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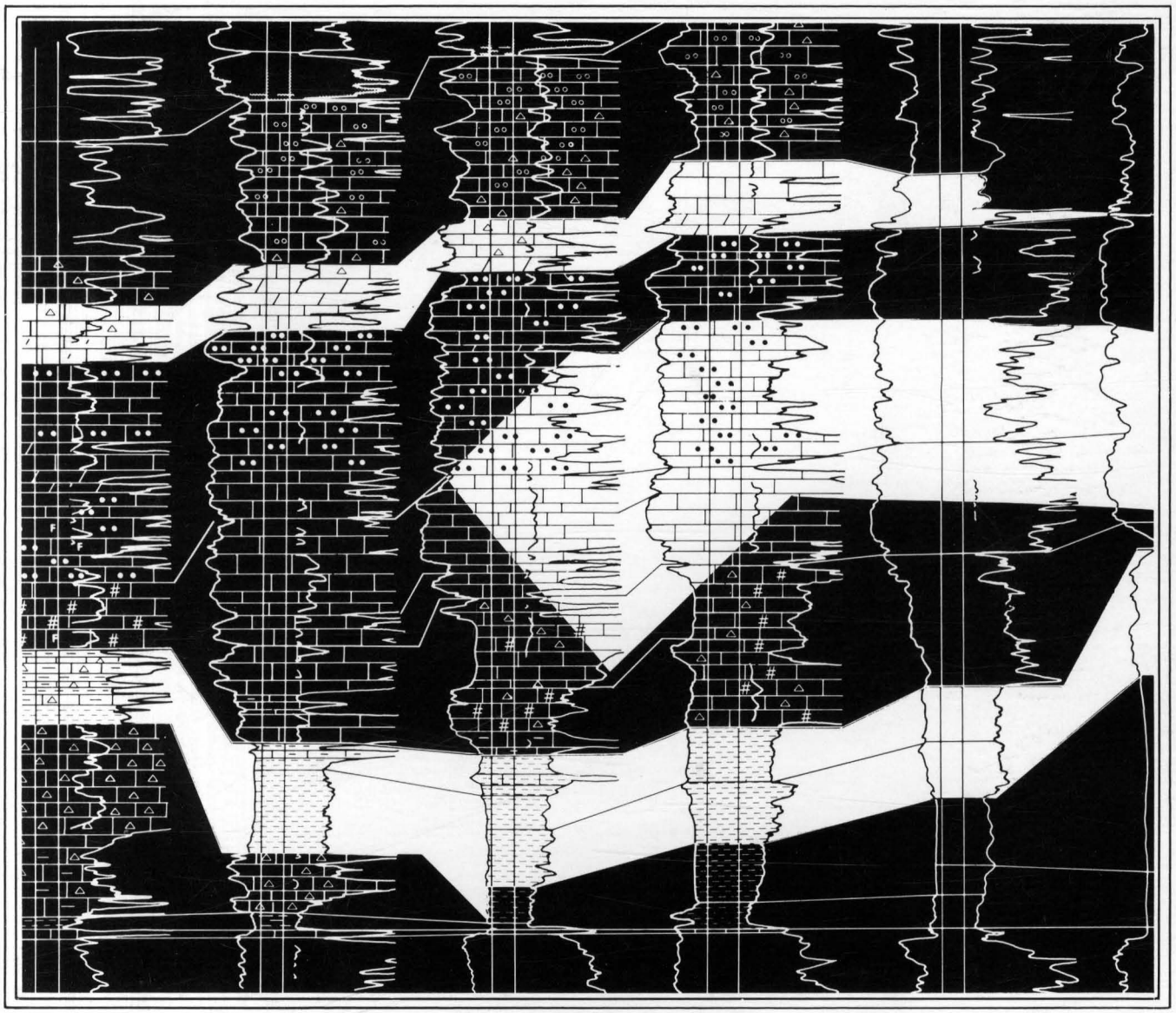
THE EASTERN MARGIN OF THE BURLINGTON-KEOKUK (VALMEYERAN) CARBONATE BANK IN ILLINOIS

Jerry A. Lineback



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Cover design and figures by Craig Ronto

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THE EASTERN MARGIN OF THE BURLINGTON - KEOKUK (VALMEYERAN) CARBONATE BANK IN ILLINOIS

ABSTRACT

The Burlington and Keokuk Limestones were deposited in a shallow shelf environment in western Illinois. At the same time, relatively greater subsidence near the middle of the Illinois Basin had produced water too deep for carbonate deposition. Excess carbonate from the shelf was moved eastward towards the deep-water basin. The Burlington-Keokuk thickens eastward, then terminates abruptly by eastward thinning along a 2 mile (3 km) wide belt extending across Illinois. This abrupt margin appears to be the leading edge of a prograding carbonate bank. The growth of the bank was terminated by the westward growth of the Borden Siltstone delta complex that buried the bank margin and temporarily halted carbonate production on the shelf. Fifteen geophysical log cross sections along the bank margin in Illinois illustrate the eastward thinning.

INTRODUCTION

Red, green, and gray shale and limestone of the Fern Glen Formation and light colored, cherty, crinoidal limestone of the Burlington and Keokuk Limestones crop out extensively along the Mississippi and lower Illinois Rivers in the type area of the Mississippian System (fig. 1). Similar strata are present in a region from Kansas, across Missouri, and into Iowa and Illinois (Lane, 1978). Well logs from central and southeastern parts of Illinois, however, do not show strata identifiable as the Burlington or Keokuk Limestones. Rather, in the structurally deeper parts of the Illinois Basin, the position of the Burlington and Keokuk is occupied in places by siltstone, siliceous carbonate, and bryozoan-rich limestone (fig. 1). Lineback (1966) showed that cherty limestone of the Burlington-Keokuk abruptly terminates in a sharply defined belt, as little as 2 miles (3 km) wide in the subsurface of central and southwestern Illinois. The Burlington-Keokuk is overlain and overlapped by siltstone of deltaic origin. This siltstone is, by convention, called the Borden Siltstone beyond the Burlington-Keokuk margin and is called the Warsaw Shale where the Burlington-Keokuk is recognizable. The Burlington and Keokuk Limestones are not separated for the purposes of this report.

The Burlington and Keokuk Limestones are shallow-water, largely bioclastic carbonate sediments that were deposited in a shelf area west of the central part of the Illinois Basin. They formed an eastward prograding crinoidal carbonate bank that stood at least 200 to 300 feet (60 to 90 m) above the floor of the deep-water basin to the east (fig. 2). The advancing deltaic clastics of the Borden were deposited adjacent to and on top of the limestone bank but generally do not intergrade with it (Swann, Lineback, and Frund, 1965). Individual beds in the Burlington and Keokuk thin abruptly eastward across a 2-mile (3 km) interval until the entire limestone sequence wedges out between the overlying deltaic clastics and the underlying Fern Glen Formation. The Warsaw Shale, which overlies the Keokuk Limestone, is part of the clastic delta and is equivalent to all but the lower few feet of the Borden Siltstone in southern Illinois. During deposition of the Fern Glen, Burlington, and Keokuk, only a few feet of mud accumulated in southern Illinois above the Kinderhookian Chouteau Limestone, which floored the basin. Shale of the Fern Glen Formation can be traced a short distance beyond the front of the Burlington-Keokuk bank on the basis of its red and green color. Where the Fern Glen cannot be recognized, it is probably represented by thin shale at the base of the deltaic sequence.

The steep eastern margin of the crinoidal carbonates that developed as shallow-water carbonate sediment was moved eastward by waves and currents into water too deep or turbid for much in situ carbonate production. Middle Mississippian strata thicken towards the present structural center of the Illinois Basin; this indicates that differential subsidence occurred between the western shelf, where the carbonate bank developed, and a deep-water sediment-starved basin in southeastern Illinois.

Fifteen electric log cross sections have been constructed across the bank margin (fig. 3). These logs show the stratigraphic and depositional relationship of the bank margin to the advancing Borden clastics along its entire length in

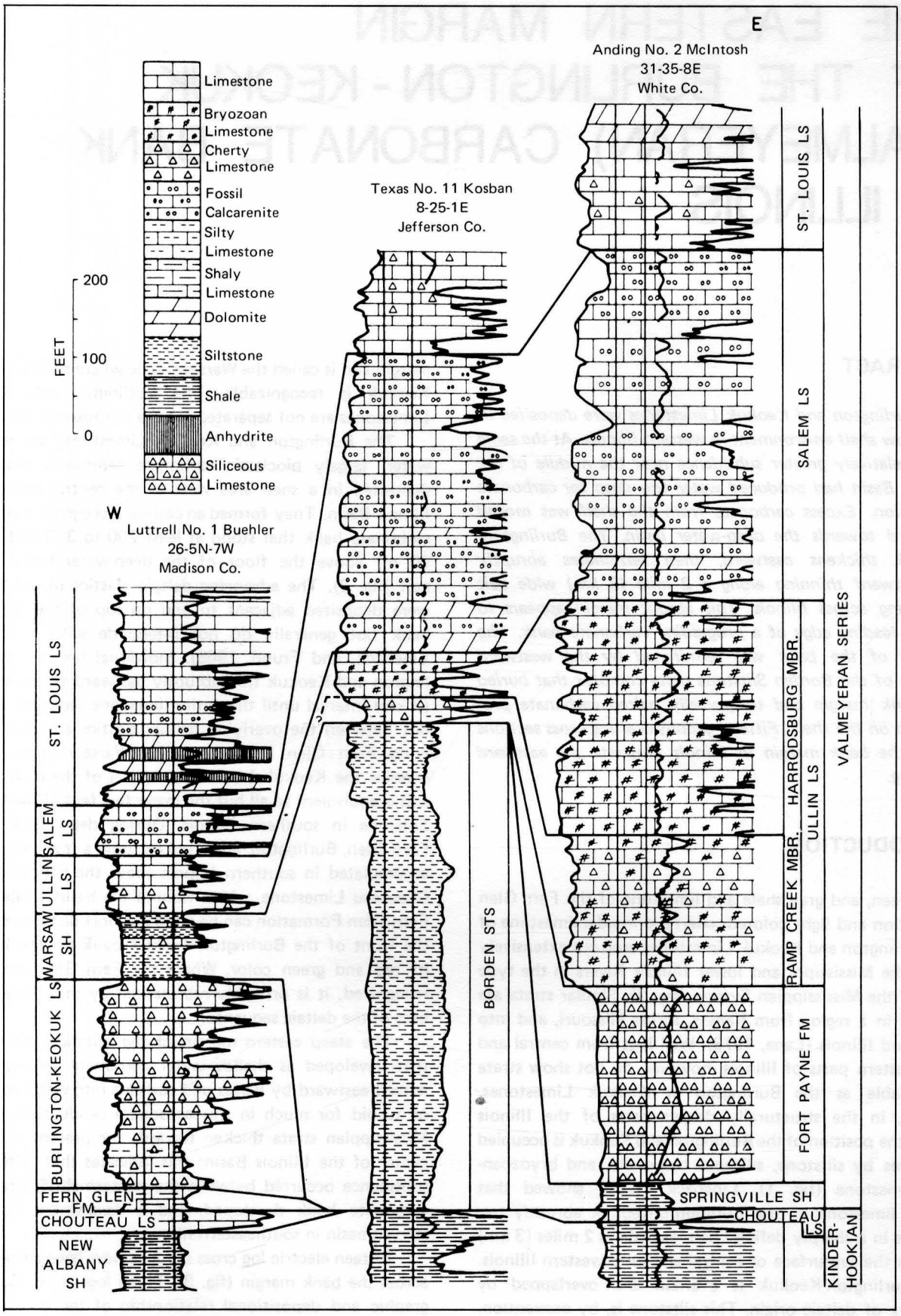

Figure 1. Electric and lithologic logs showing the four major lower Valmeyeran units and stratigraphic nomenclature. (From Lineback, 1966.)

Illinois. In addition, details of the bank topography are illustrated by means of logs from closely spaced wells in Christian County, Illinois (cross section E).

The Borden and the Warsaw are overlain in places by the Ullin, Salem, and St. Louis Limestones. The Ullin Limestone thins and pinches out to the northwest in central Illinois (Lineback, 1966). North of the recognizable Ullin, either the Salem or St. Louis Limestone rests on the Borden or Warsaw. The Salem grades laterally into the St. Louis to the north, and strata equivalent to the Salem are called St. Louis where they are no longer recognizable as Salem on a lithologic basis (Lineback, 1972). These stratigraphic relationships are summarized in Willman et al. (1975).

