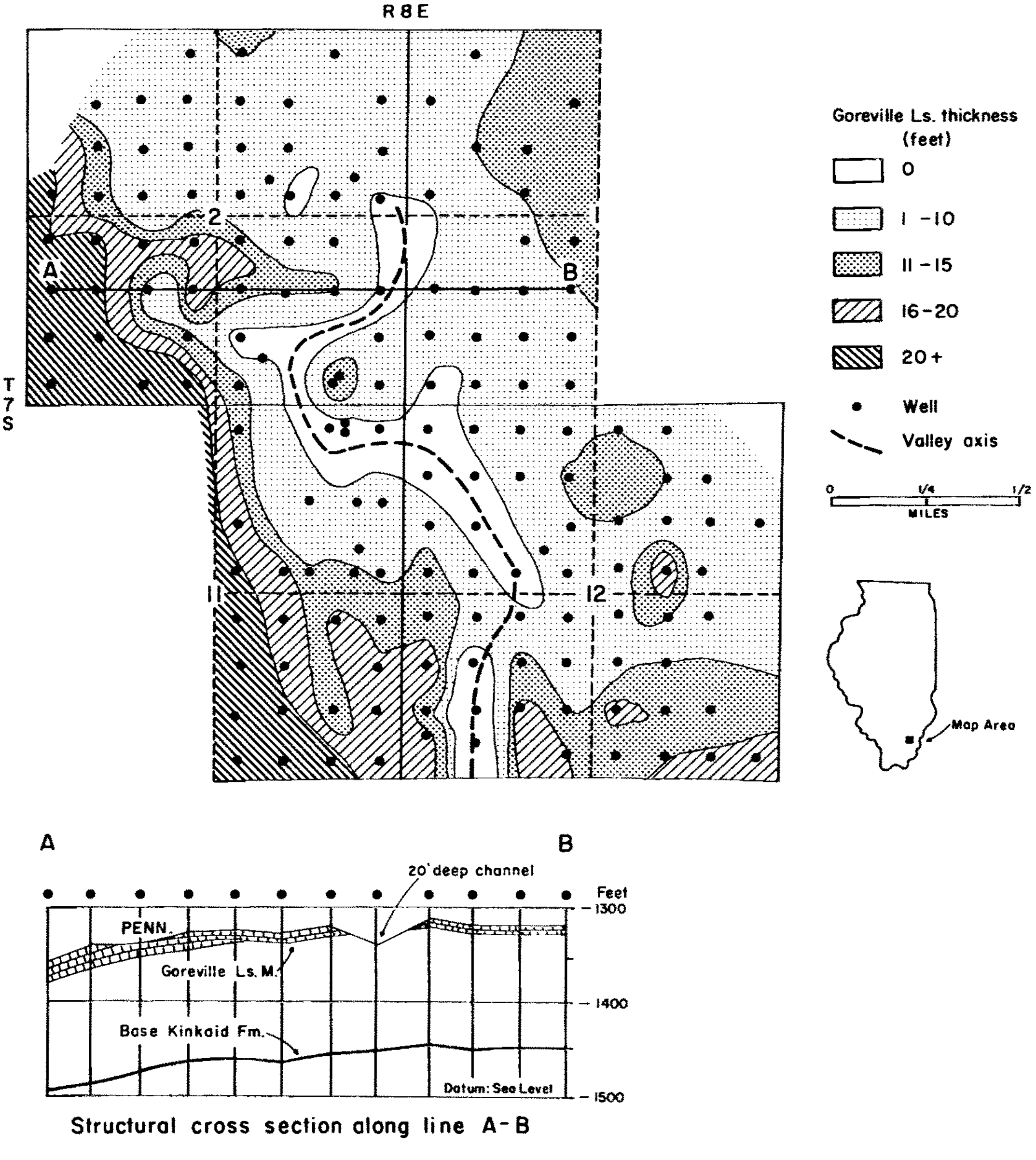


Fig. 7 - Erosion of Goreville Limestone Member of Kinkaid Formation in small sub-Pennsylvanian valley in southwestern White County, Illinois.

