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Stratigraphy and Depositional History of the Drum Limestone  
and Associated Strata (Pennsylvanian) in the  
Independence, Kansas, area:  
A Field Trip Guidebook and Road Log

by

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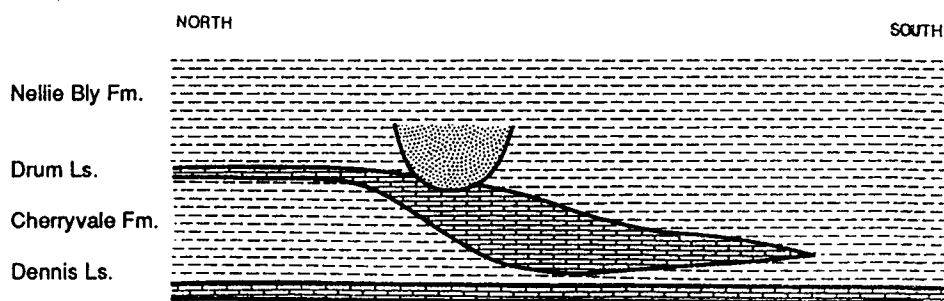
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**KANSAS GEOLOGICAL SURVEY**  
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# Stratigraphy and depositional history of the Drum Limestone and associated strata (Pennsylvanian) in the Independence, Kansas, area—A field trip guidebook and road log

Howard R. Feldman and Evan K. Franseen  
Kansas Geological Survey



In conjunction with the Midcontinent Core Workshop  
1991 AAPG Midcontinent Section Meeting  
Wichita, Kansas

September 1991

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# Introduction

This field trip focuses on the Drum Limestone and associated units present in Montgomery County, Kansas (figs. 1 and 2). The Drum Limestone is being studied because it contains an isolated oolite body that is potentially analogous to Lansing-Kansas City Group oolitic petroleum reservoirs in central and western Kansas. The Independence area was selected for study because it is located at or near a depositional break in slope where dramatic thickness and facies changes in the Drum Limestone and other units occur over short distances and because a porous oolitic lithofacies occurs in the Drum Limestone in this area.

The Drum Limestone is part of the Missourian (Upper Pennsylvanian) Kansas City Group. This group is characterized by alternating limestones, which are commonly oolitic, and siliciclastic units. During Kansas City Group deposition, eastern Kansas was the site of shallow water to terrestrial settings on a stable shelf. Siliciclastic wedges prograded to the south and southwest from Missouri. The Anadarko and Arkoma basins in southern Kansas, Oklahoma, and Arkansas were rapidly subsiding and dominated by siliciclastic deposition (fig. 3). The

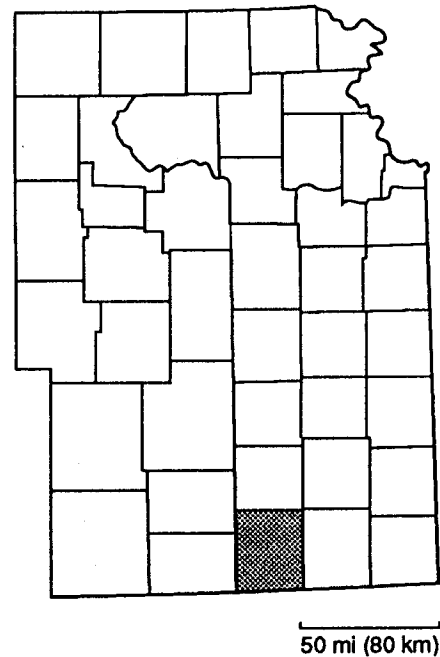


FIGURE 1—MAP SHOWING LOCATION OF MONTGOMERY COUNTY, KANSAS.

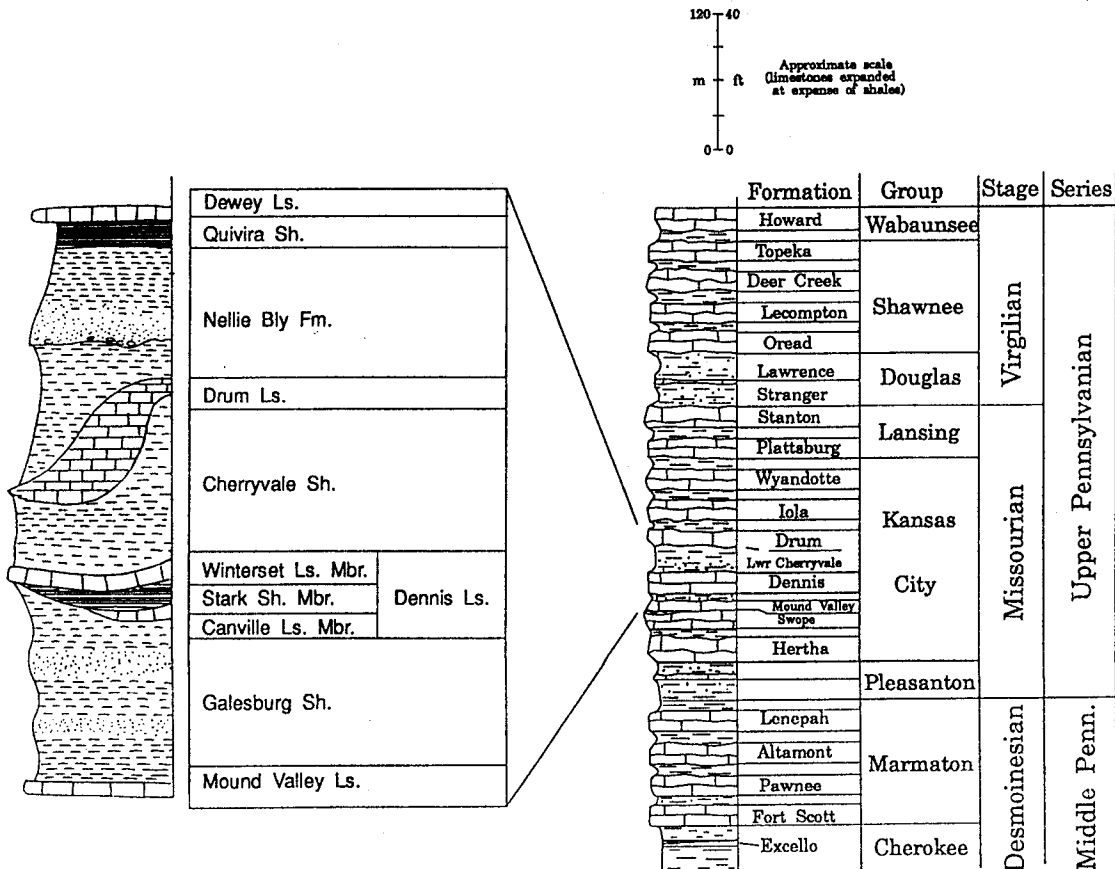


FIGURE 2—SCHEMATIC DIAGRAM OF THE STRATIGRAPHY IN THE STUDY AREA.

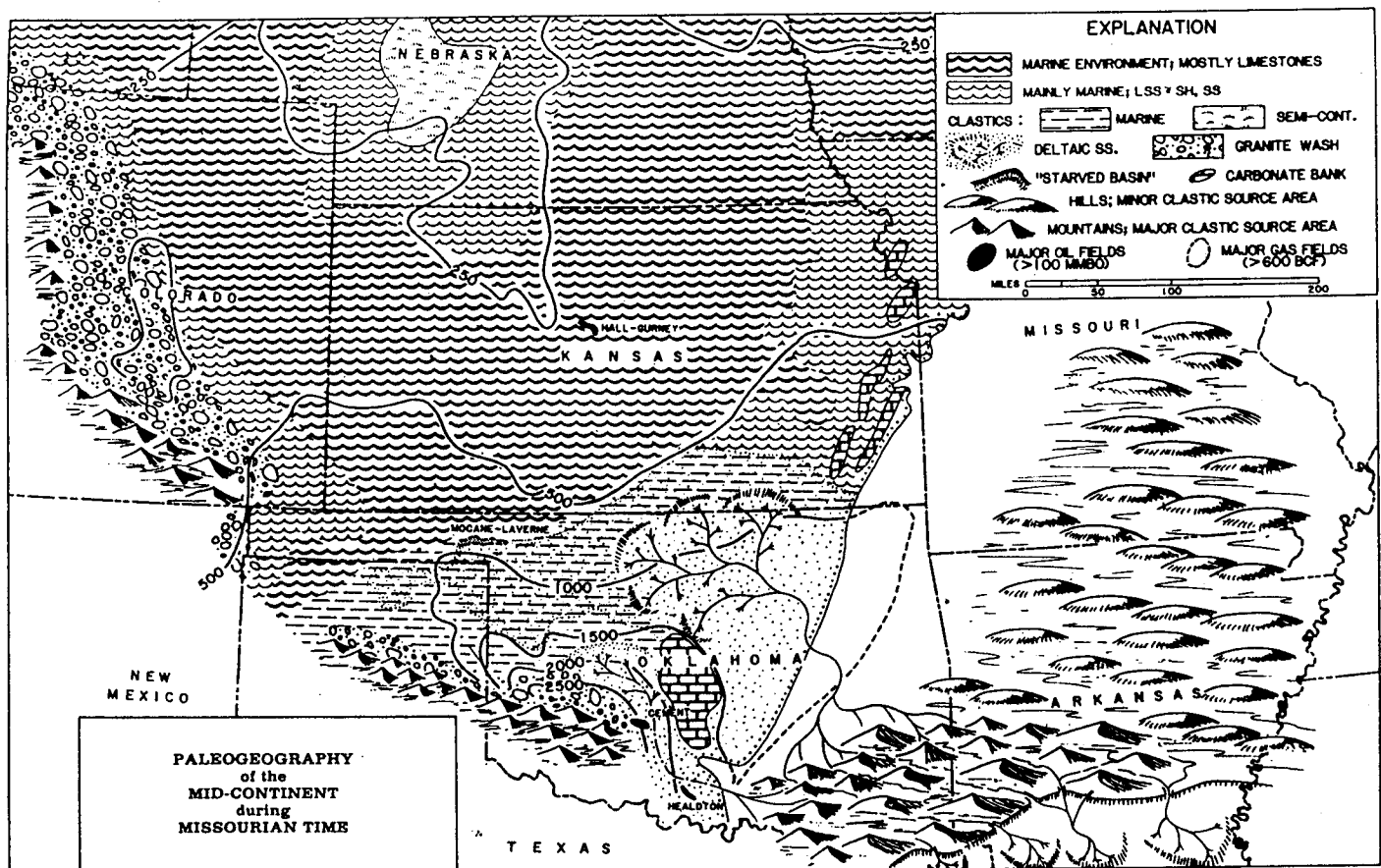


FIGURE 3—LITHOFACIES AND PALEOGEOGRAPHY DURING MISSOURIAN TIME IN THE SOUTHERN MIDCONTINENT (from Rascoe and Adler, 1983).

field-trip area is near the southern limit of carbonate deposition within the Kansas City Group. South of the field area the succession increases in thickness and is dominated by siliciclastic sedimentary rocks.