THE BANK MARGIN—NORTH TO SOUTH

The Burlington-Keokuk Limestone in Vermilion County (cross section A, fig. 4) was closest to the deltaic clastics being deposited contemporaneously in Indiana. It was also the first area to be overwhelmed by the clastics as the delta invaded Illinois. The cross section suggests that there is some interbedding of limestone and siltstone at the margin and possibly some lateral gradation. Because the distance between wells is greater in this cross section than in others and because of steep depositional slopes in the deltaic clastics, it is difficult to be certain of correlations (Swann, Lineback, and Frund, 1965). The carbonate unit in the middle of the log for the Dollahan No. 1 Kelley well is probably a biohermal carbonate body like those occurring in the Borden in nearby Indiana (Lane, 1973).

In Piatt County (cross section B, fig. 5) there appears to be a relatively clear-cut thinning across the bank margin, although the wells are relatively far (6 miles, 10 km) apart. Cross section C, in Macon and Piatt Counties (fig. 6), shows some possible interbedding with siltstone in the marginal area. The Burlington-Keokuk thins from 195 feet (59.4 m) to 40 feet (12 m) in Section 23, attesting to the abruptness of the bank margin. This cross section also shows the Fern Glen extending beyond the margin of the carbonate bank.

Cross section D (fig. 7) and cross sections south of it do not show significant mixing of shale or siltstone with the limestone at the bank margin. Possibly this is the westward limit of influence of terrigenous clastics during the deposition of the Burlington-Keokuk, prior to the Borden-Warsaw clastics advancing over the bank front. By the time of the deposition of the Bilyeu Member, a distributary channel sand, the depth of clastic deposition in T. 14 N., R. 2 E., was nearly 400 feet (122 m) and the bank margin was completely covered. It apparently presented no physical barrier to the deposition of the Bilyeu in the area.

Wells 2 through 8 on cross section E (fig. 8) are spaced less than 1,000 feet (300 m) apart in the Assumption Consolidated Pool in Christian County. These closely spaced wells allow a look, unequalled elsewhere in Illinois,

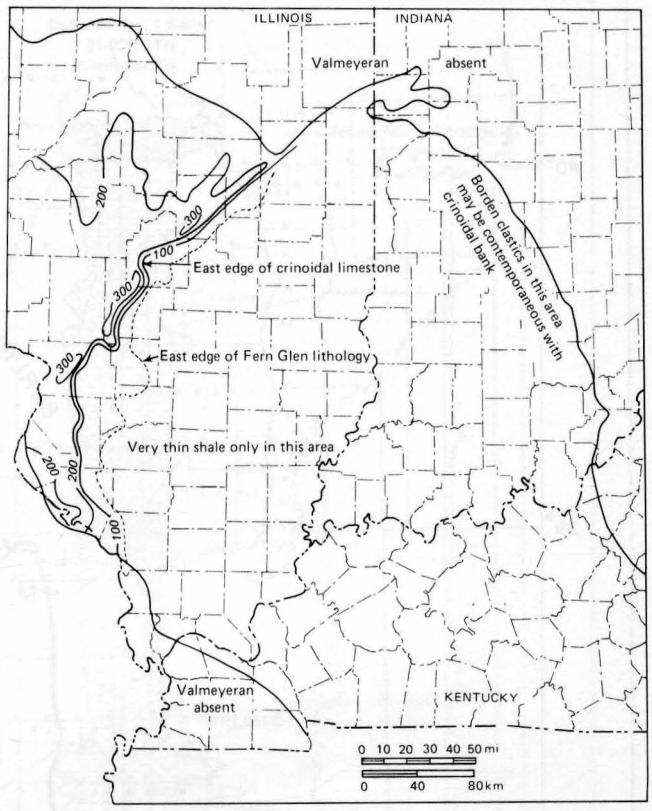

Figure 2. Thickness of the crinoidal limestone bank consisting of the Fern Glen Formation, Burlington Limestone, and Keokuk Limestone. (From Lineback, 1966.)

at the details of the carbonate bank margin (Swann, Lineback, and Frund, 1965). The interval between the top of the Chouteau and the top of the Keokuk carbonate thins from 300 feet to 100 feet (100 m to 30 m) in little more than a mile (1.6 km). All parts of the Burlington-Keokuk thin, but the greatest thinning occurs in the upper part. The Bilyeu Member of the Borden-Warsaw, as in cross section D, was deposited uniformly over the position of the bank margin that had been completely buried by siltstone.

The abundance of wells in the Assumption Pool permits detailed contouring of the thinning of the bank margin. The thickness of the interval from the top of the Chouteau to the top of the Keokuk decreases from more than 340 feet (104 m) in Section 4, T. 13 N., R. 1 E., to less than 100 feet (30 m) in about 1.5 miles (2.4 km) (fig. 9). The Fern Glen extends beyond the bank margin for about 2 to 3 miles (3 to 5 km); beyond which only Borden Siltstone lies on the Chouteau. The thickness contours show the steepness of the slope to be about 1 in 25, not precipitous, but depositionally significant. The thickness map shows the bank margin to be irregular in detail with re-entrants. The Burlington-Keokuk thickens just at the margin (figs. 8 and 9). This indicates the bank was probably prograding southeastward into deepening water at the shelf-basin margin of the main Illinois Basin.

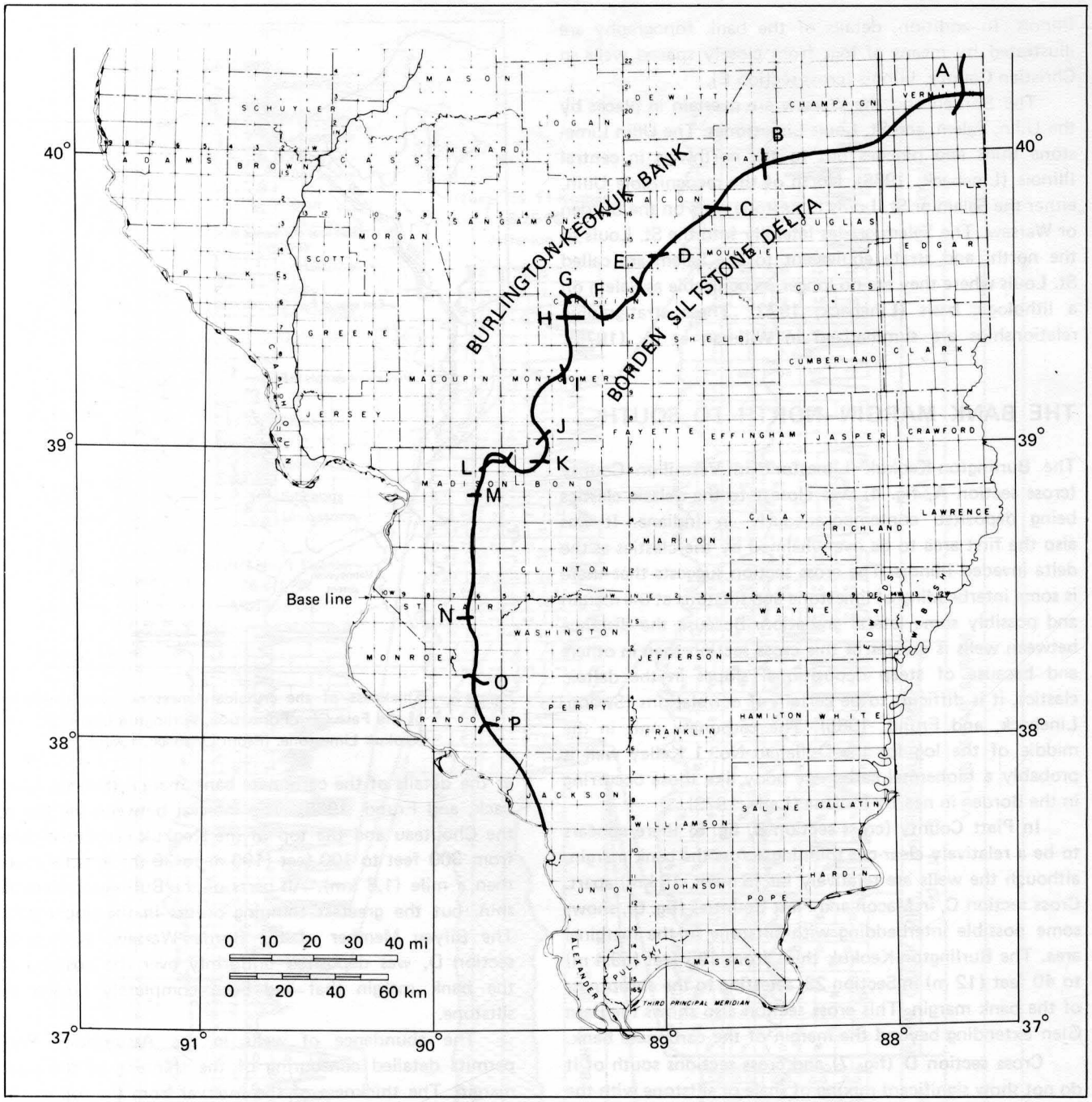

Figure 3. Location of fifteen electric log cross sections across the Burlington-Keokuk bank margin.

A major re-entrant in the margin of the Burlington-Keokuk bank is present in southwestern Christian County. Cross sections F, G, and H (figs. 10, 11, and 12) detail this feature. At a point in Section 30, T. 12 N., R. 2 W., 590 feet (180 m) of Borden Siltstone was deposited in the re-entrant with Burlington-Keokuk Limestone within a few miles on three sides.

Cross section I (fig. 13) shows that the carbonate interval thins from 240 feet (73 m) to 65 feet (20 m) in little more than a mile in northern Montgomery County. In southern Montgomery County (cross section J, fig. 14) the "Carper sand" unit of the Borden abutts the carbonate bank margin. The "Carper" is a deep-water turbidite deposited in front of the Borden delta. Several different "Carpers" have been recognized (Lineback, 1968, figs. 11, 12, and 13). This one, "Carper C," was deposited while the main delta front lay across Moultrie, Coles, Cumberland, and Jasper Counties. The Borden had probably overridden the Burlington-Keokuk bank as far south as Christian County at the same time. However, deep water, with as

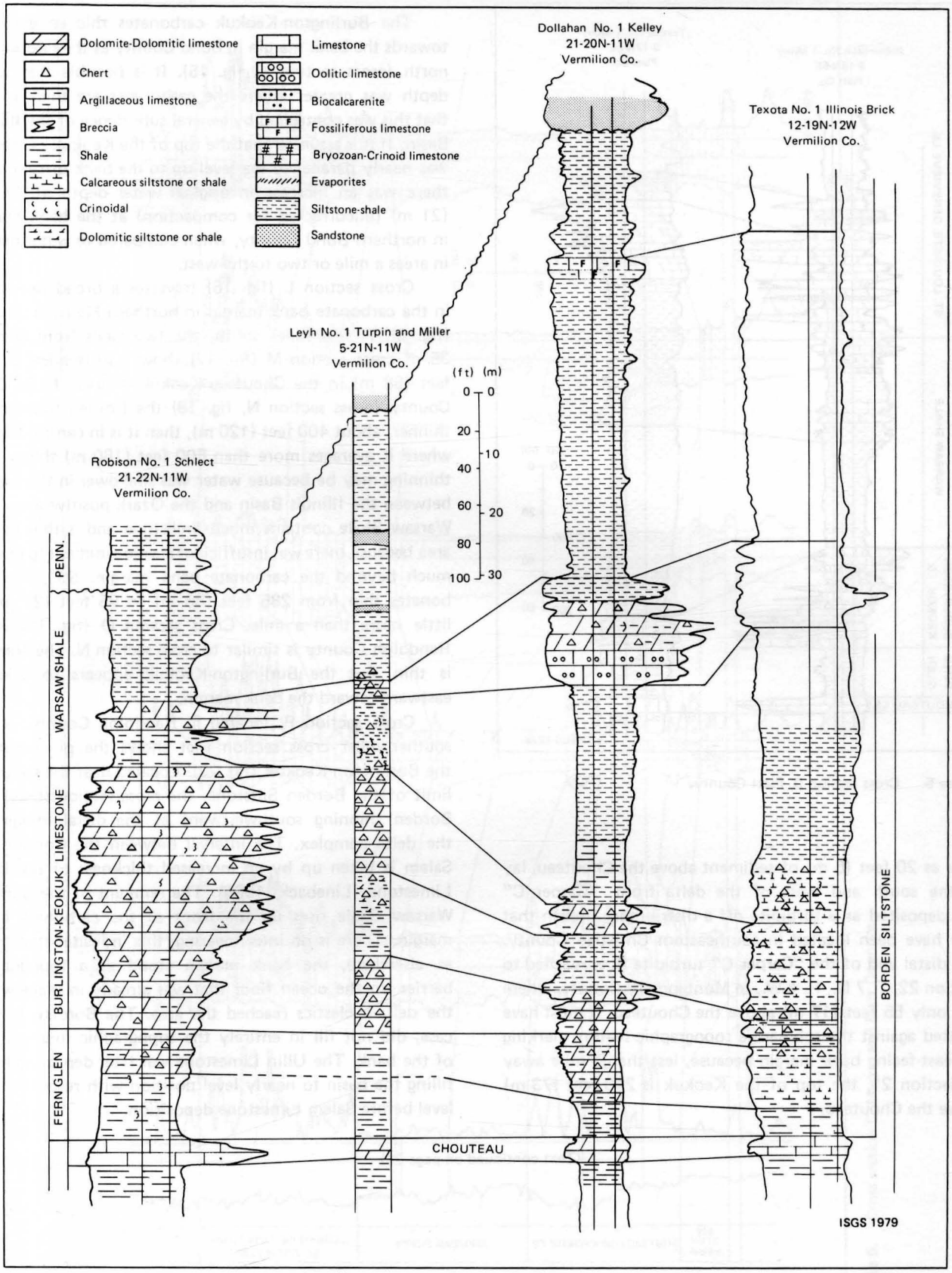

Figure 4. Cross section A, Vermilion County. The key to the patterns used in the columnar sections applies to cross sections A through P.