Goreville. In the northeastern part of T. 7 S., R. 8 E., White County, a chain of Cave Hill-Negli Creek inliers (plate 1) paralleling the Goreville subsurface valley walls of Inman Valley were at first thought to be indicative of karst topography. However, detailed mapping (fig. 7) indicates that the normally 25-feet thick Goreville has been beveled by erosion; locally, in a 20 to 30-foot deep channel, it has been completely removed. Therefore, these inliers do not represent karst topography. It is not known if karst topography underlies the Chesterian-Pennsylvanian unconformity elsewhere; evidence is difficult to obtain from available subsurface data.

Historical Summary

At the beginning of Chesterian time the present Illinois Basin area was covered by a shallow portion of a large sea occupying the area to the south. During Chesterian time an alternating sequence of carbonates and clastics (derived mainly from the northeast) gradually accumulated in the area. These sediments were deposited over a greater area than they now occupy in the Illinois Basin. This fact is indicated by plate 2 (II and IV), which shows that Chesterian units, while thinning very gradually to the north, are of nearly uniform thickness (except where subjected to pre-Pennsylvanian erosion) to the present limits of Chesterian strata.

As the sea withdrew at the end of Chesterian time, the land surface emerged and was subjected to subaerial erosion. A system of northeast-southwest oriented valleys developed over the eastern four fifths of the basin (plate 1). A rising La Salle Anticlinal Belt probably caused slight southward deflection of the Mt. Vernon-Ste. Marie and Benton-Fairfield Valleys in Clark and Edgar Counties, Illinois (fig. 4). The Clay City Anticlinal Belt, the Salem Anticline, the Louden Anticline, and most of the Rough Creek Fault Zone had no apparent effect on valley courses and therefore are assumed not to have been topographically expressed when the erosional pattern was developing. Howard Schwalb (personal communication, 1970) thinks Chesterian deposition and erosion may have been affected by complex faulting in western Grayson and eastern Ohio Counties, Kentucky.

The erosional pattern of the western fifth of the area mapped is somewhat different from that of the eastern four fifths. In the eastern four fifths of the mapped area, streams flowing southwest down the paleoslope eroded valleys across regional strike, thereby producing a linear erosional pattern. This pattern ends at about the Third Principal Meridian where the paleoslope encountered a rising Western Shelf with the Du Quoin Monocline at its eastern edge. North-south oriented valleys in the vicinity of the monocline indicate that it was topographically expressed during the development of the erosional pattern, deflecting southwestward-flowing streams to the south. North of the Du Quoin Monocline's influence, southwestward-flowing streams crossed the Western Shelf roughly parallel to the northeast-southwest regional strike; consequently, their valleys are not well delineated by geologic mapping.

In early Pennsylvanian time the present Illinois Basin area was again invaded by a shallow portion of the large sea occupying the area to the south. Plate 2 (II and IV) indicates that Pennsylvanian sediments below the Colchester (No. 2) Coal Member in Illinois entered a continually sagging depositional trough that plunged to the south. The structurally lower areas continued to sag and receive sediment even as the rim areas of the basin were still being eroded. By the time the Colchester (No. 2) Coal Member was deposited (plate 2, II and IV), Pennsylvanian deposition extended over the remaining Chesterian surface.

Post-Pennsylvanian deformation completed the present structural configuration of the Illinois Basin (plate 2, I and III).