The purpose of the field trip is to examine the facies changes in the Drum Limestone along a transect from depositional shelf (north) to basinal settings (south). Along the 15-mi (24-km)-long transect the Drum Limestone changes from a thin stromatolitic unit in the north, to a thick oolite, to an unfossiliferous mudstone in the south. The thick oolite is well exposed in several quarries near Independence. Stone (1984) interpreted the thick, localized oolite as the result of filling of a previous depression and later erosion of the upper part of the oolite. We believe that the overall geometry and facies relationships of the Drum Limestone in Montgomery County reflect depositional paleotopography related to thickness changes in the underlying units.

Analysis of surface exposures in the Independence area is only one phase of an overall study of the Drum Limestone and associated strata in Montgomery County. The study also incorporates subsurface and petrographic data. The subsurface data include well-log information, cores acquired by the Kansas Geological Survey (KGS),

and high-resolution seismic data being acquired by the KGS. This guidebook incorporates subsurface and petrographic data collected to date in a preliminary attempt to present a more complete picture of the area, only part of which is represented in outcrop exposures. In addition to this guidebook, cores and other subsurface data from the study area will be displayed in the Midcontinent Core Workshop being held in conjunction with the 1991 AAPG Midcontinent Section Meeting in Wichita, Kansas, on Sunday, September 22.

The goals of the project are to determine the geometry of the Drum oolite body, to determine the relationship between the facies and geometry of the Drum Limestone and the facies and geometry of underlying and overlying units, and to determine the role of other controlling factors such as tectonic effects and sea-level changes.

The study interval in Montgomery County represents a departure from the more typical expression of Upper Pennsylvanian strata of midcontinent shelf areas, which are characterized by thin cyclical alternations of carbonate and siliciclastic rocks termed "cyclothems" (e.g., Heckel, 1977). Many Pennsylvanian cyclothems can be traced over wide areas of the midcontinent region. Changes in cyclothem thickness, areal extent, lithofacies, and evidence

of subaerial exposure surfaces are interpreted to represent varying magnitudes of sea level fluctuations across the craton (e.g. Heckel, 1977, 1980, 1984, 1986; Watney, 1984; Watney et al., 1989) (fig. 4). As will be demonstrated on this field trip, the Drum Limestone and associated strata in the Independence area are different from the typical cyclothem in that changes in thickness and facies occur over short distances. In addition, significant changes in depositional environments, including regionally important relative sea-level changes, are not necessarily accompanied by major lithologic changes. In this regard, the integration of data from the various disciplines becomes important in trying to correlate strata and to understand the complex depositional history of the area.

The relative importance of tectonic, eustatic, and local processes that controlled depositional and erosional features associated with the Drum Limestone is currently

being evaluated. Baars and Watney (in press) have suggested that deep-seated basement faults may have played an important role in the study area in localizing the features that occur in the Drum Limestone and associated strata, as well as in older strata. Results from analysis of the relationship between facies changes and deep structural features in Montgomery County, Kansas, may provide important information that can be incorporated on a more regional scale with information gleaned from the study of more typical cyclothem to better understand the relative importance of regional eustatic and tectonic influences, as well as local processes as controlling factors of deposition. Ultimately, we hope to gain a better understanding of the controls responsible for the features in the strata examined on this field trip, some of which may be analogous to strata that are reservoirs in central and western Kansas.

## Outline of major stratigraphic units

The stratigraphic units focused on here extend from the Mound Valley Limestone to the Quivira Shale (fig. 2). The Mound Valley Limestone is generally a wackestone to packstone that gradually gets thicker to the north (up to 25 ft [7.5 m]) in Montgomery County. The overlying Galesburg Shale (up to 60 ft [18 m] thick) consists of sandstone, shale, and coal. The most noteworthy feature of the Galesburg Shale in the study area is that it is thinnest beneath the thickest portions of the Drum Limestone. Above the Galesburg Shale are the Canville Limestone Member, Stark Shale Member, and Winterset Limestone. The Canville and Winterset limestones both increase in thickness to the north.

Thickness and facies changes in the Drum Limestone are interpreted to result from significant pre-Drum topography. Relief on the pre-Drum seafloor was apparently related to (if not a direct result of) major thickness changes in the underlying sequence of rocks down to the Canville Limestone Member and possibly including the Galesburg Shale. The general pattern of deposition of siliciclastic and carbonate units in this interval (from Canville Limestone Member to Drum Limestone) is that each successive unit had a depositional shelf edge that extended a few miles further south compared to the previous unit (Watney et al., 1989). As each unit prograded to the south, a shallow-water platform was extended farther in that direction. For example, during Winterset deposition the depositional shelf edge was in southern Wilson County a few miles north of the Montgomery County border. The Winterset thins from nearly 100 ft (30 m) thick in central Wilson County to under 20 ft

(6 m) thick in central Montgomery County (fig. 5; Watney et al., 1989). The Cherryvale Shale apparently filled in some of the low areas left from Winterset deposition and extended the depositional shelf edge to central Montgomery County (fig. 6). The Drum Limestone is thin (generally under 20 ft [6 m]) where either the Cherryvale Shale or Winterset are thick (plate I), and increases in thickness up to 75 ft (22.5 m) as the Cherryvale thins to the south where the Winterset is thin (figs. 7 and 8). Thus, deposition of the Drum Limestone extended the depositional shelf a few miles south of the Cherryvale Shale platform (figs. 9, 10, 11, and 12).

The Nellie Bly Formation overlies the Drum Limestone. The Nellie Bly consists of interbedded sandstone, siltstone, shale, and coal, and includes thin limestones in the upper portion. Ripple crossbedding, starved ripples, sediment loading, and soft-sediment deformation structures are all common features in the Nellie Bly. There is a sharp, irregular erosional contact near the middle of the Nellie Bly (fig. 11). This erosional surface is overlain by a fining-upward sequence of conglomerate, sandstone, and shale. The erosion surface occurs extensively throughout the study area. In the subsurface southwest of Independence, a lag of shells or limestone intraclasts directly overlies the erosion surface and is in turn overlain by sandstone and shale. The erosional surface can be traced on well logs and high-resolution seismic lines (fig. 13).

The Quivira Shale lies directly above the Nellie Bly Formation and consists of up to 10 ft (3 m) of black, platy shale.

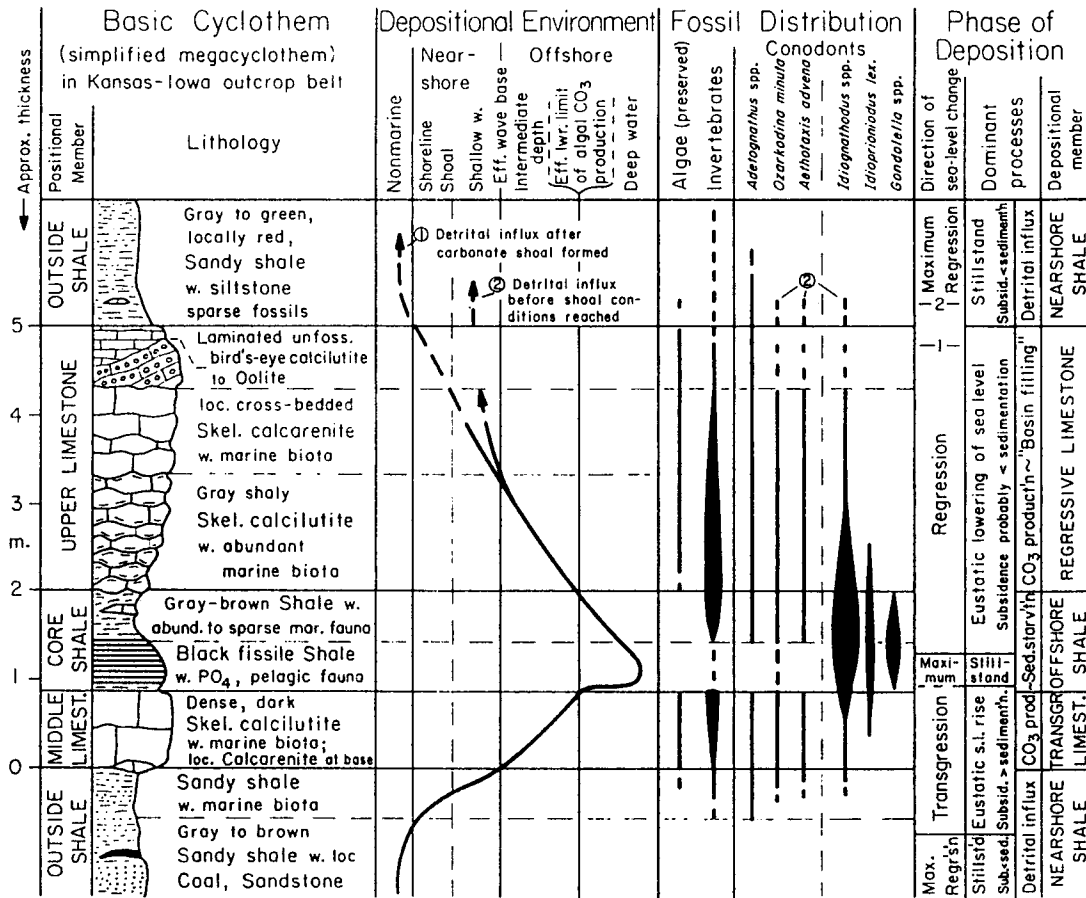


FIGURE 4—SCHEMATIC DIAGRAM OF IDEAL MISSOURIAN CYCLOTHEM IN KANSAS (from Heckel, 1977).

FIGURE 5 (right)—ISOPACH MAP OF THE WINTERSSET LIMESTONE MEMBER IN MONTGOMERY COUNTY, KANSAS.

FIGURE 6 (right)—ISOPACH MAP OF THE CHERRYVALE SHALE IN MONTGOMERY COUNTY, KANSAS.