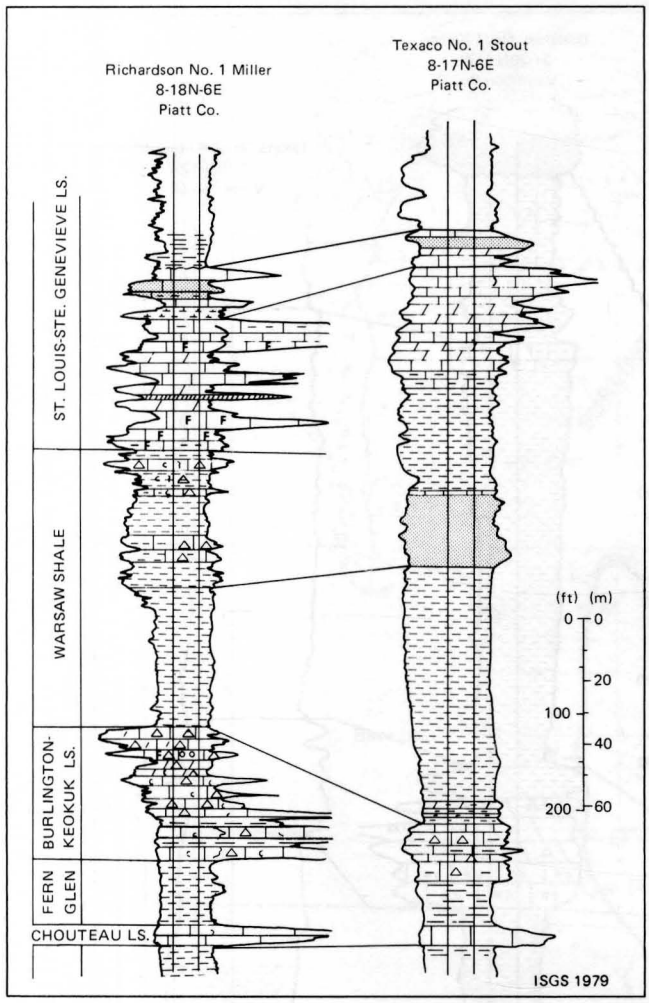

Figure 5. Cross section B, Piatt County.

little as 20 feet (6 m) of sediment above the Chouteau, lay to the south and west of the delta front. "Carper C" was deposited as a turbidite off a distributary mouth that may have been located in southeastern Christian County. The distal end of the "Carper C" turbidite flow reached to Section 22, T. 7 N., R. 4 W., in Montgomery County, where it is only 55 feet (17 m) above the Chouteau. It must have abutted against the submarine topographic feature marking the east-facing bank margin because, less than a mile away in Section 21, the top of the Keokuk is 240 feet (73 m) above the Chouteau.

The Burlington-Keokuk carbonates thicken eastward towards the bank margin in Bond County as they do farther north (cross section K, fig. 15). It is possible that water depth was greater where the carbonates are thickest and that this was controlled by general subsidence of the Illinois Basin. If it is assumed that the top of the Keokuk carbonate was nearly parallel to sea level up to the bank margin, then there was an increase in original water depth of 70 feet (21 m) (uncorrected for compaction) at the bank margin in northern Bond County, when compared to water depths in areas a mile or two to the west.

Cross section L (fig. 16) traverses a broad re-entrant in the carbonate bank margin in northern Madison County (fig. 3). A few miles south, the two wells from Section 35 of cross section M (fig. 17) show a difference of 223 feet (68 m) in the Chouteau-Keokuk interval. In St. Clair County (cross section N, fig. 18) the Borden Siltstone is thinner, about 400 feet (120 m), than it is in central Illinois where it averages more than 600 feet (180 m) thick. This thinning may be because water was shallower in this region between the Illinois Basin and the Ozark positive area. The Warsaw Shale contains much limestone and is thin in this area because there was insufficient clastic sediment to extend much beyond the carbonate bank margin. Still, the carbonates thin from 285 feet (86 m) to 95 feet (29 m) in little more than a mile. Cross section O (fig. 19) from Randolph County is similar to cross section N. The Warsaw is thin, but the Burlington-Keokuk appears to thicken eastward toward the bank margin.

Cross section P, located in Randolph County, is the southernmost cross section that shows the pinch-out of the Burlington-Keokuk (fig. 20). Located near the southern limit of the Borden Siltstone, the cross section shows the Borden thinning southwestward at the distal margin of the delta complex. The interval between the Borden and Salem is taken up by an increased thickness of the Ullin Limestone (Lineback, 1966). The remnant of the Borden-Warsaw Shale rises up the front of the carbonate bank margin. There is no interfingering; this indicates that here, as elsewhere, the bank margin stood as a topographic barrier on the ocean floor that was already in place when the deltaic clastics reached the area. The Borden, in this case, did not fill in entirely the topographic low in front of the bank. The Ullin Limestone was later deposited here, filling the basin to nearly level position with respect to sea level before Salem Limestone deposition.

(Text continued on page 23)

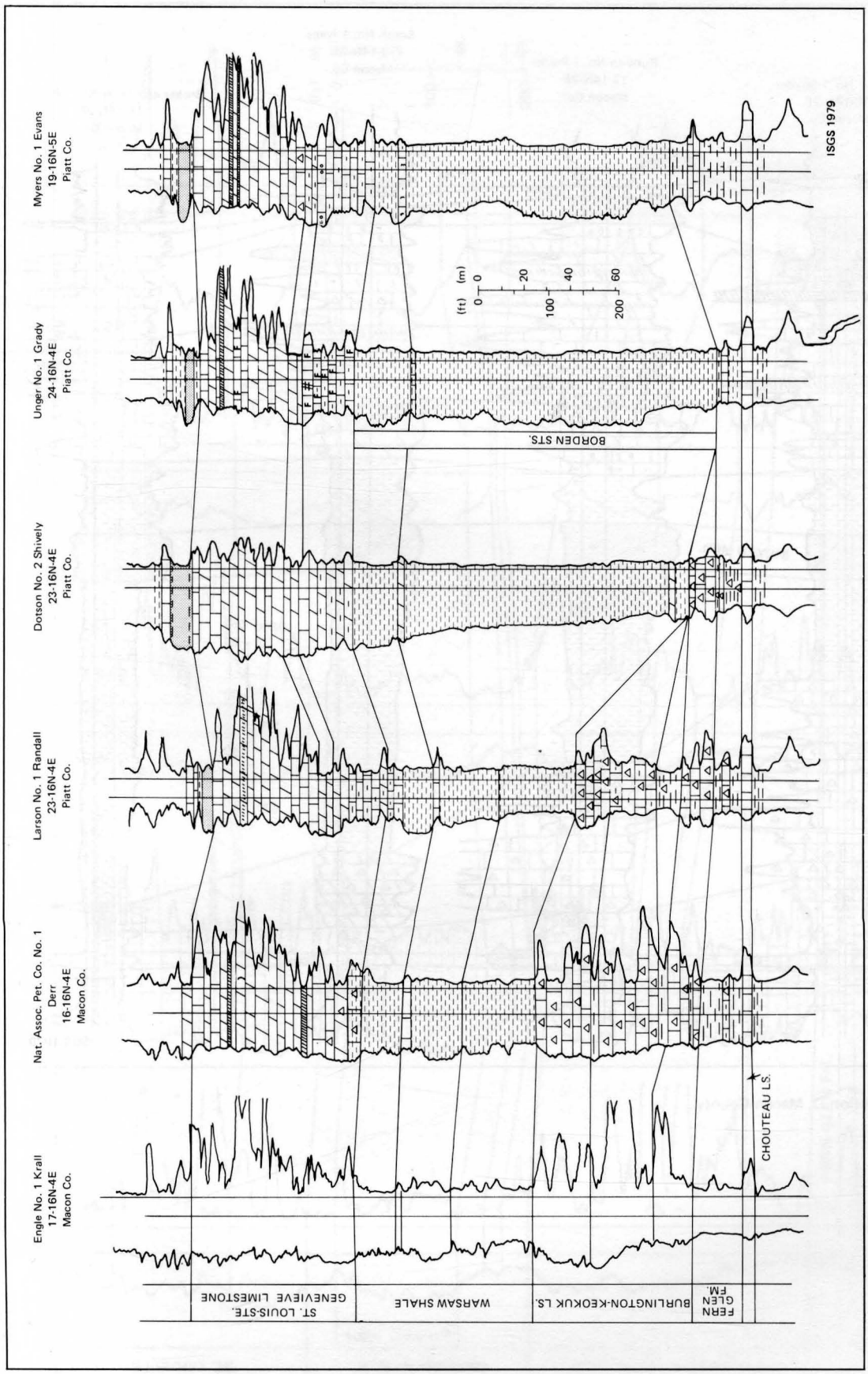

Figure 6. Cross section C, Macon and Piatt Counties.