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(Chemical Group continued on next page)

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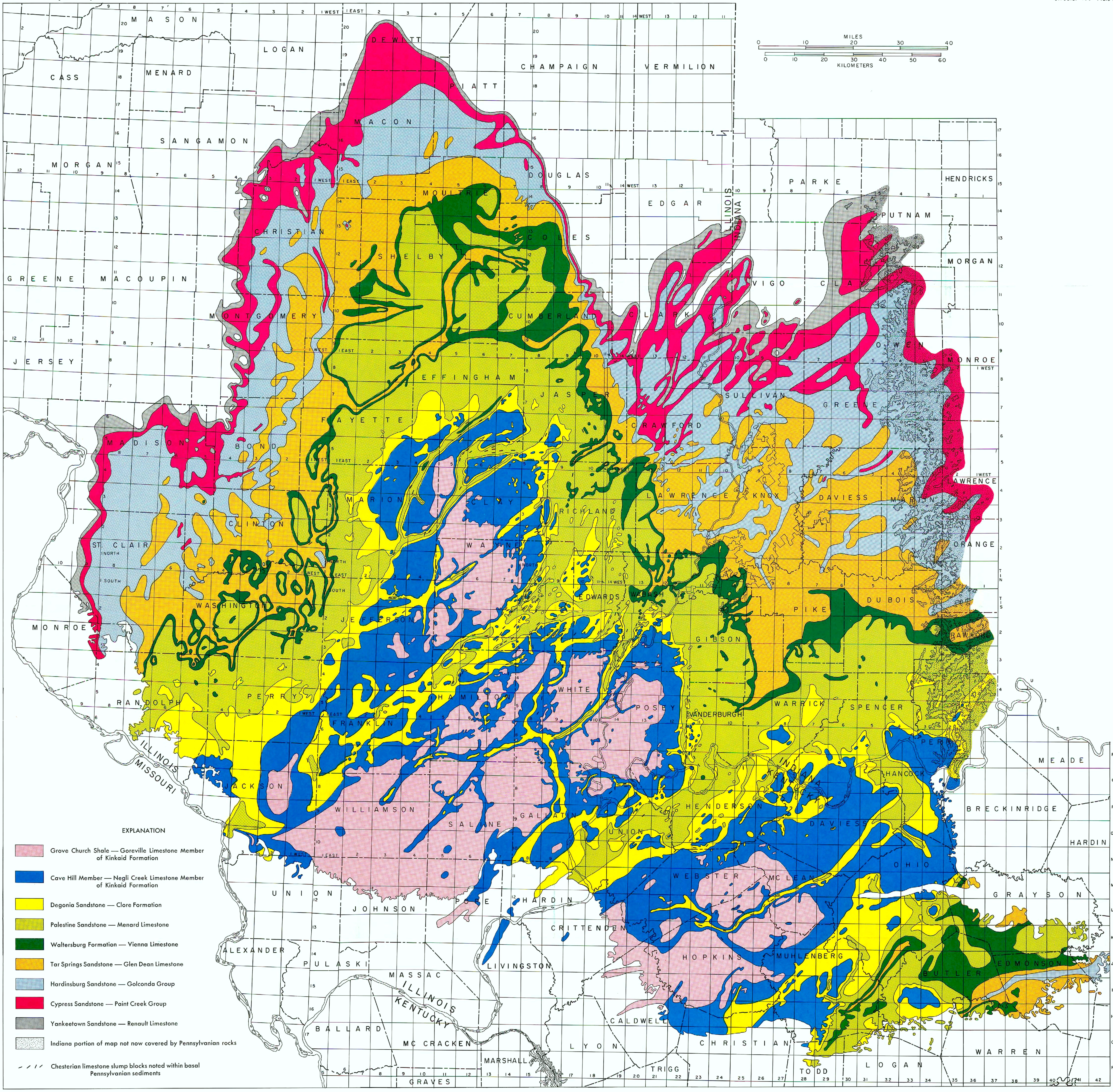
Topographic mapping in cooperation with the
United States Geological Survey.