FIGURE 5

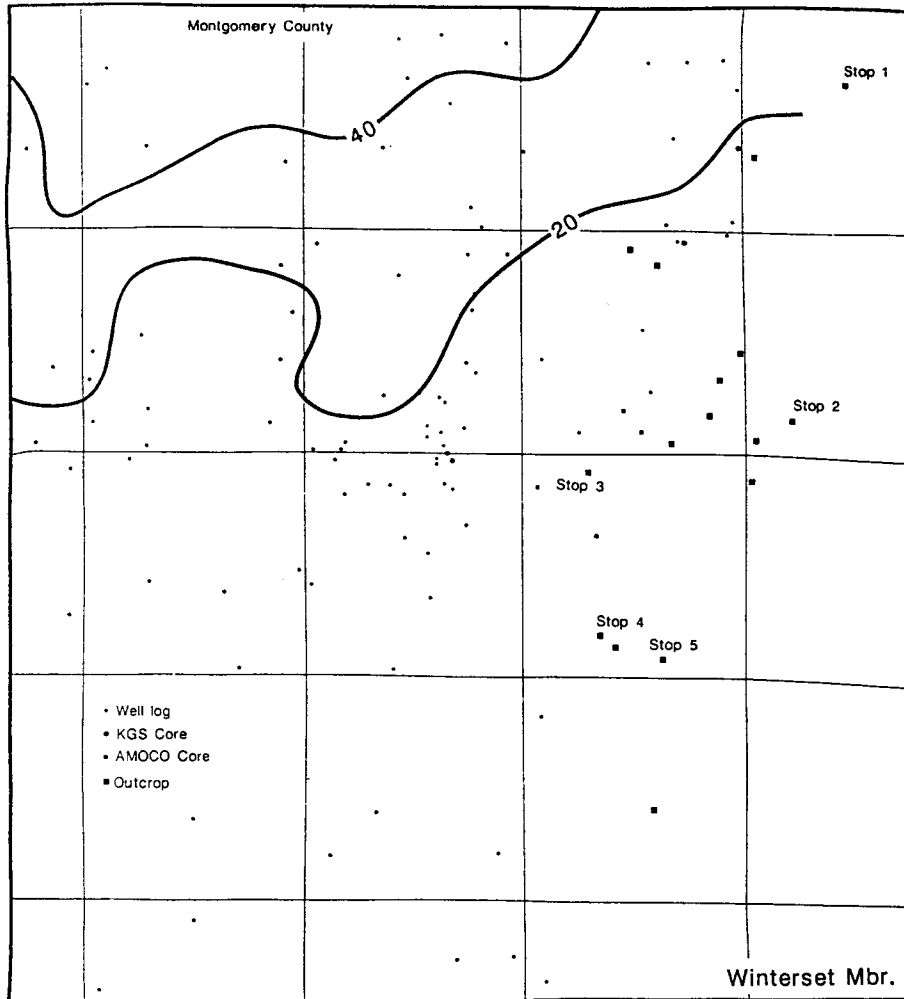
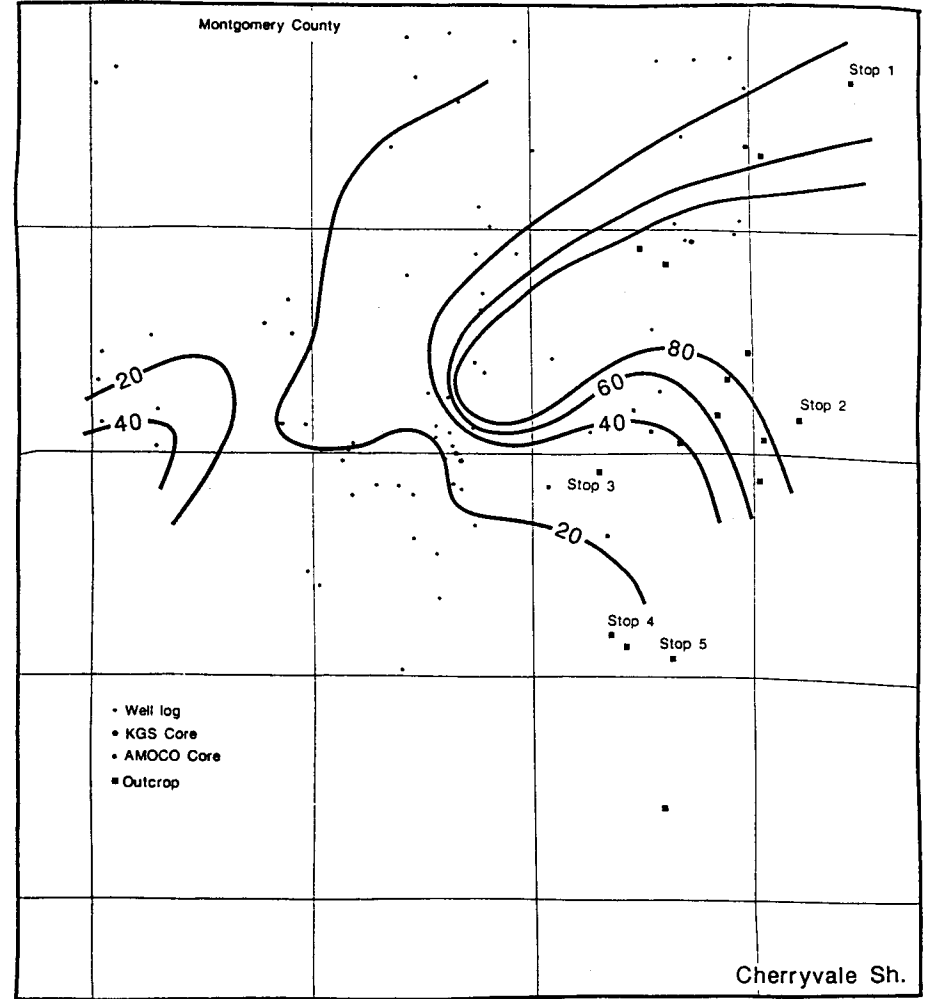


FIGURE 6



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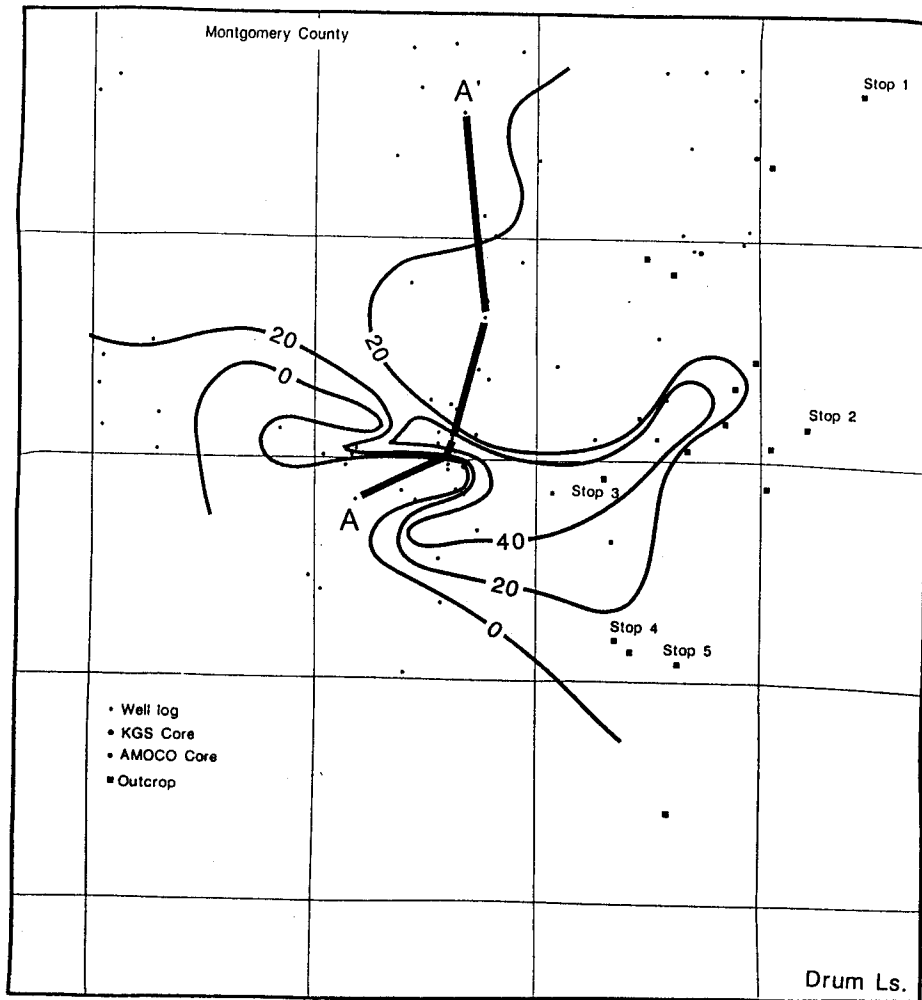


FIGURE 7—ISOPACH MAP OF THE DRUM LIMESTONE IN MONTGOMERY COUNTY, KANSAS.

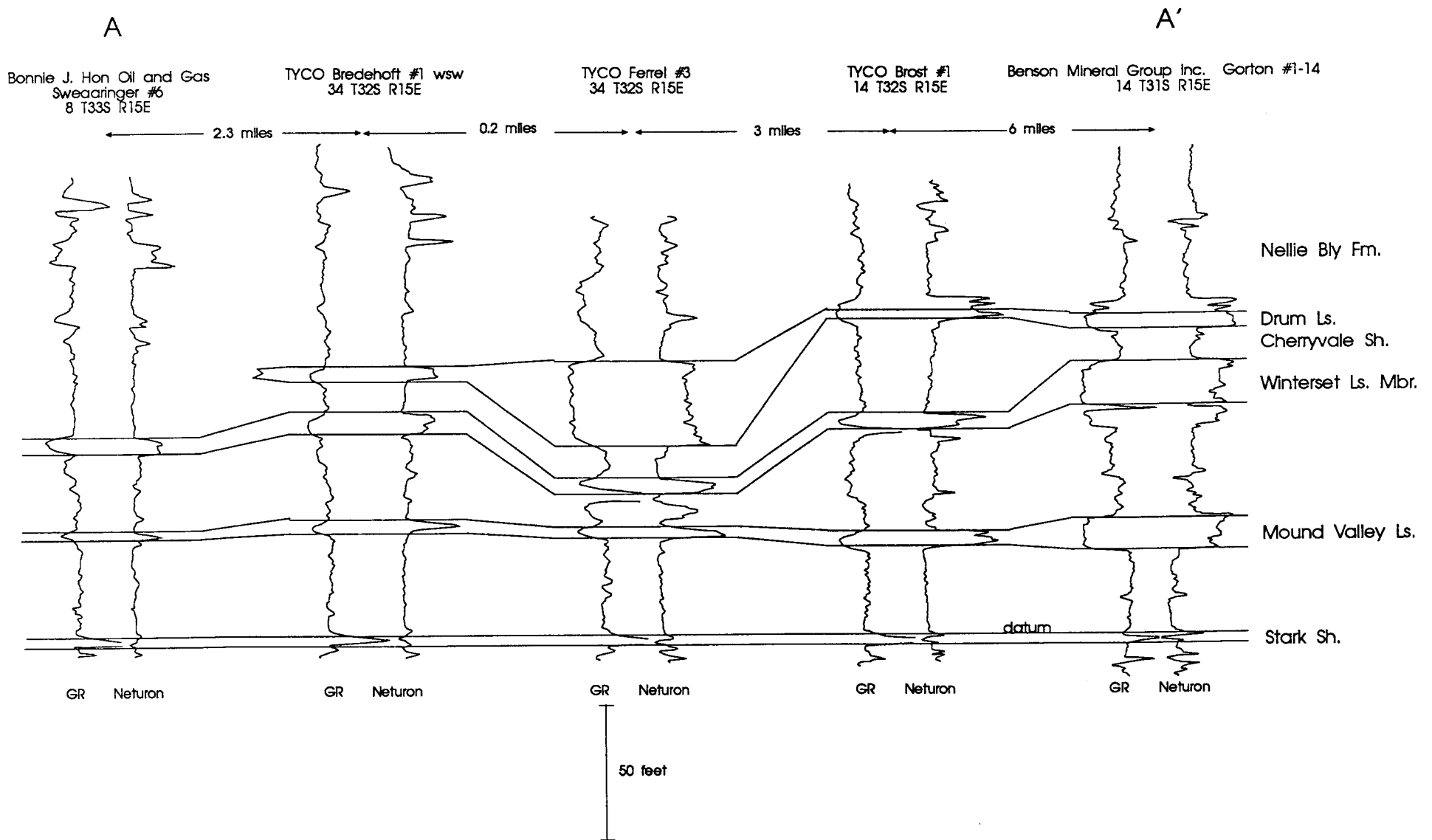


FIGURE 8—CROSS SECTION STUDIED INTERVAL SHOWING PROGRESSIVE PROGRADATION OF SHELF EDGE TO THE SOUTH. Line of cross section shown in fig. 7.