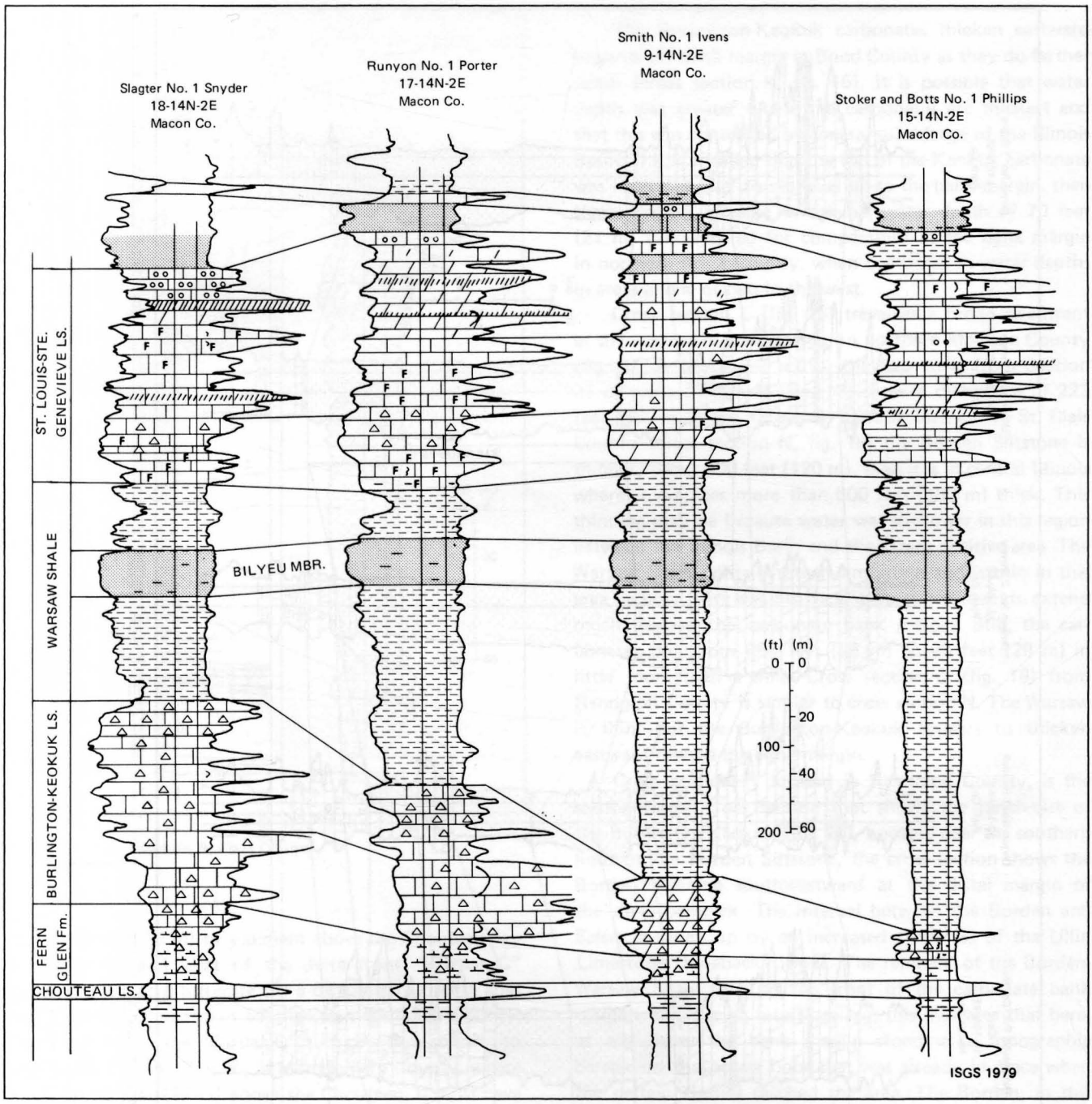

Figure 7. Cross section D, Macon County.

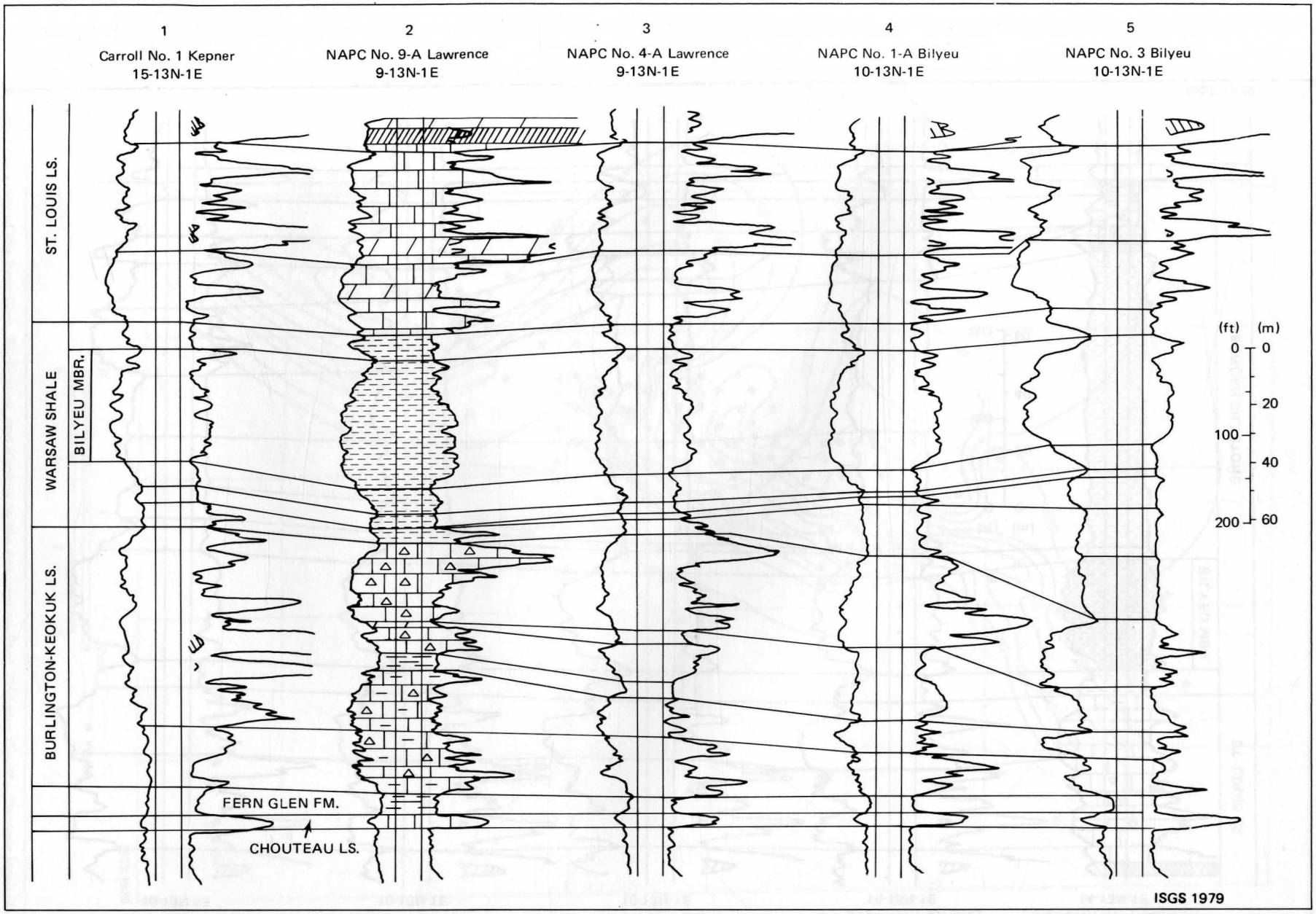

Figure 8. Cross section E, closely spaced wells in the Assumption Field, Christian County. (Modified from Swann, Lineback, and Frund, 1965.)

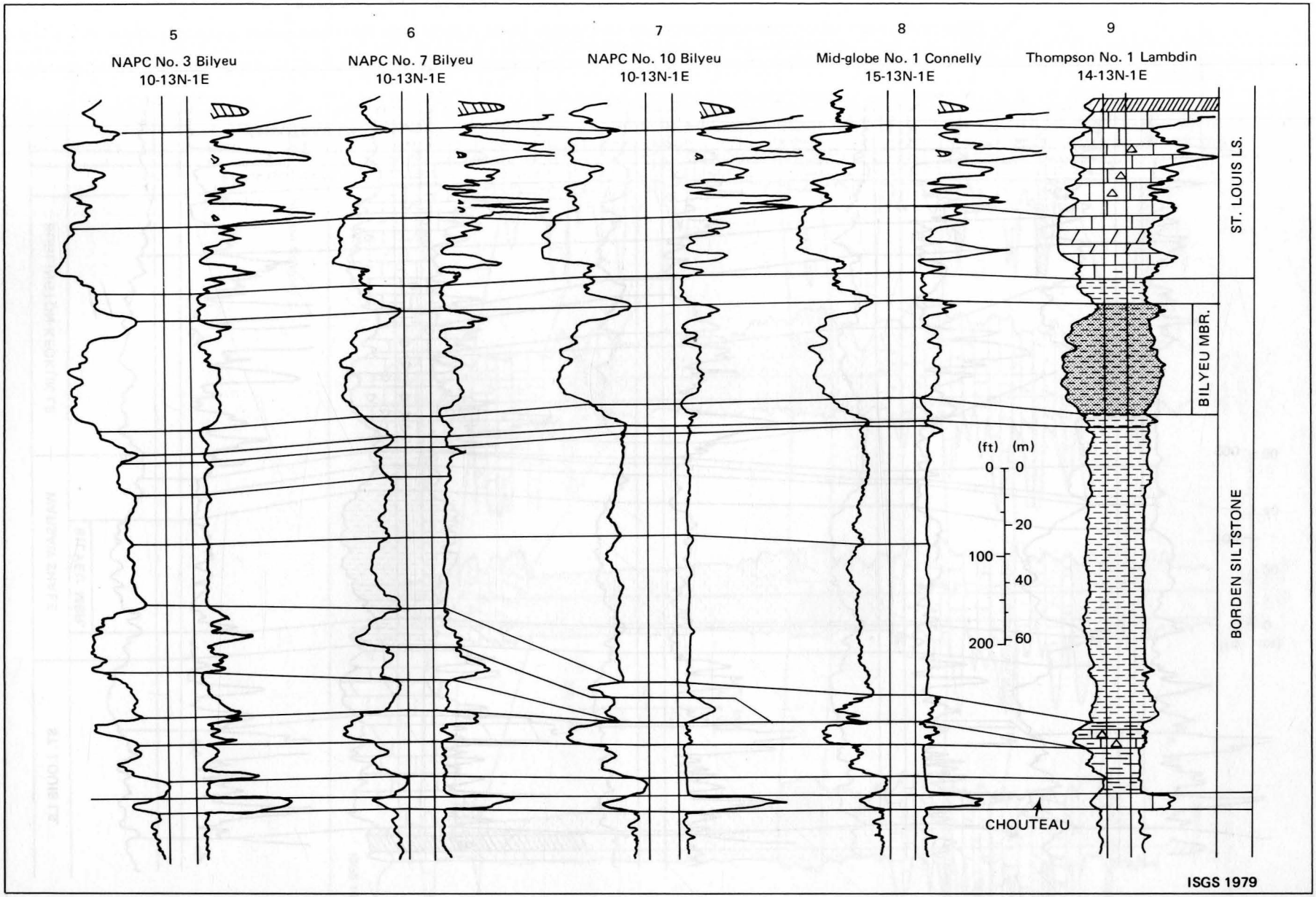

Figure 8. *Continued.*

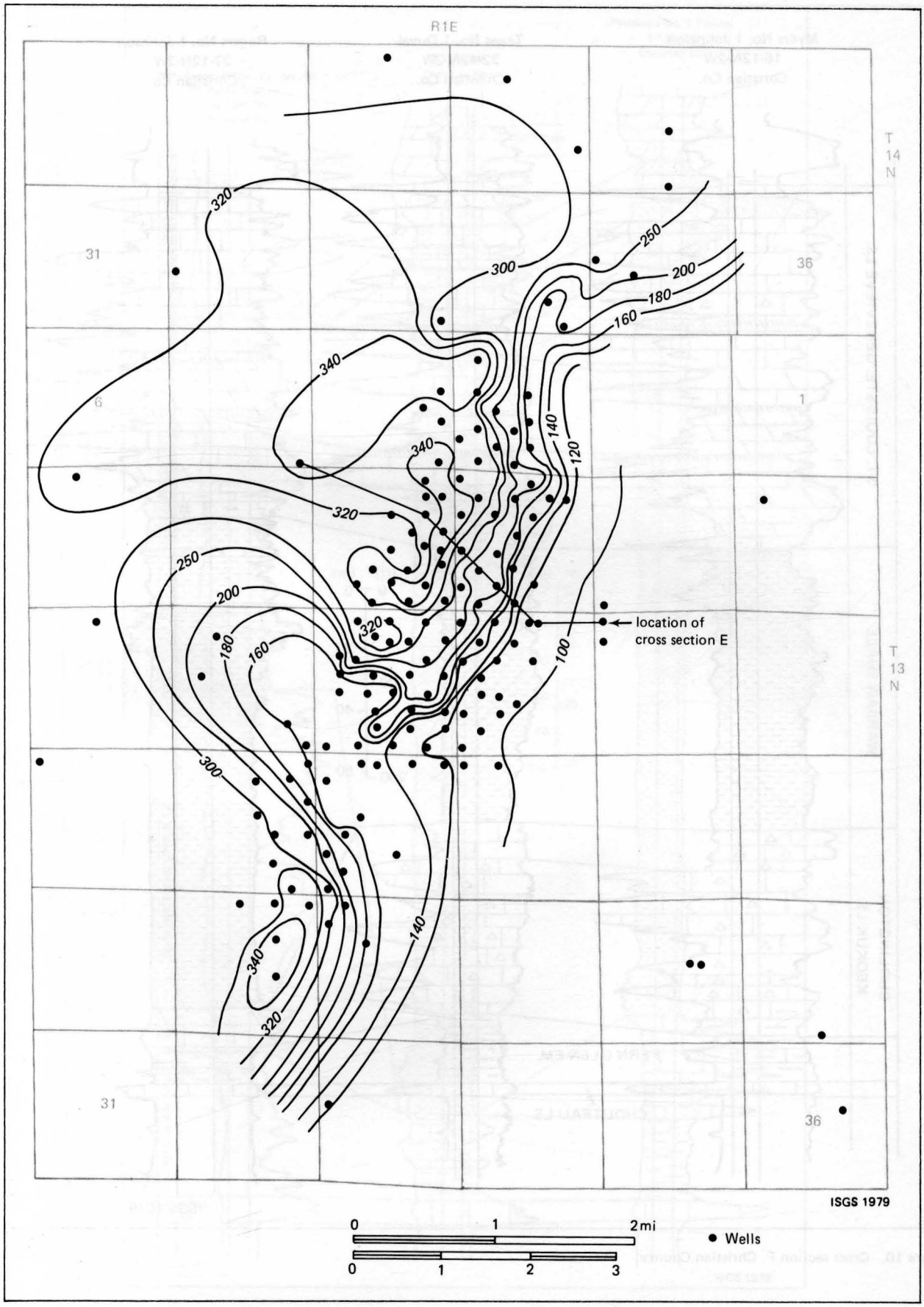

Figure 9. Combined thickness of the Fern Glen, Burlington, and Keokuk in the Assumption Pool, Christian County. Contour interval variable: 20 feet (6 m) from 100 to 200 feet (30 to 60 m); 50 feet (15 m) on the steep slope between 200 and 300 feet (60 to 90 m).