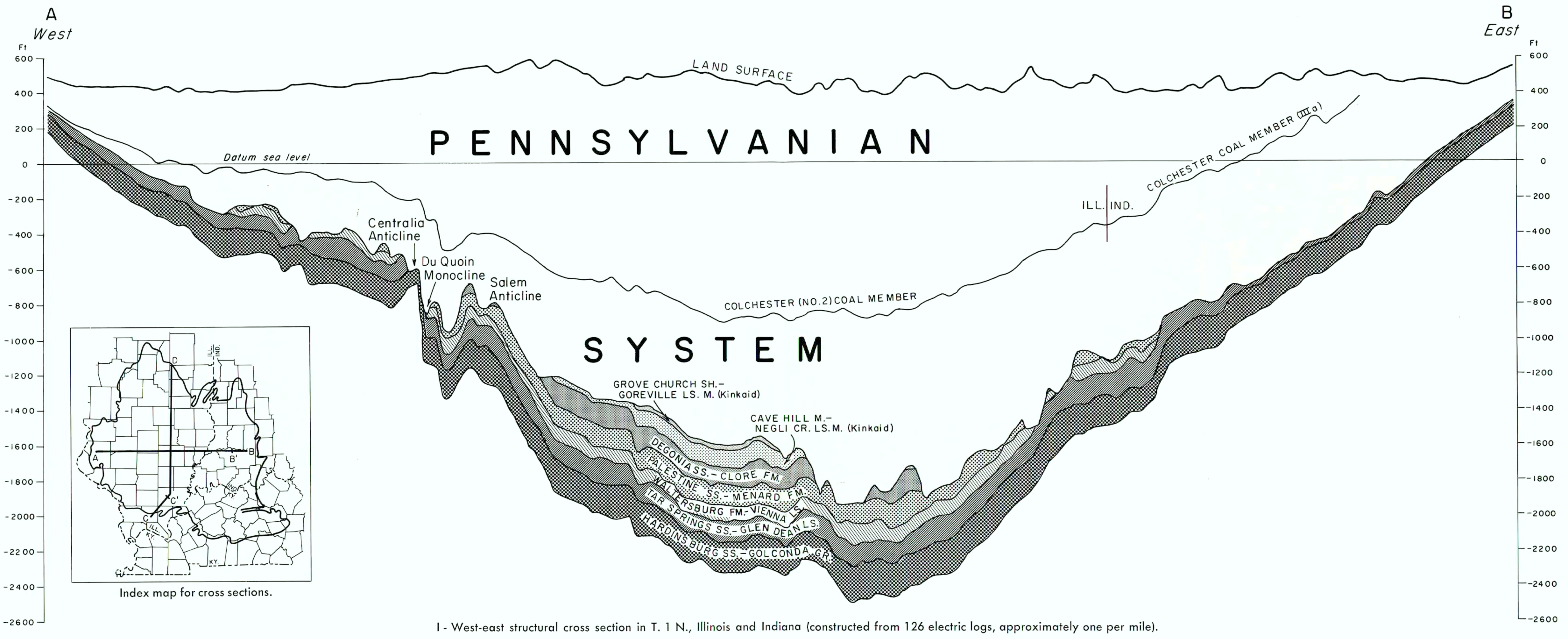


PALEOGEOLOGIC MAP OF THE SUB-PENNSYLVANIAN CHESTERIAN SURFACE IN THE ILLINOIS BASIN

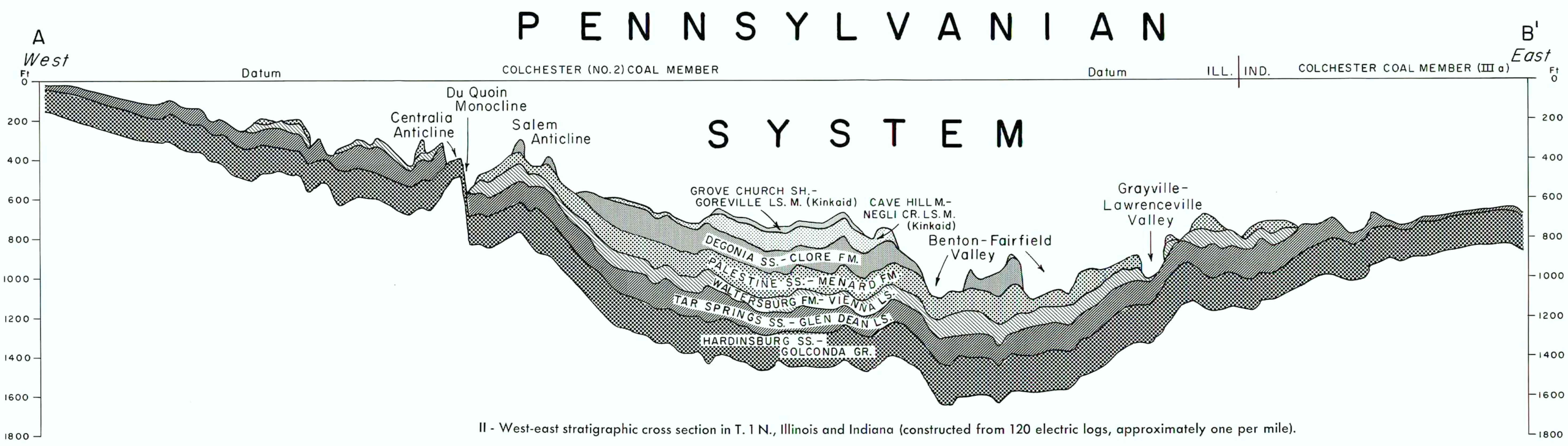
by

H. M. Bristol and R. H. Howard

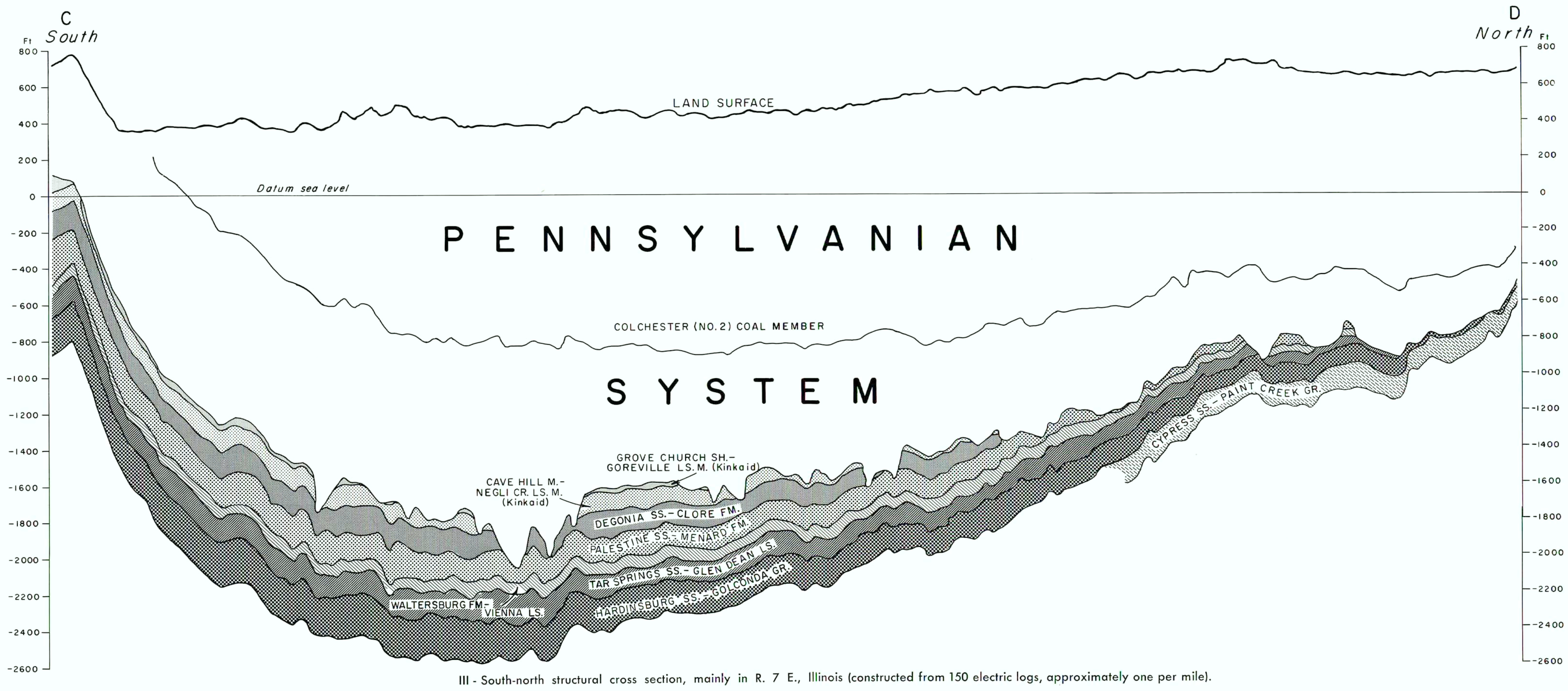
1971



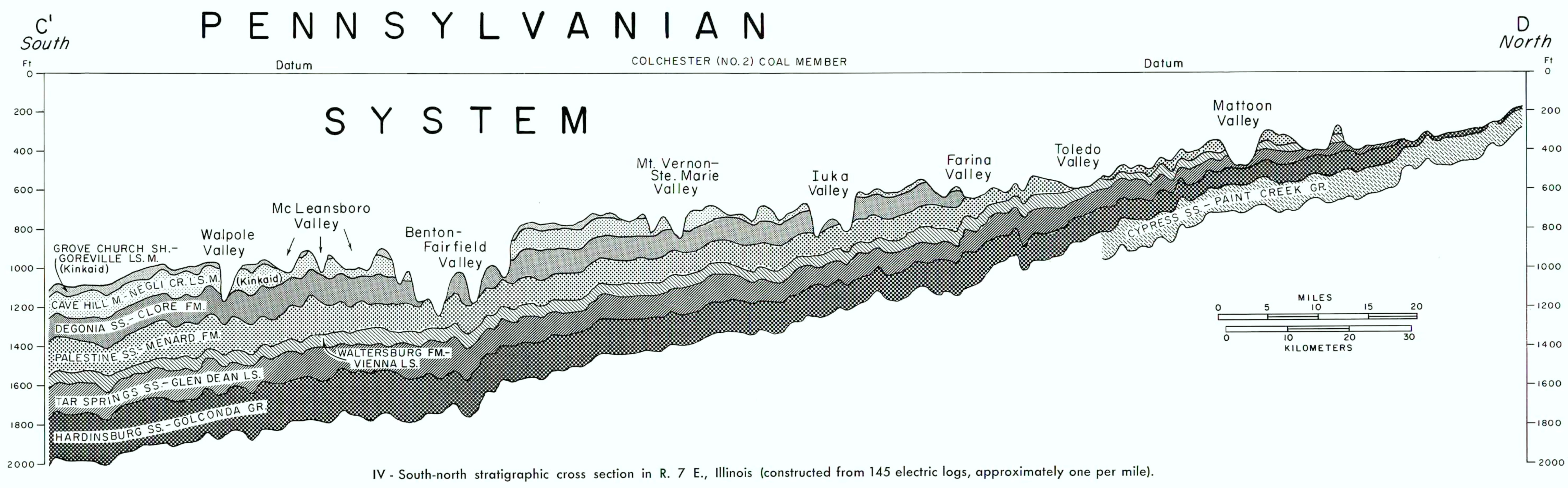
I - West-east structural cross section in T. 1 N., Illinois and Indiana (constructed from 126 electric logs, approximately one per mile).



II - West-east stratigraphic cross section in T. 1 N., Illinois and Indiana (constructed from 120 electric logs, approximately one per mile).



III - South-north structural cross section, mainly in R. 7 E., Illinois (constructed from 150 electric logs, approximately one per mile).



IV - South-north stratigraphic cross section in R. 7 E., Illinois (constructed from 145 electric logs, approximately one per mile).

STRUCTURAL AND STRATIGRAPHIC CROSS SECTIONS OF UPPER PART OF CHESTERIAN AND OVERLYING PENNSYLVANIAN STRATA

by

H. M. Bristol and R. H. Howard

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