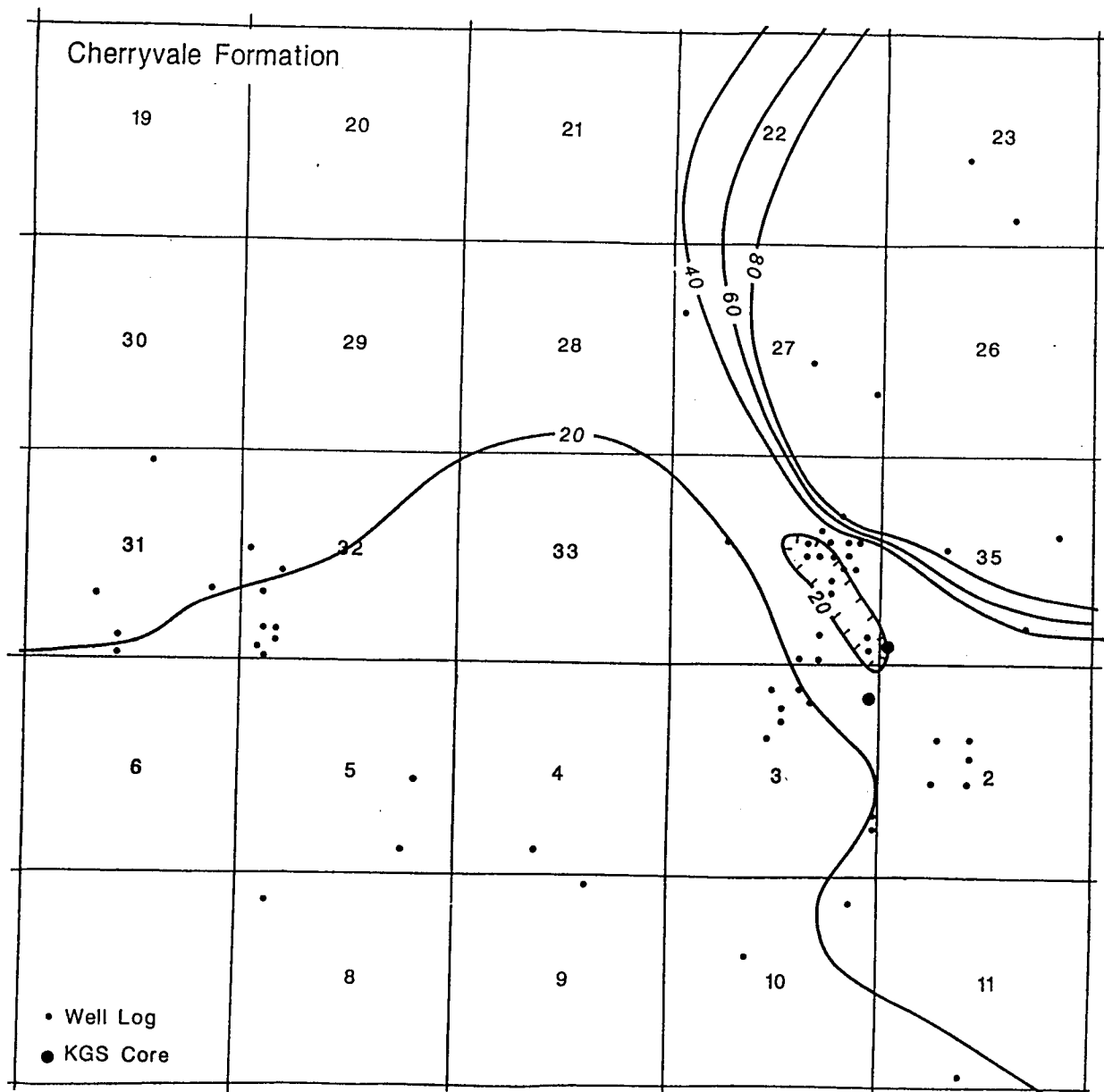


FIGURE 9—ISOPACH MAP OF CHERRYVALE SHALE IN CENTRAL MONTGOMERY COUNTY IN AREA WHERE CORE AND SEISMIC DATA HAVE BEEN COLLECTED. Numbered squares are sections.

## Inferred depositional environments

The Cherryvale Shale was part of a marine deltaic system that generally prograded to the south and southwest. The Cherryvale is distributed in one major lobe in the study area (fig. 6). This lobe has a northeast-southwest axis, parallel to one direction of basement structures in the area, although this relationship remains enigmatic. The lobe of Cherryvale Shale thins abruptly to the south from 90 ft (27 m) to 20 ft (6 m) over a distance of about 1 mi (1.6 km) in the subsurface southwest of Independence. The southern and western edge of the Cherryvale lobe is interpreted as the depositional slope that was left after cessation of delta progradation, although some minor erosion occurred prior to, or concomitant with, initial

Drum deposition (Stop 2, plate IIC). Depositional environments of the Cherryvale are difficult to interpret because of the lack of sedimentary structures and the homogeneity of the shale. The relatively flat top of the Cherryvale lobe suggests that sediment accumulated up to local base level. It is likely that the sea was very shallow over the depositional shelf created by the Cherryvale delta.

The Drum Limestone marks the end of siliciclastic deposition and the beginning of carbonate deposition in the study area. The lowest bed in the Drum Limestone is locally rich in fossils and shale clasts, and rests on an erosional surface on top of the Cherryvale Shale (Stop 2, plate IIC). This lowest limestone may represent deposition

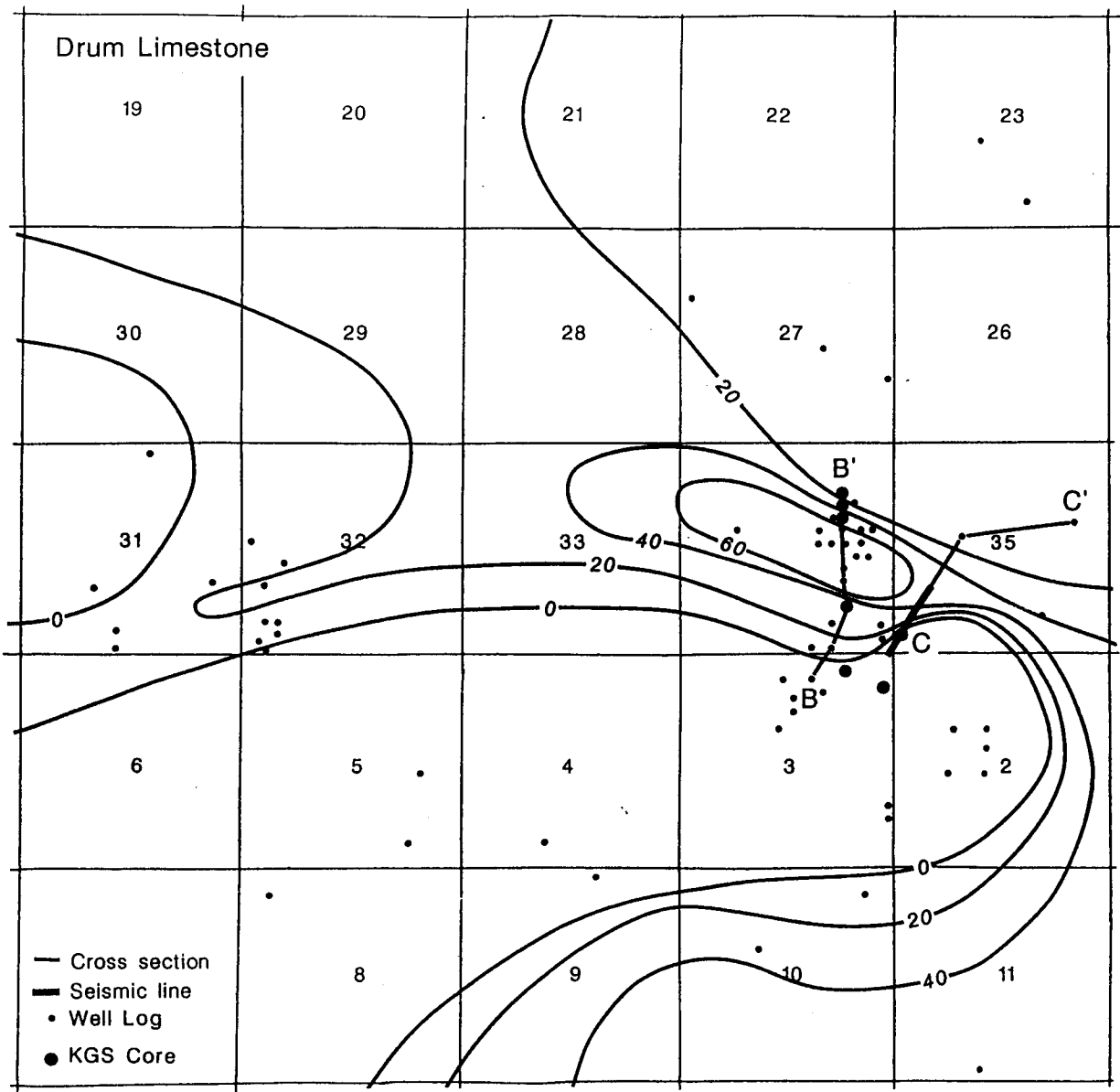


FIGURE 10—ISOPACH MAP OF DRUM LIMESTONE IN THE SAME AREA AS FIG. 9.

during a transgression and initial relative sea-level rise. Local scouring and/or channeling in lower Drum beds suggests relatively shallow water conditions. Above the lowest limestone bed in the Drum are alternating shale and laminated carbonate mudstones. The paucity of bioturbation, fossils, and current structures all suggest a quiet, relatively deep-water environment of deposition. The alternating shale and laminated carbonate mudstone facies always occurs at the base of the Drum Limestone and gradually increases in thickness basinward. Above this facies is the main portion of the Drum Limestone and it is this upper part that shows the rapid facies and thickness changes in the study area.

Where the combined thickness of the Dennis Limestone (fig. 2) and Cherryvale Shale are over 50 ft (15 m)

thick, the Drum is a thin (generally under 10 ft [3 m]), tight (low porosity/permeability) limestone. Outcrops of the Drum in this area are composed of laminated carbonate mudstone and stromatolitic and fossiliferous wackestone. Deposition in mostly normal marine water is evidenced by the abundant and diverse fauna in the wackestone and packstone.

Near the basinward edge of the Cherryvale Shale (where the Canville and Dennis limestones are generally thin), the Drum increases in thickness and becomes more oolitic. Near the depositional shelf edge the Drum typically consists of three units: a lower unit of alternating carbonate mudstone and shale, a middle unit composed of mudstone to fossiliferous wackestone, and an upper crossbedded oolitic unit. Evidence of erosion prior to

oolite deposition is common, and a possible karst surface has been recognized (Stop 2, plates II, III, and IV). Basinward of the break in the slope of the Cherryvale, the Drum thickens abruptly to a maximum of 75 ft (22.5 m) in the subsurface. On outcrop and in cores, most of the Drum in this area is composed of crossbedded, fossiliferous, oolitic grainstone. Hamblin (1969) interpreted bimodal crossbed orientations in the Kansas City Group oolites to be the result of tidal currents. Crossbed orientations in the Drum oolite are also bimodal, but are dominated by southwest orientations, suggesting a setting dominated by ebb currents. Oolites were probably being generated in shallow water near the edge of the Cherryvale depositional shelf and transported basinward into lower-lying areas, possibly as a series of tidal deltas in some locations. The oolite is now preserved as several lobes extending basinward from the depositional shelf edge (compare figs. 11 and 12).