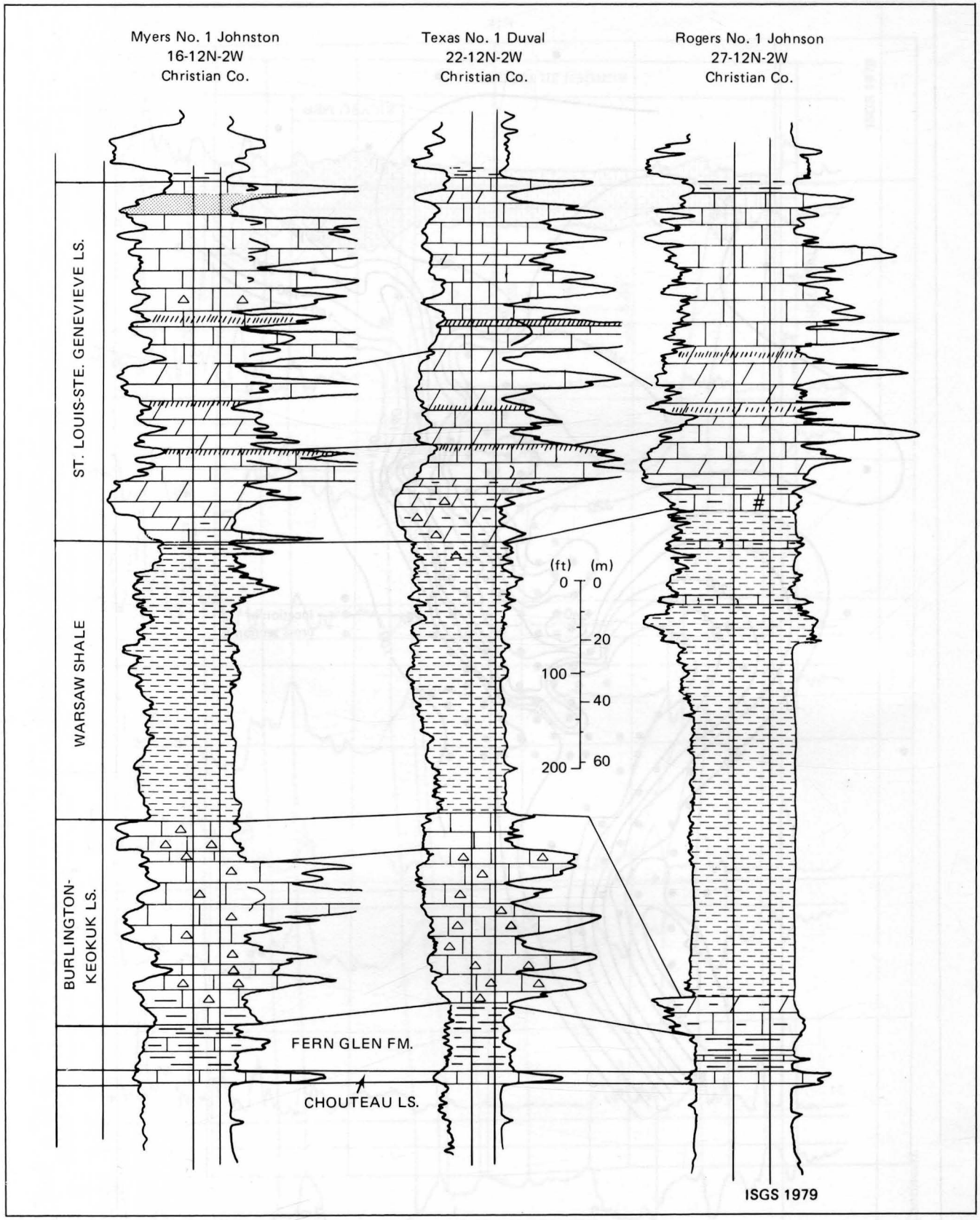

Figure 10. Cross section F, Christian County.

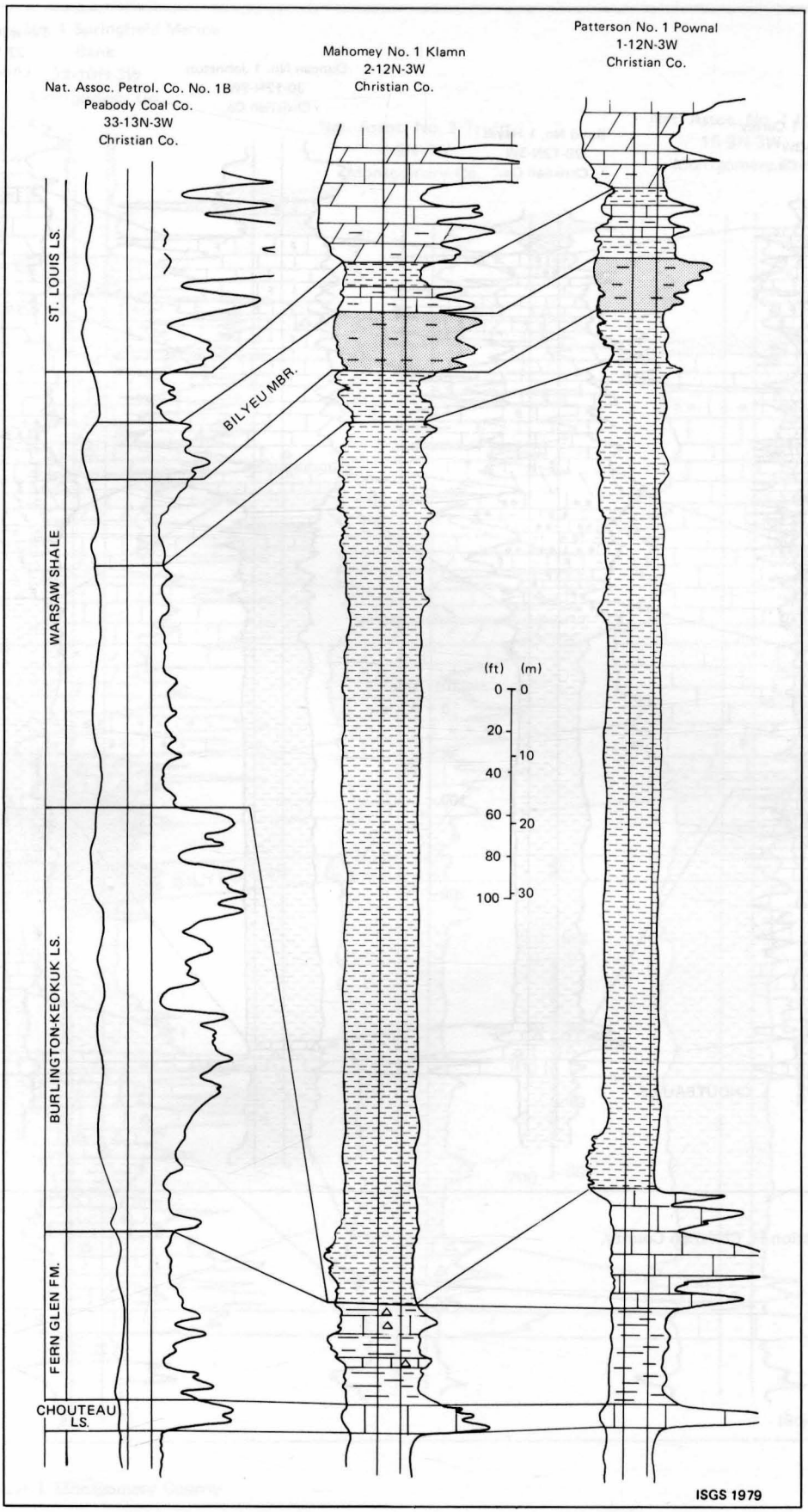

Figure 11. Cross section G, Christian County.

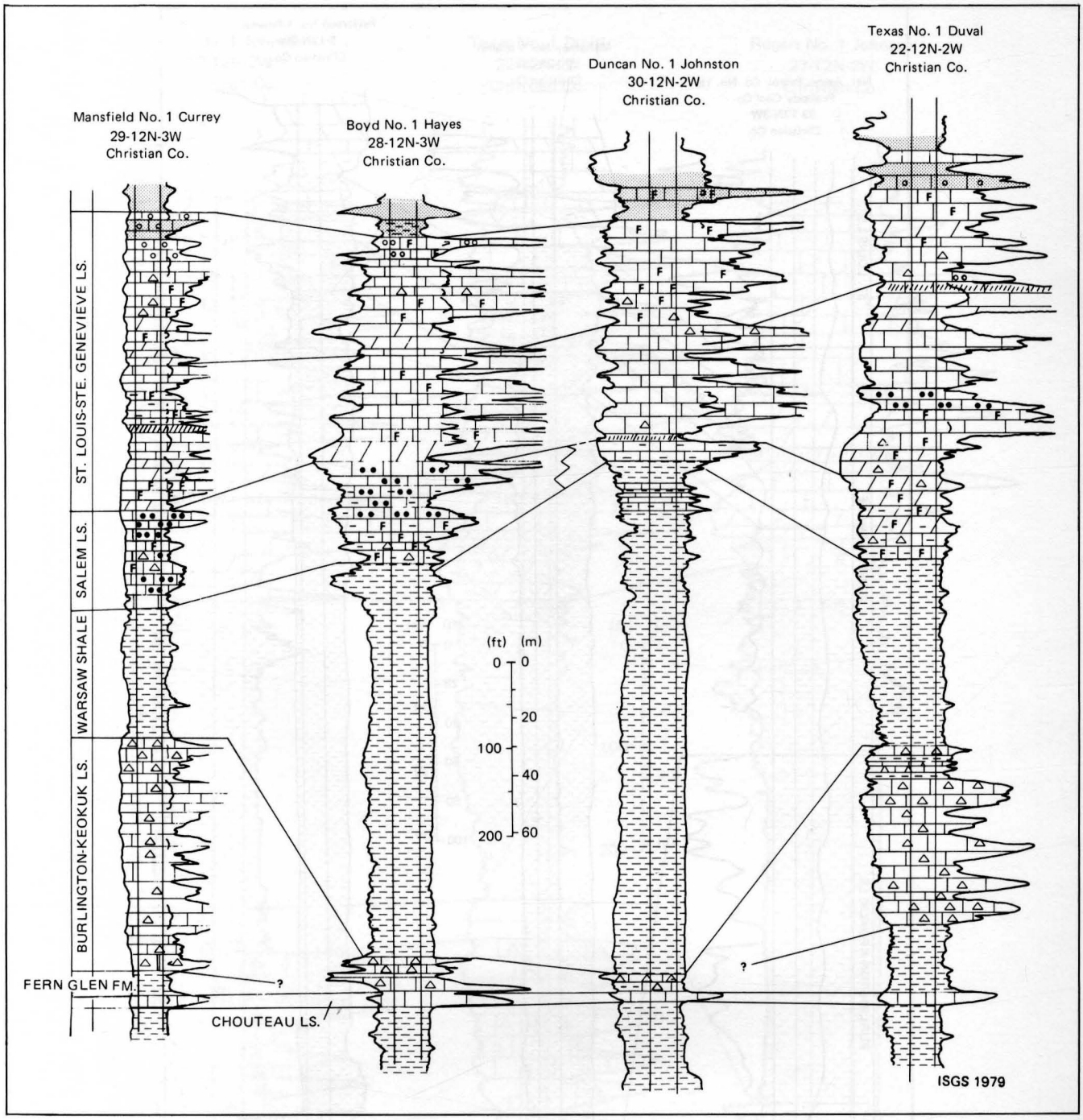

Figure 12. Cross section H, Christian County.

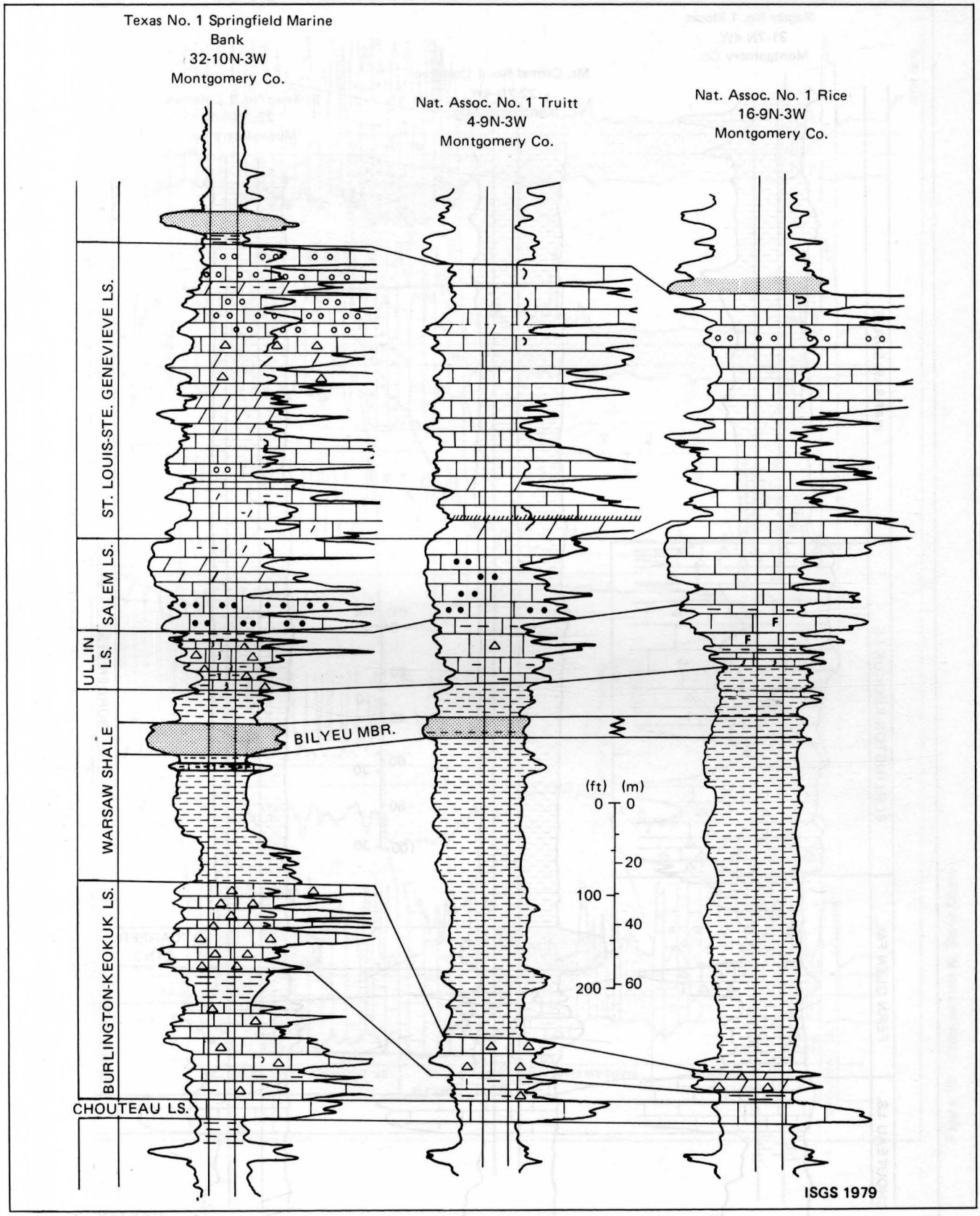

Figure 13. Cross section I, Montgomery County.

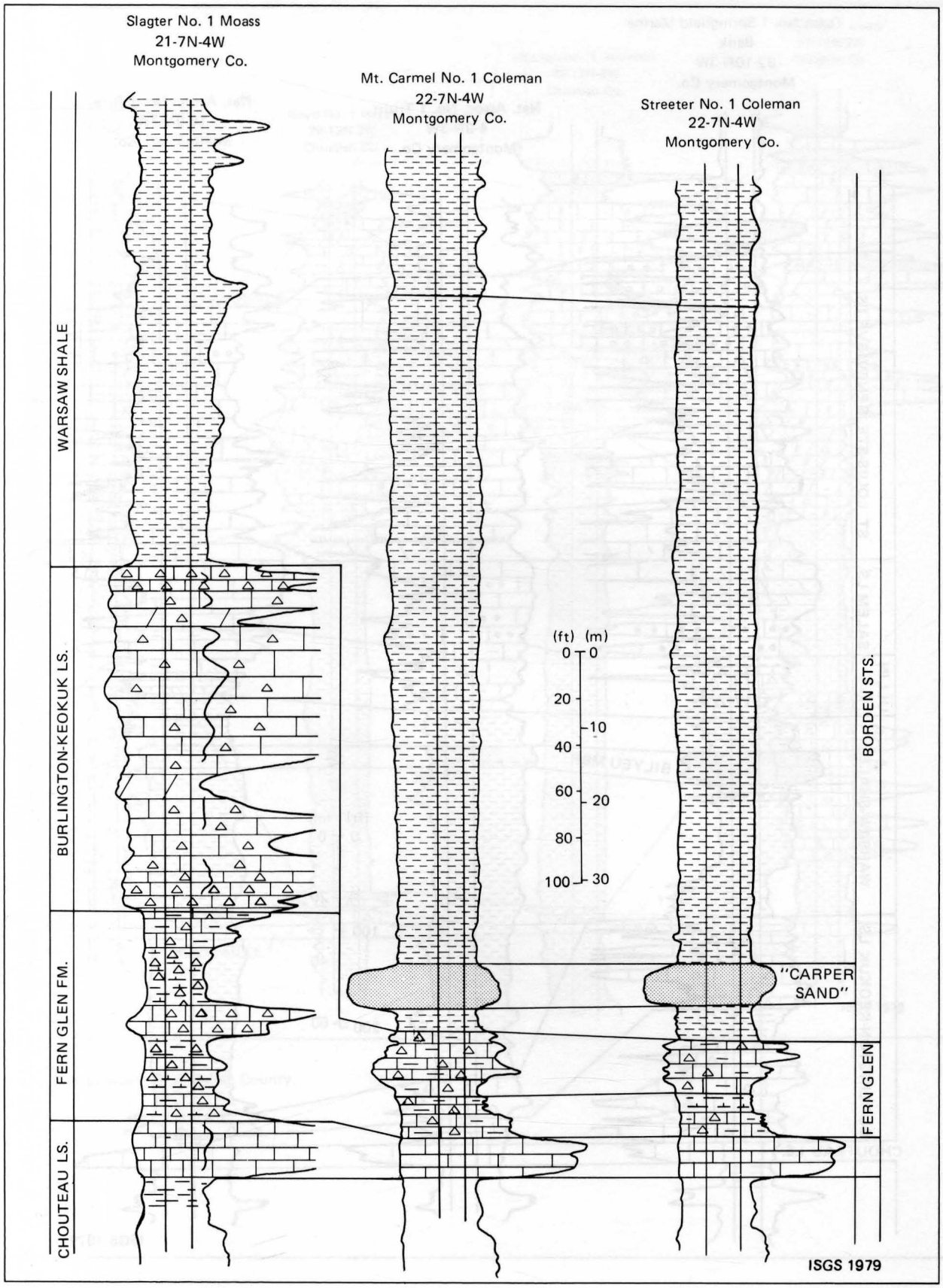

Figure 14. Cross section J, Montgomery County.

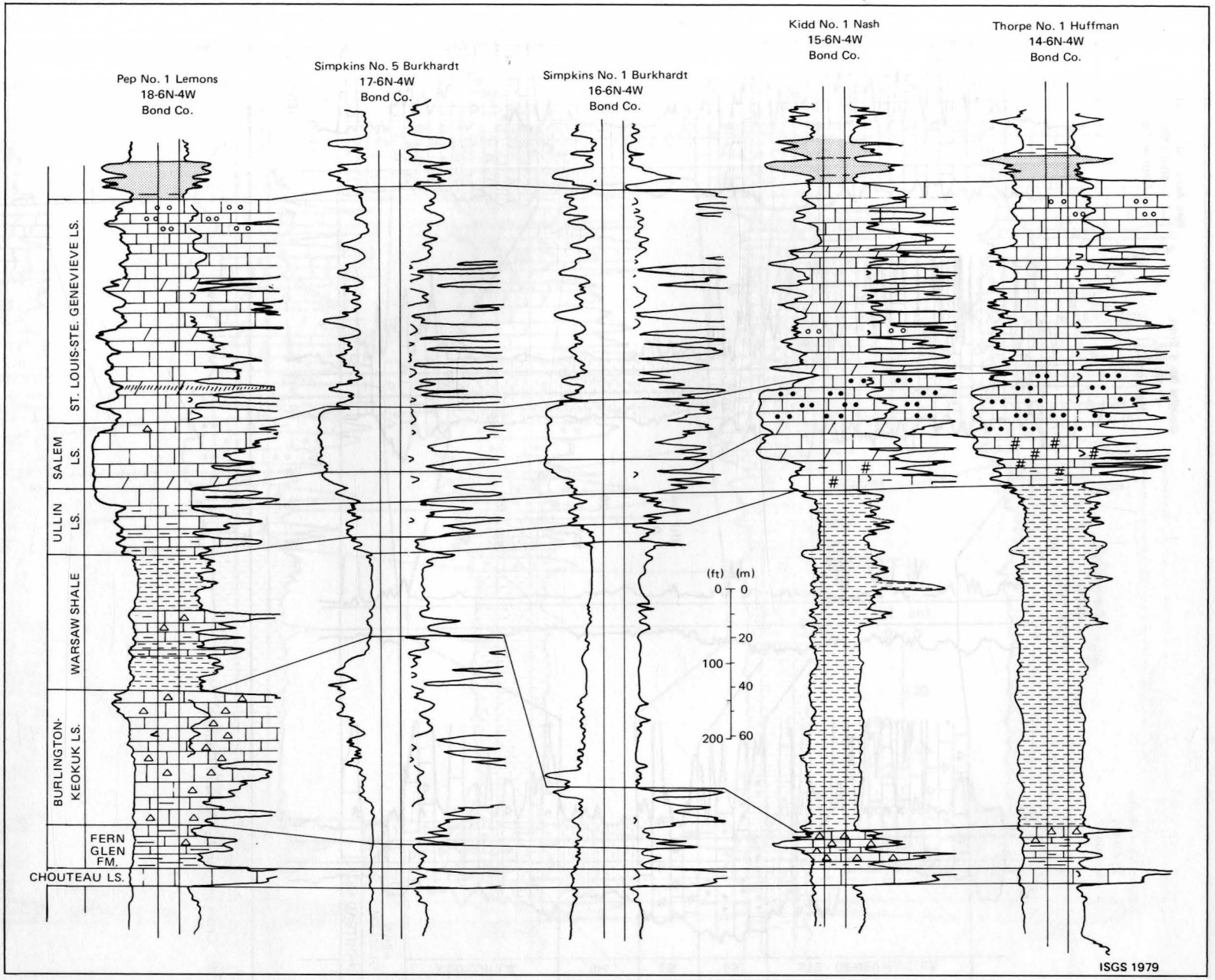

Figure 15. Cross section K, Bond County.