In basinward locations south of the major oolitic accumulations, the exposed Drum is represented predominantly by unfossiliferous, laminated micrite, possibly

reflecting a relatively deep, oxygen-starved environment. The Drum is locally absent in basinal areas in the subsurface. The distance of the transition from thin shelf limestone to thick oolite to thin basinal limestone is as little as 1 mi (1.6 km) in the subsurface. On outcrop this transition occurs over a distance of about 15–20 mi (24–32 km).

A minor flooding event followed Drum Limestone deposition, resulting in widespread deposition of the crossbedded sandstones and intervening shales of the Nellie Bly Formation. Current ripples, the lack of fossils, low-diversity trace fossil assemblages, and possible rhythmic tidal bedding suggest deposition in a shallow, estuarine environment. A fall in relative sea level may be the cause of the erosional surface that occurs within the Nellie Bly, although no subaerial exposure features have been identified to date. Locally, the erosional surface appears to truncate part of the Drum Limestone (Stop 5, fig. 18). Deposition of the overlying black, platy Quivira Shale likely represents the next major marine transgression.

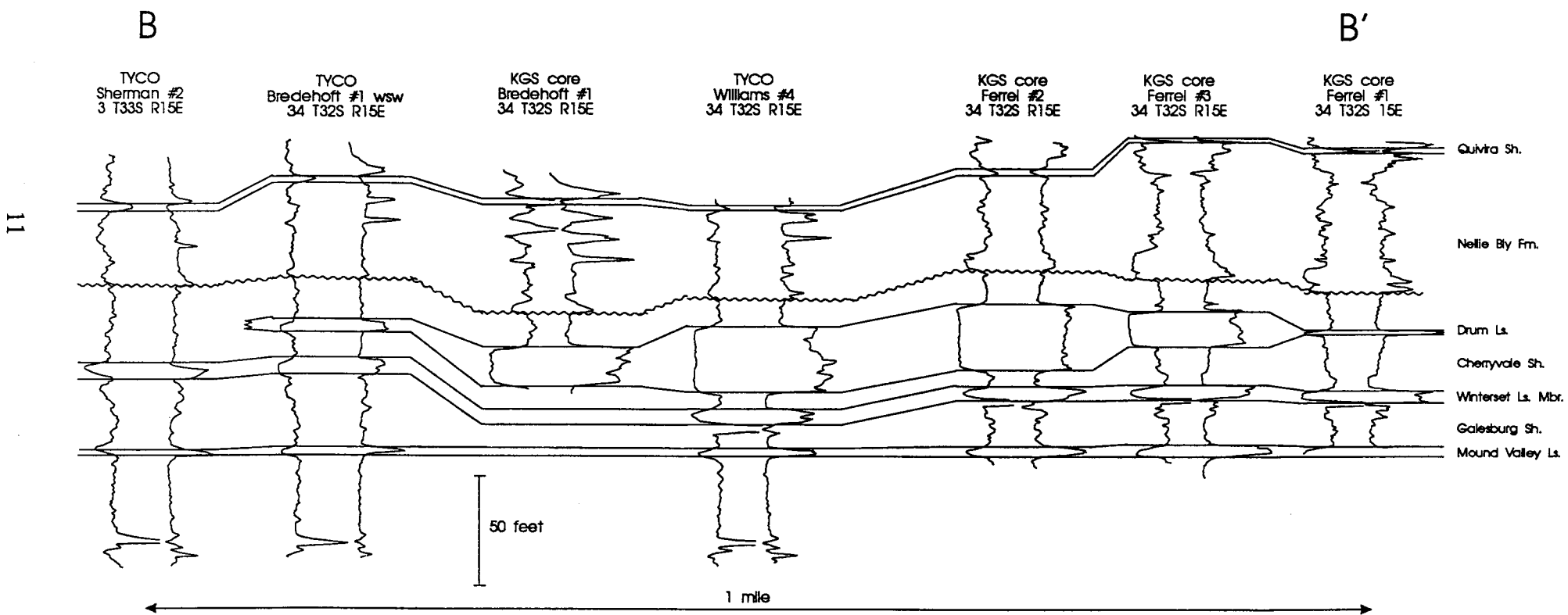


FIGURE 11—CROSS SECTION OF STUDY INTERVAL INCLUDING KGS CORE WELL LOGS. Location of cross section shown in fig. 10.

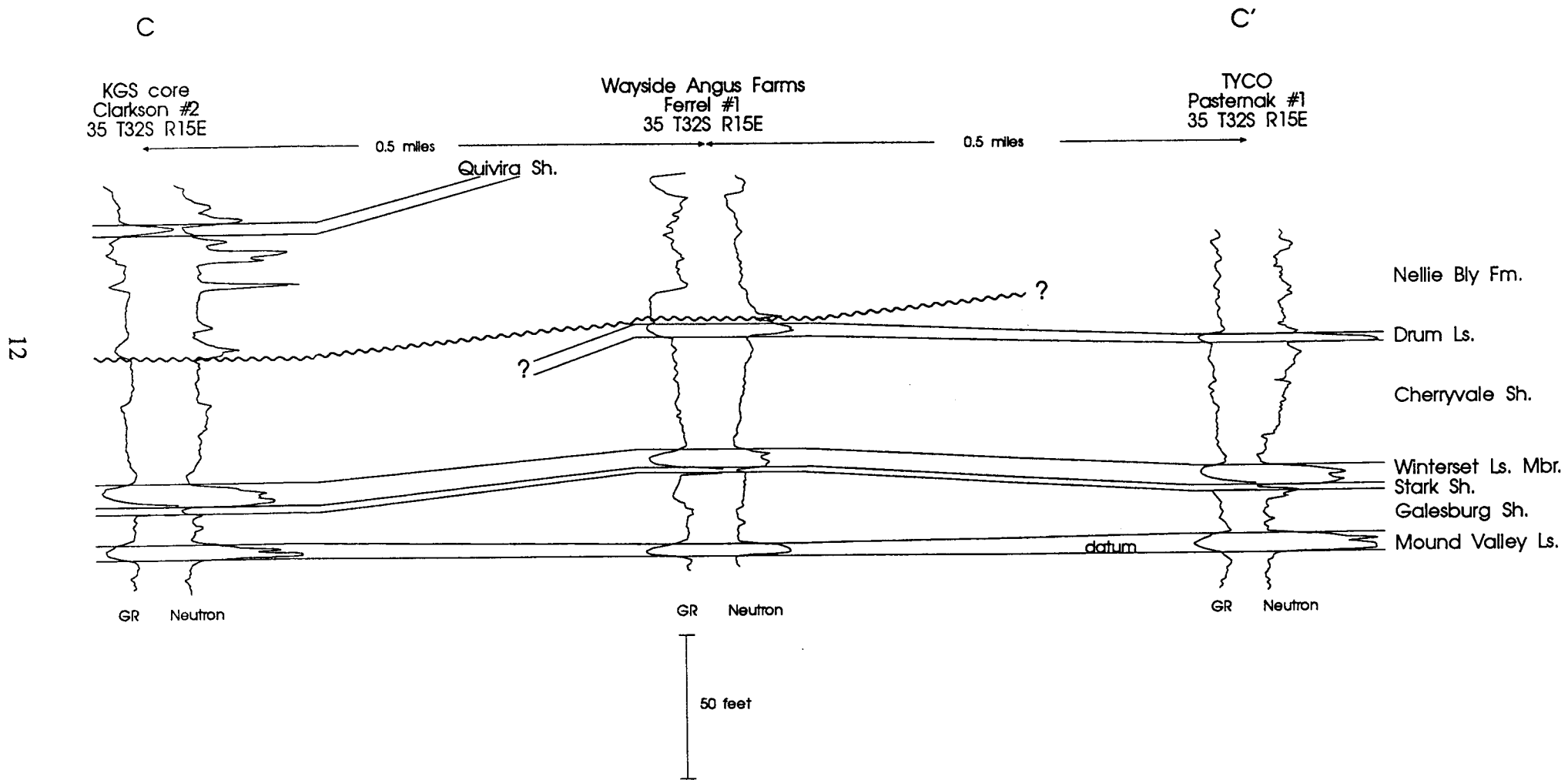


FIGURE 12—CROSS SECTION OF STUDY INTERVAL ALONG SEISMIC LINE. Location of cross section shown in fig. 10. The oolite, if present at all, is much less well-developed than in the location of fig. 11. This cross section may represent an interlobe position.

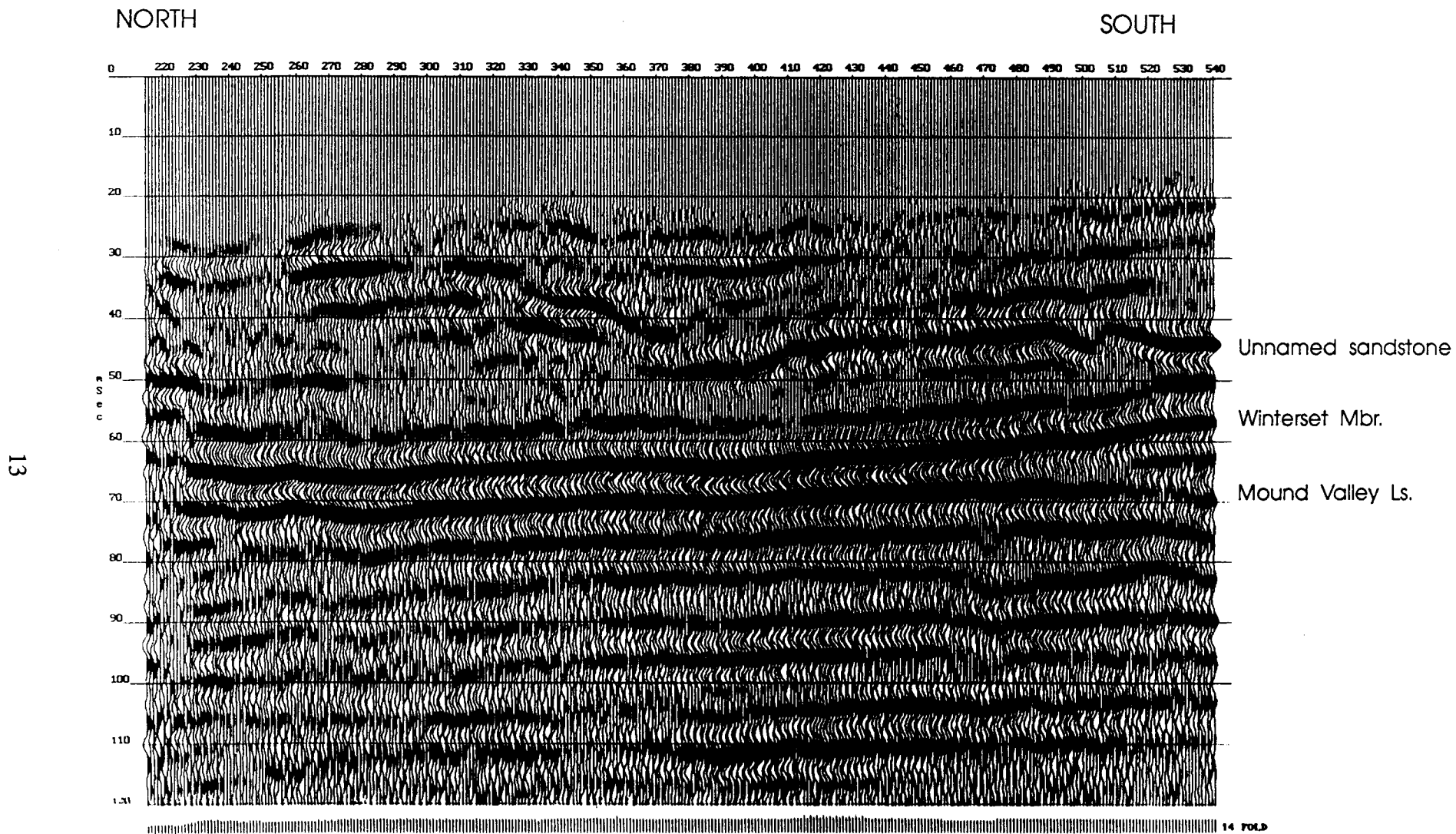


FIGURE 13—HIGH-RESOLUTION SEISMIC LINE SHOWING THINNING OF GALESBURG SHALE BETWEEN THE MOUND VALLEY AND WINTERSSET LIMESTONES. The Drum Limestone may be present in the northern part of the transect. Location of seismic line shown in fig. 10.

# Stop descriptions

**STOP 1:** The Drum Limestone at this location overlies the thickest combined Dennis Limestone and Cherryvale Shale (about 90 ft [27 m]). The Drum Limestone consists of a lower unit of interbedded mudstone and shale, and an upper unit of stromatolitic limestone (fig. 14). The lower unit was likely deposited during flooding of the Cherryvale shelf. The upper unit contains many well-developed stromatolites (up to 1 ft [30 cm] thick) and oncolites indicating deposition in shallow water. The 3-ft (1-m)-thick stromatolitic Drum rests on interbedded shale and laminated micrite.

2. 2-ft (60-cm) stromatolitic limestone. The stromatolites are composed of fossiliferous to unfossiliferous, laminated wackestone to packstone. Fill between stromatolites composed of fossiliferous wackestone to packstone.
1. 2.9-ft (87-cm) interbedded shale and limestone. Limestone beds range up to 0.6 ft (18 cm) thick and are composed of fossiliferous packstone to laminated mudstone.

There are two cycles of stromatolite development. Each cycle starts with a small stromatolite composed of poorly laminated, argillaceous micrite. This is followed by a second phase of stromatolite growth composed of crinkly laminated micrite with fenestrate bryozoans and few other fossils (plate I). The laminated stromatolites have steep to overhanging sides indicating that they were firm or hard during deposition. Fossiliferous wackestone to packstone fills the volume between stromatolites. The stromatolites are best exposed on overturned blocks on the south side of the road.

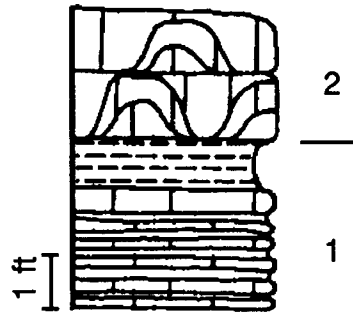


FIGURE 14—MEASURED SECTION AT STOP 1.

**STOP 2:** This location is near the inferred break in slope on the Cherryvale delta (fig. 6). Here the Cherryvale is about 100 ft (30 m) thick, but, compared to Stop 1, the Drum is thicker (about 10 ft [3 m]) and more oolitic (fig. 15), reflecting proximity to the edge of a Cherryvale lobe. At this stop, we will examine exposures in three separate outcrops along the road, starting at the easternmost exposure and walking to the west (plate II).

The first two road cuts expose the Drum Limestone and the lower portion of the Nellie Bly Formation. In these exposures, the basal 3–8 ft (1–2.4 m) of the Drum consists mostly of mudstone (locally stromatolitic) and fossiliferous wackestone with large fenestrate and encrusting bryozoans, brachiopods, bivalves, and echinoderm debris. Some oolitic packstones-grainstones were deposited, apparently in local scours or channels. Locally, a sharp, erosional surface (overlain by a thin carbonate layer containing fossil fragments and oolites) separates the lower mudstone and overlying wackestone. Some brecciation, laminated crusts, and iron-staining along the surface may indicate that the surface formed during subaerial exposure of the underlying strata. The top contact of the fossiliferous wackestone facies is an erosional surface that formed steep-sided cavities in the underlying strata. This erosion surface has at least 5 ft (1.5

m) of relief along its trace in outcrop (plates II and III). Autobrecciation, iron-staining, laminated crusts, fractures (some possibly root molds), and circumgranular cracking along the surface suggest that it formed from subaerial exposure (plate IV). Some of the orange-stained fill of the cavities may be a paleosol. The fill in the cavities includes a coarse, bioclastic packstone (not identified elsewhere) and oolites, presumably derived from the overlying oolite facies during its deposition.

Overlying the erosional surface is up to 5 ft (1.5 m) of crossbedded, fossiliferous, oolitic grainstone that locally laps out against the erosion surface. Fossils in this unit include fenestrate bryozoans, brachiopods, myalinid and other bivalves, echinoderm debris, and gastropods. Crossbeds dip predominantly to the northeast.

The third and easternmost of the road cut exposures reveals the contact of the Drum Limestone with the underlying Cherryvale Shale (plate IV). Here the Cherryvale Shale is 90 ft (27 m) thick. The contact with the overlying Drum Limestone is a sharp, irregular, and apparently erosional (10's of inches) surface. The basalmost Drum is a fossiliferous packstone to grainstone with overlying interbedded mudstone and shale. Some evidence of truncation within basal Drum beds, likely due to channeling, is visible in this exposure.

9. 5 ft (1.5 m) silty shale and siltstone. Thin layers of fossiliferous packstone and mudstone with cone-in-cone structures. Brown siderite concretions.
8. 2.7 ft (8.1 m) interbedded fossiliferous, oolitic grainstone and shale. Limestone in trough crossbedded lenses.
7. 2.5–6 ft (75 cm–1.8 m) crossbedded oolitic, fossiliferous grainstone.
6. 0–1 ft (0–30 cm) oolitic grainstone and fossiliferous wackestone. Orange-colored weathered zone on top.
5. 0–4 ft (0–1.2 m) fossiliferous wackestone and boundstone. Encrusting bryozoans in apparent growth position on laminated mudstone. Dark, laminated micrite crust coats upper surface. Irregular, erosional upper surface.
4. 1.4 ft (42 cm) sparsely fossiliferous wackestone. Intraclasts on upper surface. Oncolites present near top.
3. 1–2.6 ft (30–78 cm) interbedded shale and laminated mudstone.
2. 0.4–0.8 ft (12–24 cm) intraclastic, fossiliferous grainstone.
1. 10 ft (3 m) gray shale.

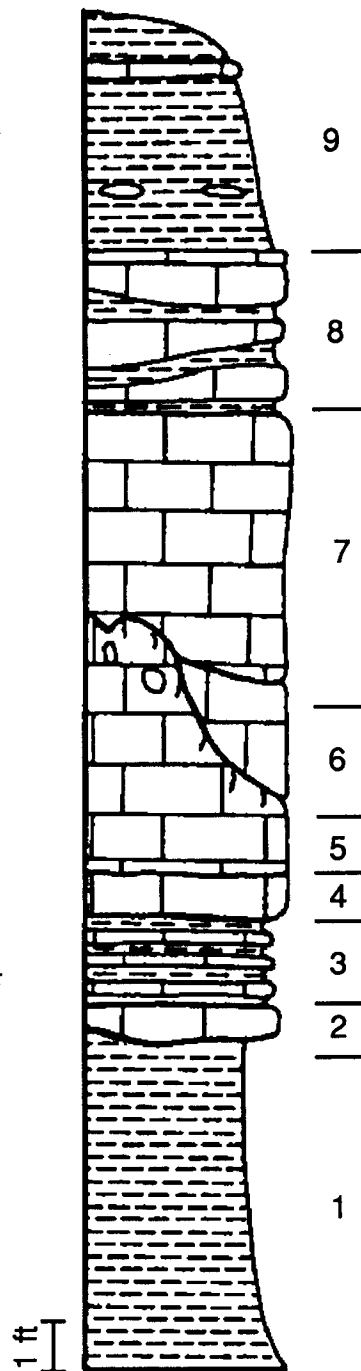


FIGURE 15—MEASURED SECTION AT STOP 2.

**STOP 3:** This stop is a quarry located in the thickest part of the Drum oolite facies that occurs on a distal portion of a Cherryvale delta lobe. Here the Cherryvale Shale is only about 35 ft (10.5 m) thick. The Drum is about 50 ft (15 m) thick and is exposed in a mile-long quarry high wall (fig. 16; plate V). The lowest part of the exposed Drum

consists of interbedded laminated mudstone and shale. This is overlain by 40 ft (12 m) of crossbedded, fossiliferous, oolitic limestone. Tabular planar crossbeds are up to approximately 6 ft (1.8 m) thick near the base of the oolite and generally thin upwards. The upper 10 ft (3 m) of Drum consists of interbedded shale and poorly sorted,

skeletal grainstone. Ooids are present but not as abundant as below. Trough crossbedding predominates in the upper skeletal grainstones. The uppermost troughs are encased in shale.

Crossbeds in the oolite dip predominantly to the southwest (Hamblin, 1969) in a basinward direction. Bimodal crossbedding in the Kansas City Group oolites indicates a tidal influence. The thick crossbeds exposed here may represent a series of tidal deltas.

4. 8 ft (2.4 m) interbedded limestone and shale. Limestone occurs in crossbedded troughs composed of poorly sorted echinoderm-rich, fossiliferous, oolitic grainstone.

3. 6–10 ft (1.8–3 m) trough crossbedded fossiliferous, oolitic grainstone. Abundance of echinoderms increases upwards.

2. 25 ft (7.5 m) crossbedded, fossiliferous, oolitic grainstone. Crossbed sets up to 7 ft (2.1 m) thick.

1. 1 ft (30 cm) interbedded laminated carbonate mudstone and shale.

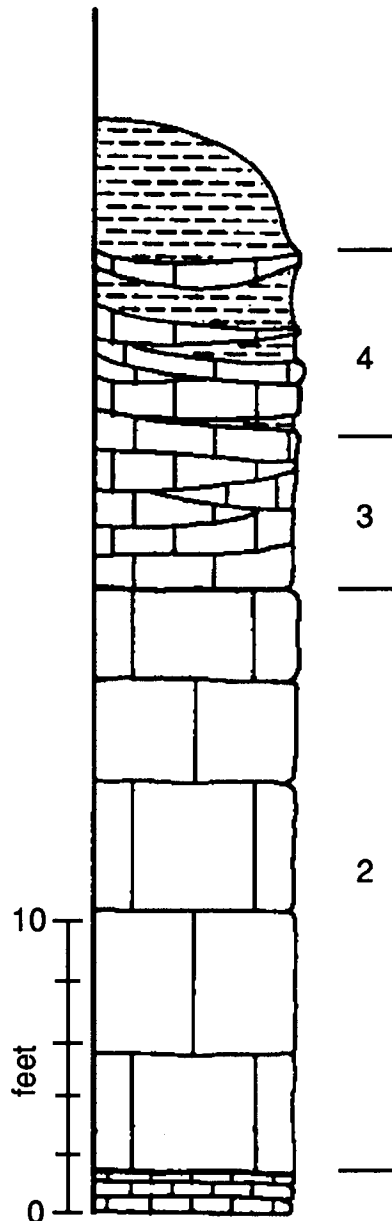


FIGURE 16—MEASURED SECTION AT STOP 3.