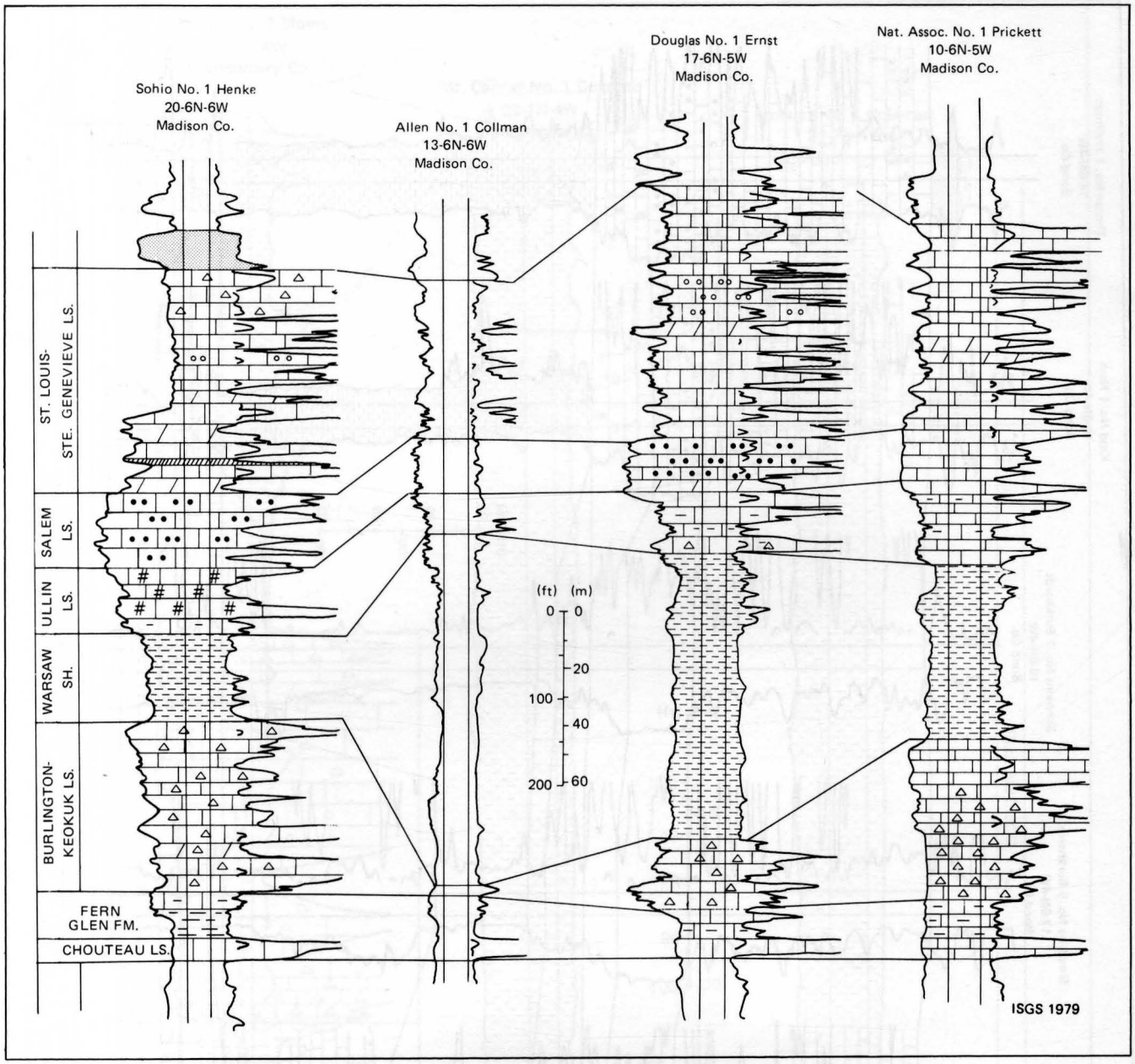

Figure 16. Cross section L, Madison County.

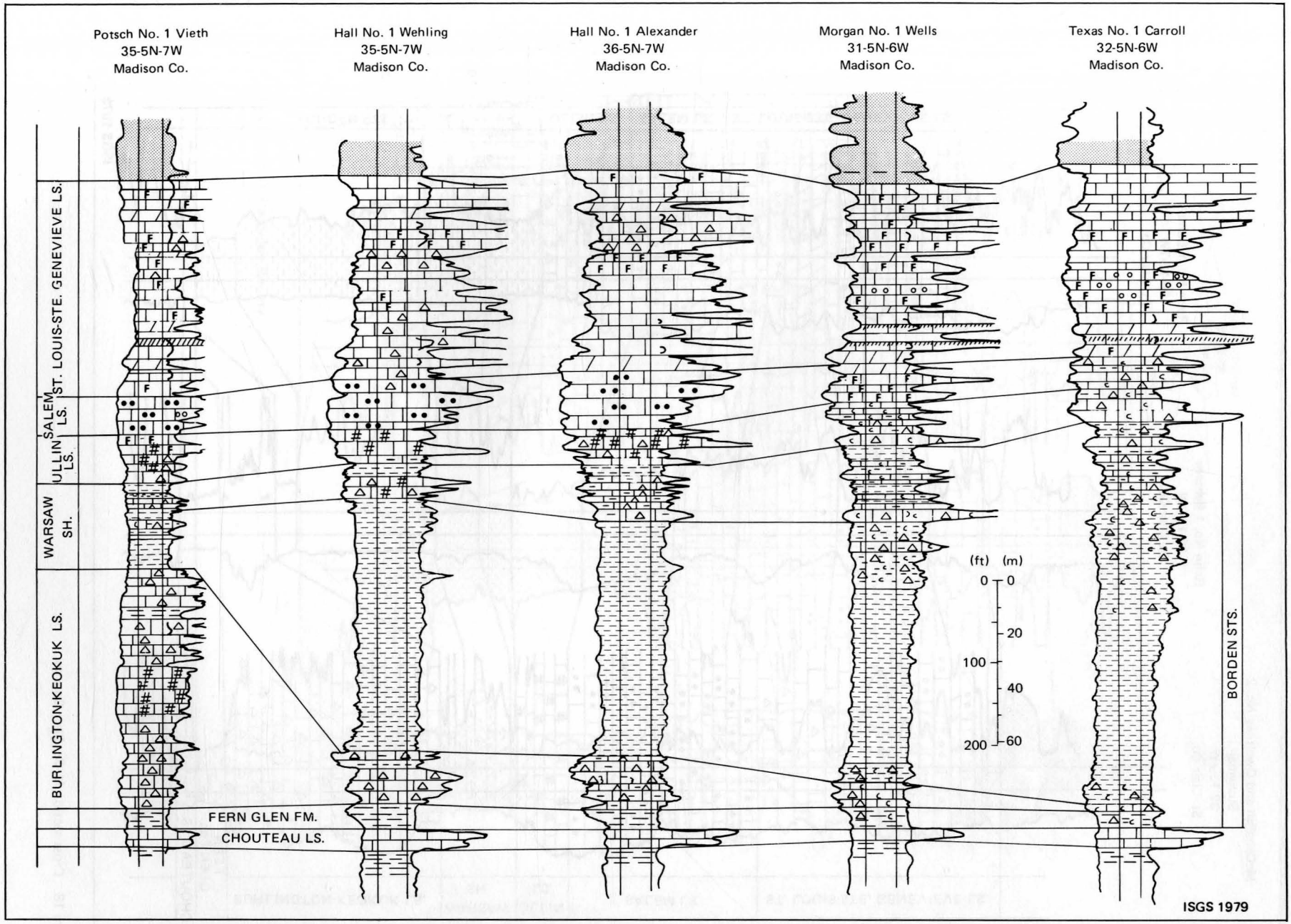

Figure 17. Cross section M, Madison County.

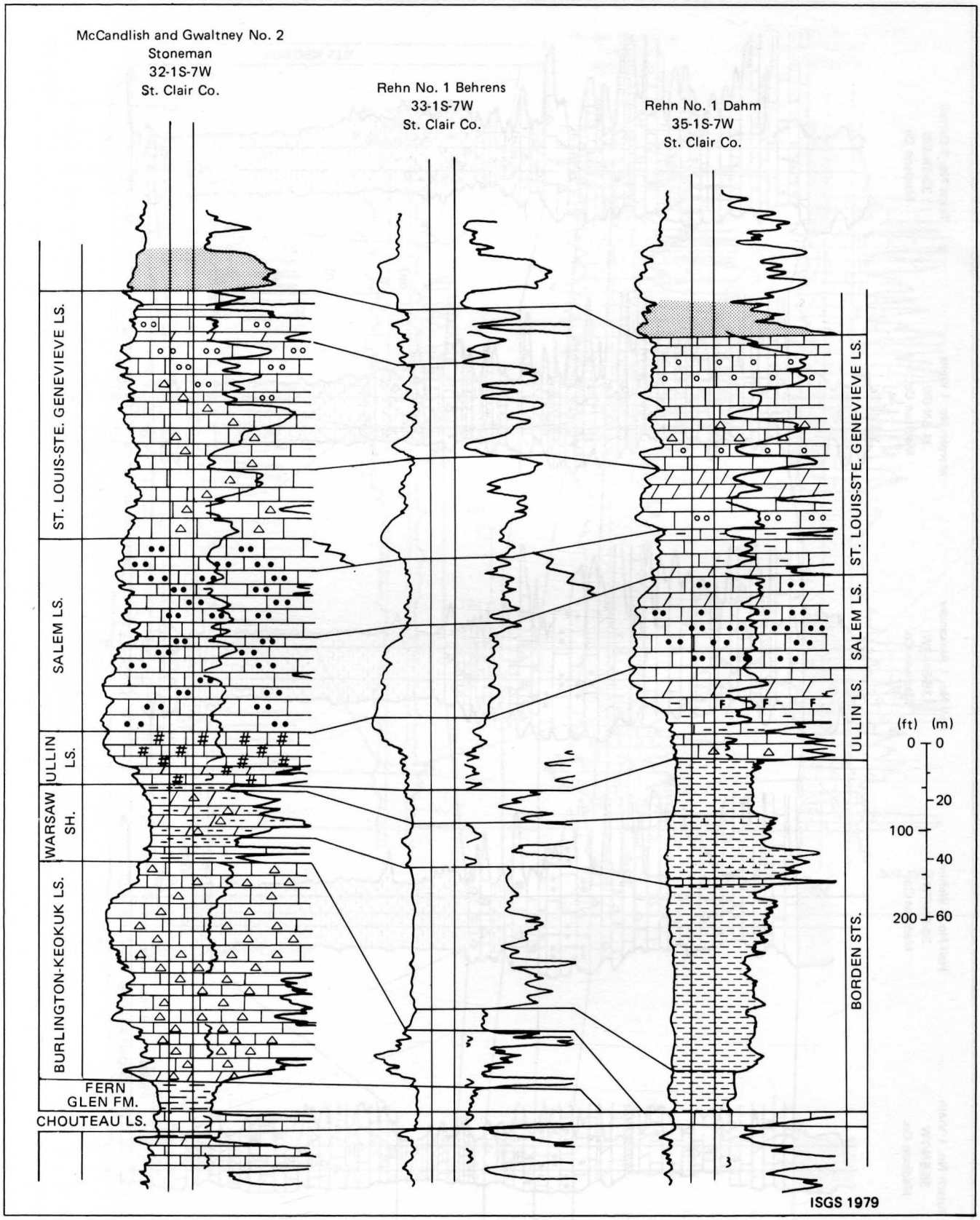

Figure 18. Cross section N, St. Clair County.