**STOP 4:** This location is 3 mi (4.8 km) basinward of Stop 3. Here the oolite is dramatically thinner (only 2 ft [60 cm] thick) (fig. 17). The lowest 5 ft (1.5 m) of exposed Drum consist of interbedded laminated mudstone and shale without fossils or burrows (plate VI). This interval is overlain by 9 ft (2.7 m) of burrowed, laminated mudstone and capped by 2 ft (60 cm) of oolite. This exposure generally represents a shallowing-upward succession. The

change from non-burrowed to burrowed mudstone may indicate a change from oxygen-starved stagnant water to increasingly well-mixed, more oxygenated water. The oolites may indicate shallow, turbulent water conditions.

Approximately 17 ft (5 m) above the top of the Drum is sandstone with a sharp lower contact. This may be the same sandstone identified in the subsurface within the Nellie Bly.

7. Micaceous medium-grained sandstone.
6. 17 ft (5.1 m) micaceous gray shale with brown siderite concretions.
5. 1.3 ft (39 cm) interbedded shale and limestone. Limestone is oolitic, fossiliferous grainstone to packstone with shale intraclasts.
4. 2 ft (60 cm) oolitic grainstone.
3. 1 ft (30 cm) covered.
2. 9 ft (2.7 m) of thin beds of bioturbated, laminated mudstone separated by shale seams.
1. 6 ft (1.8 m) interbedded laminated carbonate mudstone and shale.

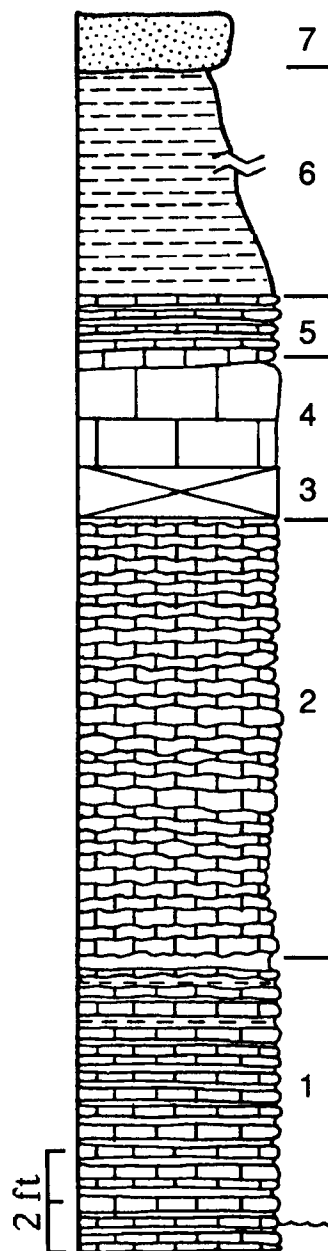


FIGURE 17—MEASURED SECTION AT STOP 4.

**STOP 5:** This location exhibits a sequence similar to that at Stop 4, but oolites are not present. At this stop sandstones are resting erosively upon Drum Limestone, although the contact is not exposed. At the top of the hill, the Drum Limestone (composed of interbedded laminated mudstone and shale) is overlain by sandstone. We interpret this as a Nellie Bly (or possibly Noxie sandstone) channel because there is no sandstone in the Cherryvale Shale in the study area. The lower road cut is probably also Nellie Bly, but it is topographically below most of the Drum. Therefore, the hill likely intersects a sandstone-filled channel eroded into the underlying Drum Limestone (fig. 18). Alternatively, the road cut could intersect a fault, but we have found no evidence for such to date. If this is a Nellie Bly channel eroded into the Drum, then it indicates that there was a significant lowering of local base level, probably due to lowering of relative sea level.

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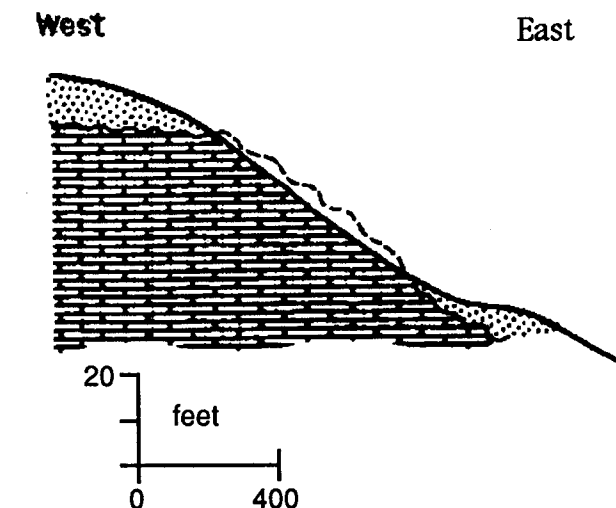


FIGURE 18—CROSS SECTION ALONG ROAD AT STOP 5.

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# Field trip road log

Refer to fig. 19 for a map of the field-trip route.

0.00 - **START** in Independence at intersection of US-75 and US-160, continuing east on K-96. Courthouse is on northeast corner

0.7 - Independence city limits, continue east on US-160/US-96.

1.2 - bridge

1.5 - cross Verdigris River, Drum outcrops on south side (right)

2.4 - road cut in Drum oolite to the south (right) and small quarries in Drum oolite to the north (left)

2.7 - road cut to the south exposing a thin limestone stratigraphically above the Drum

4.2 - road cuts to north and south exposing Nellie Bly

4.8 - road cut to north exposing possibly the base of the Drum Limestone

5.4 - cross Drum Creek

6.6 - turn north (left) on US-160/US-69.

10.1 - Cherryvale city limits

10.8 - leave Cherryvale city limits

14.0 - turn west (left) onto K-37

15.2 - quarry in Dennis Limestone to the east (right) of the road

15.7 - stop sign. continue north

16.8 - turn west (left) onto gravel road

17.2 - cross bridge

17.3 - cross bridge. Some Dennis Limestone exposed

17.6 - **STOP 1**. Continue west after this stop

18.0 - turn to the south (left)

18.4 - exposure of Drum Limestone (mudstone facies)

19.1 - stop sign. Turn east (left) onto blacktop

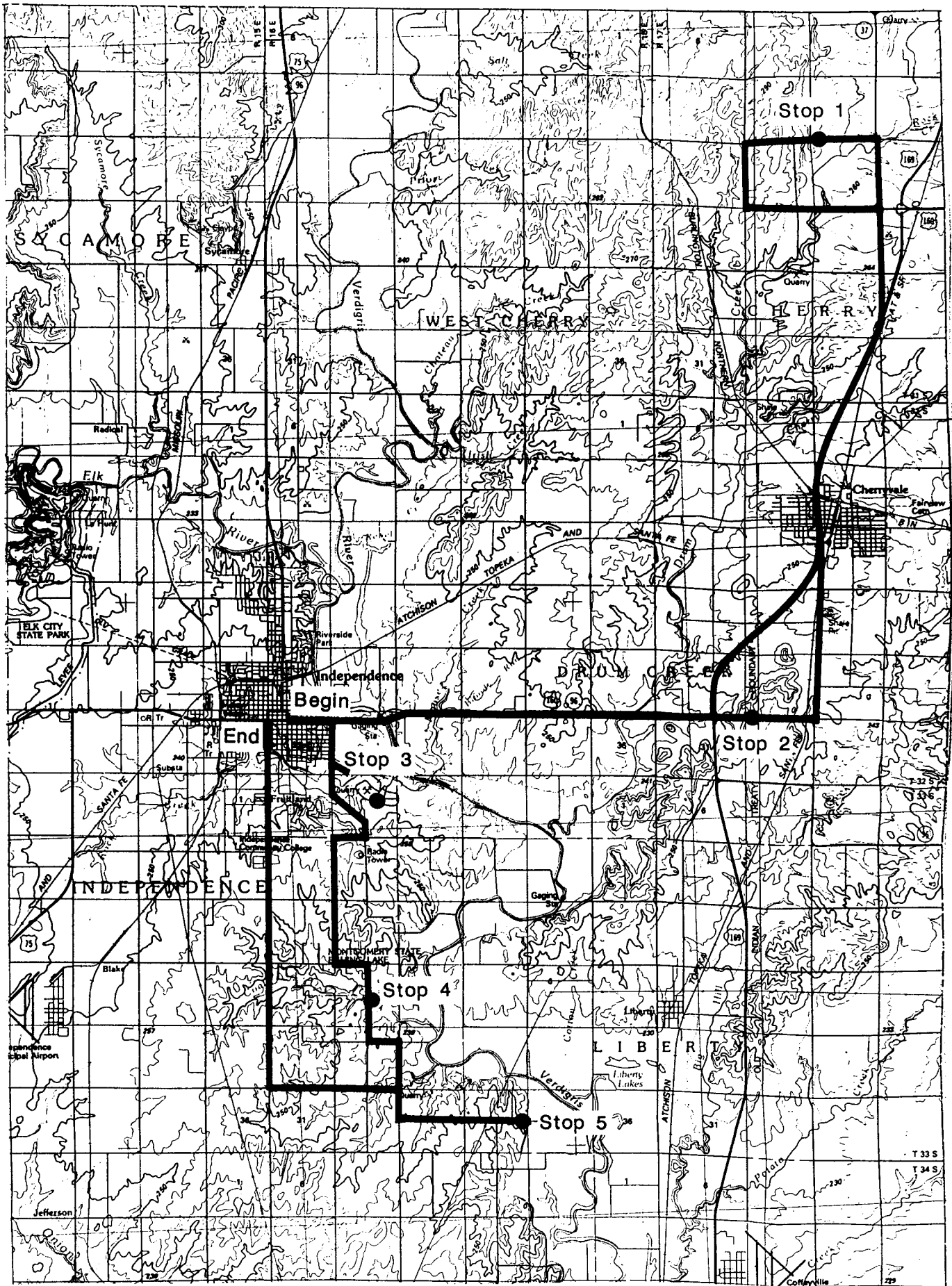


FIGURE 19—MAP OF EASTERN HALF OF MONTGOMERY COUNTY SHOWING FIELD-TRIP ROUTE.

19.5 - cross bridge

20.3 - stop sign. Turn south (right) onto K-37

22.0 - intersect US-160/US-169 turn right (south)

24.6 - "welcome to Cherryvale" sign

25.1 - Cherryvale city limits

25.9 - leave Cherryvale city limits

26.2 - turn left onto blacktop, continue south

26.6 - stop sign, jog to left, cross railroad tracks and continue south on gravel road

27.0 - abandoned shale pit exposing 60 ft (18 m) of Cherryvale Shale

28.7 - crossroads, turn west (right)

28.8 - cross railroad tracks

29.0 - exposures of Cherryvale Shale to north and south with capping Drum Limestone

29.9 - **STOP 2** .