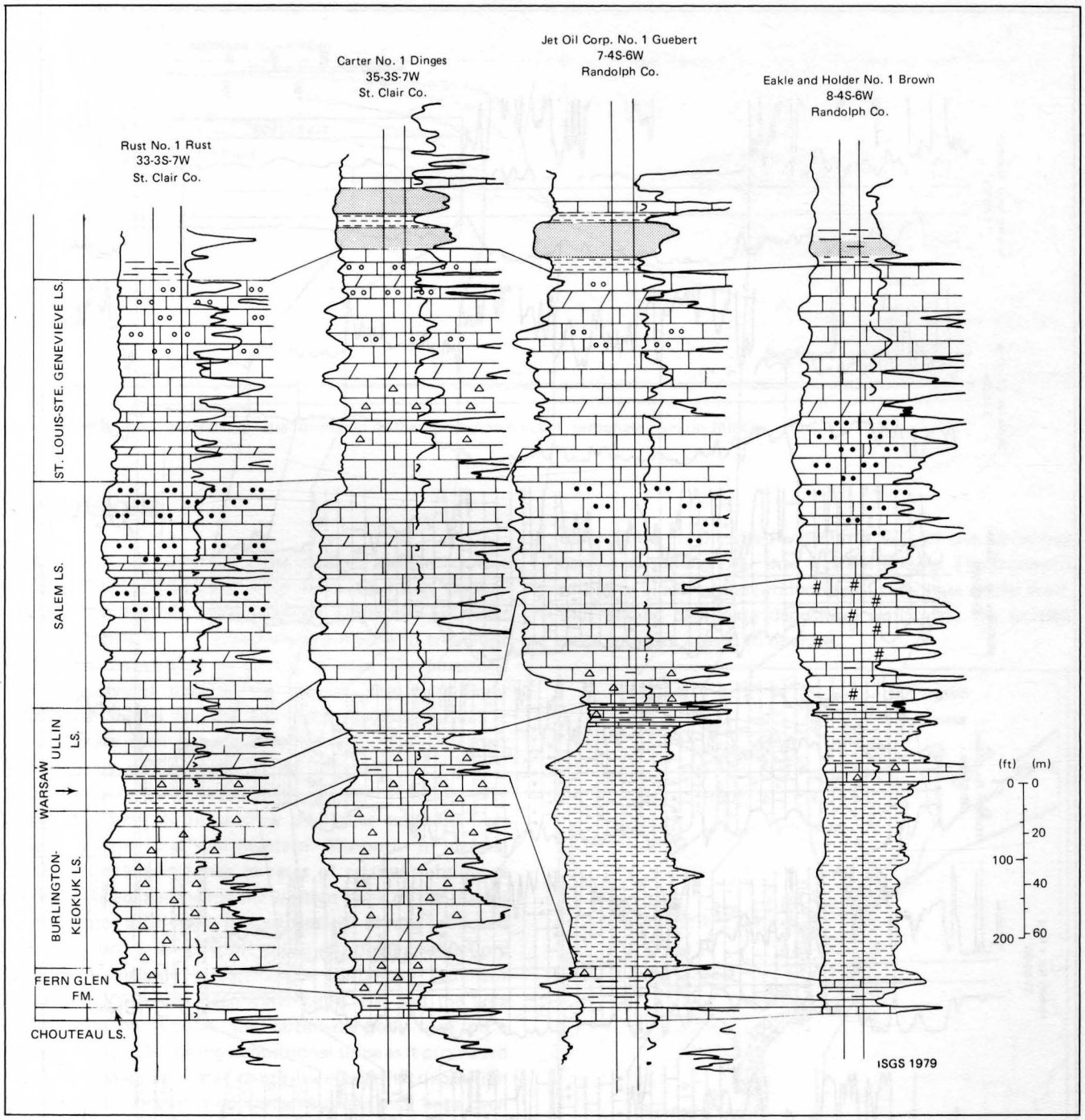

Figure 19. Cross section O, Randolph County.

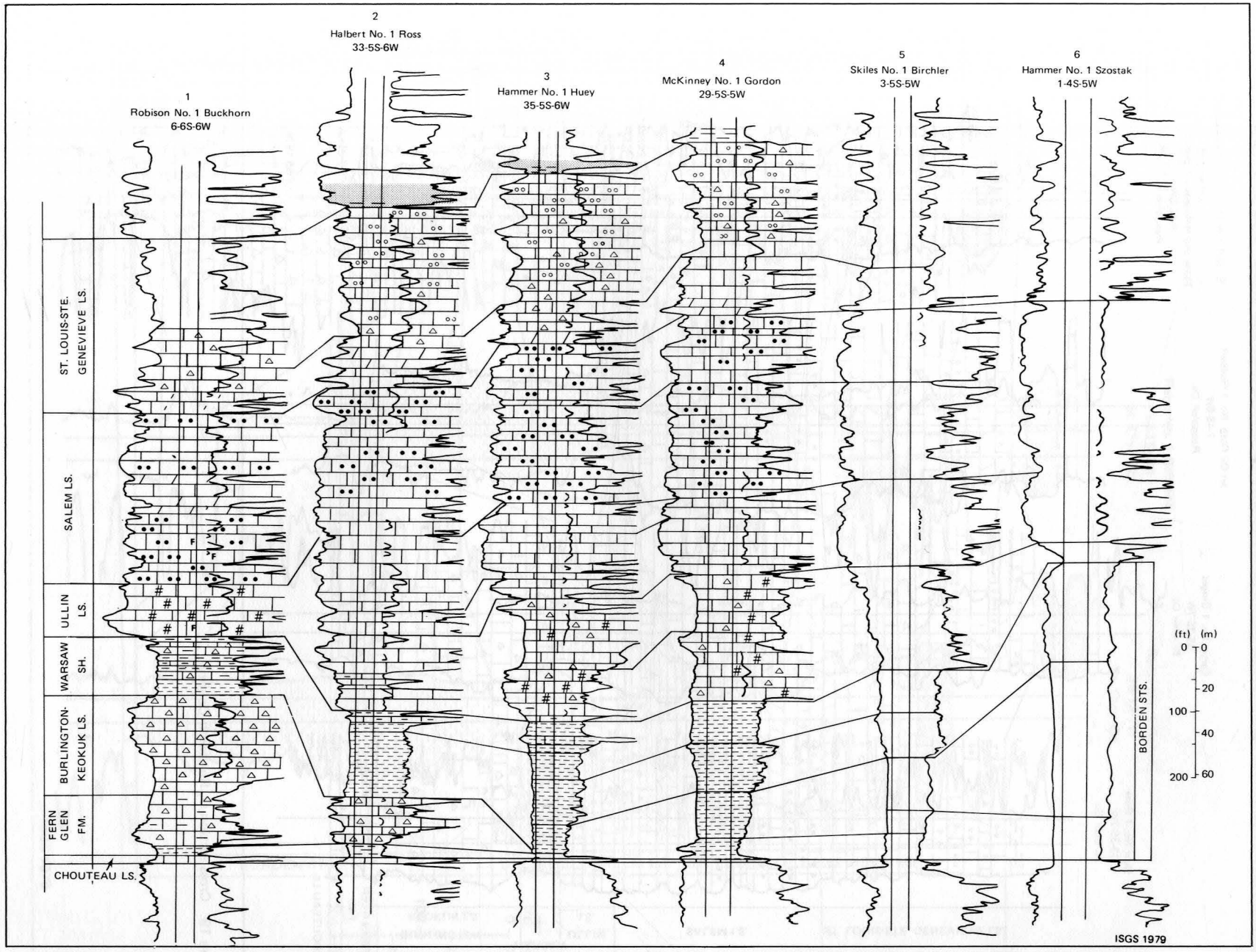

Figure 20. Cross section P, Randolph County.

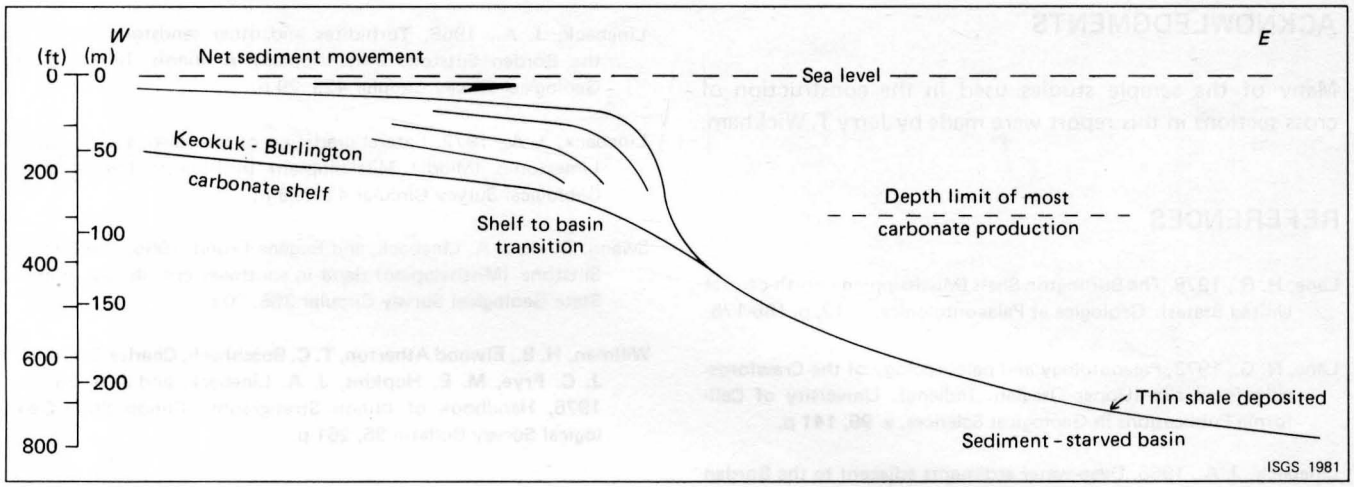

Figure 21. Depositional model for the formation of the Burlington-Keokuk carbonate bank in Illinois.

CONCLUSIONS

Evidence derived from the cross sections presented here and the detailed thickness map from Christian County indicates that the Burlington-Keokuk Limestone extended as a depositional entity across western Illinois to an abrupt depositional termination in central Illinois. The limestone thickens eastward towards the margin. The most likely depositional model for the Burlington-Keokuk is that it is a carbonate shelf deposit terminated along a steep marginal bank by deeper water in the Illinois Basin (fig. 21). Limestone accumulated from the growth of calcite-producing organisms in the shallow shelf that extended over western Illinois and northeastern Missouri. In central Illinois, a shelf-basin break in rates of relative subsidence may have taken place along the western flank of the Illinois Basin. Greater subsidence in southeastern Illinois produced water too deep for significant in situ carbonate production. Waves and currents moved excess carbonate sediment eastward towards this deep-water basin. Beyond the area of carbonate production, the carbonate body took on a relatively steep, east-facing depositional slope as it prograded into deep water. As water depth lessened with deposition at the margin, locally produced carbonate may have been added.

A thickness map of the Burlington Limestone shows that it is thickest near the bank margin in southwestern Illinois, but has its maximum thickness somewhat west of the present bank margin in central Illinois (fig. 22). This may indicate that the limestone at the bank margin in central Illinois is largely the younger Keokuk Limestone. This substantiates the eastward progression of the carbonate bank in central Illinois. The youngest carbonate would then be at the bank margin in east-central Illinois where it may interfinger somewhat with the Borden delta. The delta advanced southwestward at a geologically fast pace, partially filling in the deep-water area east of the carbonate bank and spilling over into western Illinois. The increased turbidity hindered the production of carbonate on the shelf, thus ending carbonate deposition until after the Borden delta complex ceased to operate.

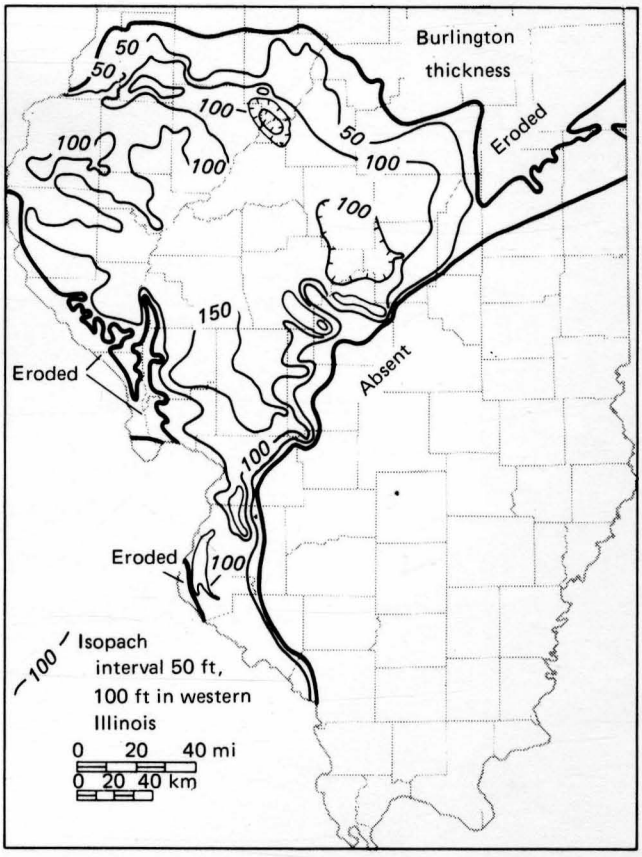

Figure 22. Thickness of the Burlington Limestone. (From Willman et al., 1975.)

ACKNOWLEDGMENTS

Many of the sample studies used in the construction of cross sections in this report were made by Jerry T. Wickham.

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