30.1 - **STOP 2** continued

30.2 - road turns sharply to the north (left)

30.4 - intersection with US-160/US-169, turn south

0.5 - turn west to go to Independence, come to stop sign, cross southbound lane and continue to Independence

31.8 - cross Drum Creek, continue west

35.7 - cross Verdigris River

36.5 - Independence city limits, turn south (left) onto Cement Street

37.5 - entrance to Heartland Cement Company

38.0 - **STOP 3**. Quarry highwall

38.7 - cross Missouri & Pacific railroad tracks

39.2 - small quarries in Drum oolite to the right (south)

40.0 - stop sign. Turn west (right) onto blacktop

40.5 - turn to south (left) onto gravel road

42.5 - stop sign, turn east (left)

43.0 - turn south (right)

44.2 - turn east (left)

44.7 - turn south (right)

45.3 - **STOP 4.** Cross bridge. Outcrop is underneath the bridge; best access is on northeast corner. After stop 4, continue south

46.0 - turn east (left)

47.8 - **STOP 5.** East of crest of hill contact with Nellie Bly/Drum Limestone. Contact with Drum\Nellie Bly at base of hill (crossing little creek); after that Nellie Bly is on left side

48.0 - turn around at bottom of hill and head back to the west

50.1 - T-intersection; turn to the north (right)

50.6 - turn west (left)

52.6 - stop sign; turn north (right) onto blacktop towards Independence

57.8 - cross Rock Creek; outcrop of Quivira Shale on east

58.5 - **END** of road log at intersection of Main Street (US-75) and US-160

# Plates I–VI

## PLATE I: STOP 1

- A: Stromatolitic facies of the Drum Limestone. Stromatolite heads are indicated by black arrows. Carbonate sediment surrounding and filling in-between heads is shown by white arrows. Note that the blocks containing stromatolites in outcrop at this stop have been overturned. This photo is oriented upside-down to show correct growth orientation of the stromatolites.
- B: Stromatolitic laminations are commonly composed of alternating layers of micrite (locally with skeletal material) and encrusting bryozoans. Bar scale is 2 mm.

## PLATE II: STOP 2

This stop is made up of three consecutive road-cut exposures traversing from east (A) to west (C).

- A: Mudstone and wackestone facies in basal portion of Drum Limestone have been eroded. The erosional surface (white line) is interpreted as a subaerial exposure surface. This surface is overlain and overlain by oolitic facies of the Drum Limestone. Note hammer in center left for scale.
- B: Middle road-cut exposure of Drum Limestone. Basal Drum wackestone beds are truncated by the surface (white line) interpreted as a subaerial exposure surface (see plate IV and text). The surface is overlain by Drum oolite facies. See plate III for additional details of this exposure. Note hammer in center for scale.
- C: West road-cut exposure. Here the contact of the Drum Limestone and underlying Cherryvale Shale is exposed (arrow). The contact is sharp, irregular, and apparently erosional. Basal Drum beds are fossiliferous packstones to grainstones locally with evidence of scouring and/or channeling. Overlying Drum beds are interbedded mudstones and shales.

## PLATE III: STOP 2

Photograph and line drawing showing details and interpretations of middle road-cut exposure (plate IIB).

## PLATE IV: STOP 2

Some features associated with the interpreted subaerial erosion surface that separates Drum wackestone facies from oolite facies. Features shown here are taken from the middle road-cut exposure (plate IIB). See text for additional details.

- A: Autobrecciation (arrow).
- B: Dark laminated crust (arrows) that locally coats the erosion surface.
- C: Fracturing and circumgranular cracking. Some fractures have tapered ends possibly indicating alteration by roots. The arrow points to a possible root mold that was filled in by overlying sediment. Note also oolites in the upper left of the photo as part of the cavity sediment-fill. The oolites likely filtered in during deposition of the overlying Drum oolite facies. Scale bar is 2 mm.
- D: Coarse-grainstone cavity fill. This facies, characterized by very coarse crinoid debris (arrow), locally fills cavities immediately above the erosion surface. This facies has not been identified elsewhere.

**PLATE V: STOP 3**

- A: Crossbedded, fossiliferous, oolitic grainstone facies of the Drum Limestone in quarry exposure.**
- B: Oolitic-rich packstone-grainstone with minor skeletal fragments. Oomoldic porosity is abundant in this sample. Scale bar is 2 mm.**
- C: Fossiliferous, oolitic grainstone with abundant echinoderm fragments. This sample is more tightly cemented compared with B. Scale bar is 2 mm.**

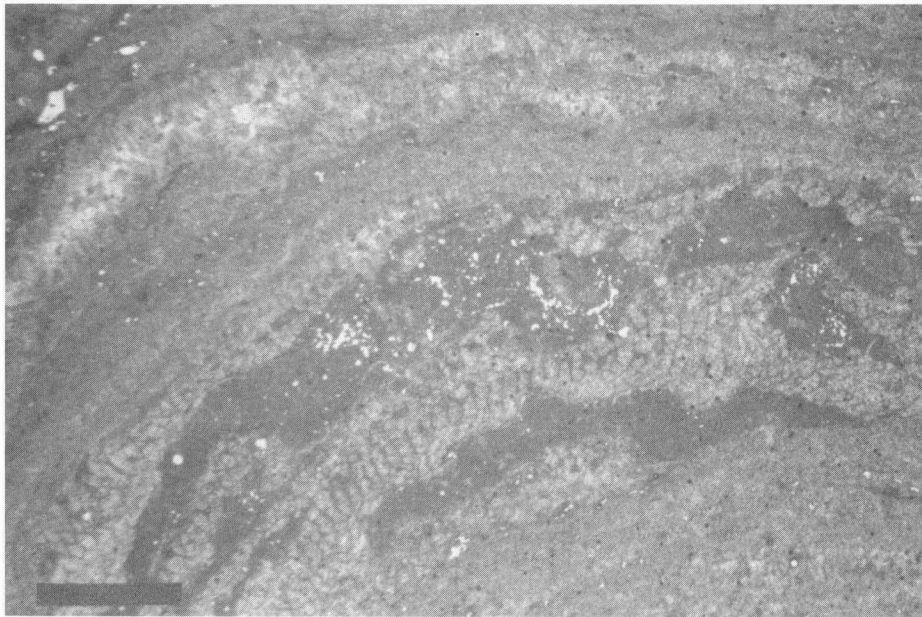
**PLATE VI: STOP 4**

- A: Laminated, non-burrowed to burrowed mudstone facies of the Drum Limestone. White line marks the transition from non-burrowed to burrowed, likely indicating an increase in oxygen abundance upwards.**
- B: Burrowed mudstone.**
- C: Laminated mudstone.**

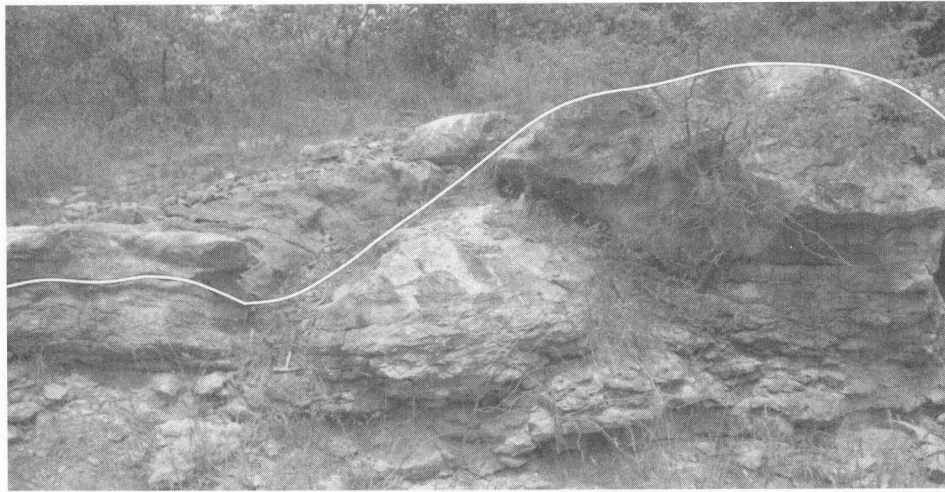
**PLATES I–VI FOLLOW**



A



B



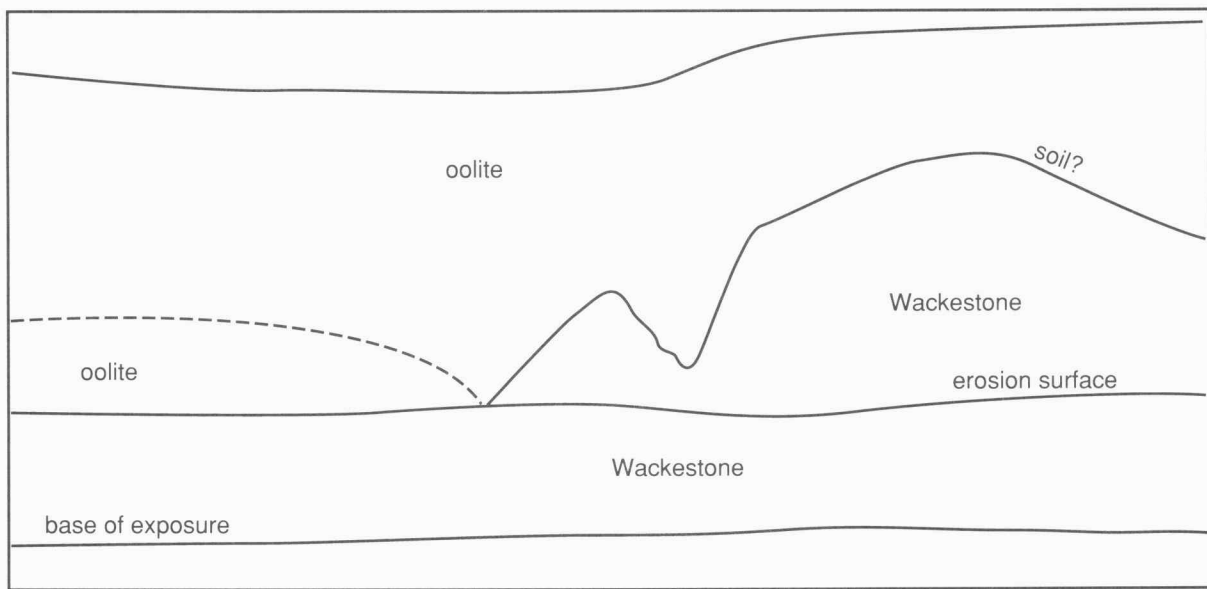
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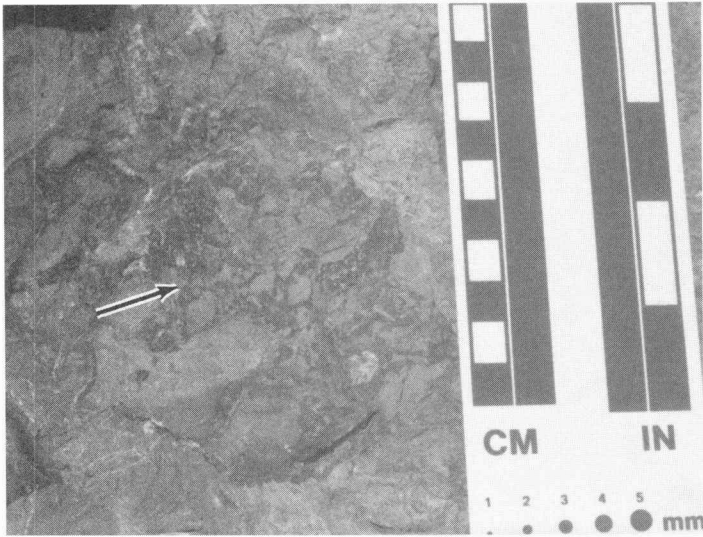


B

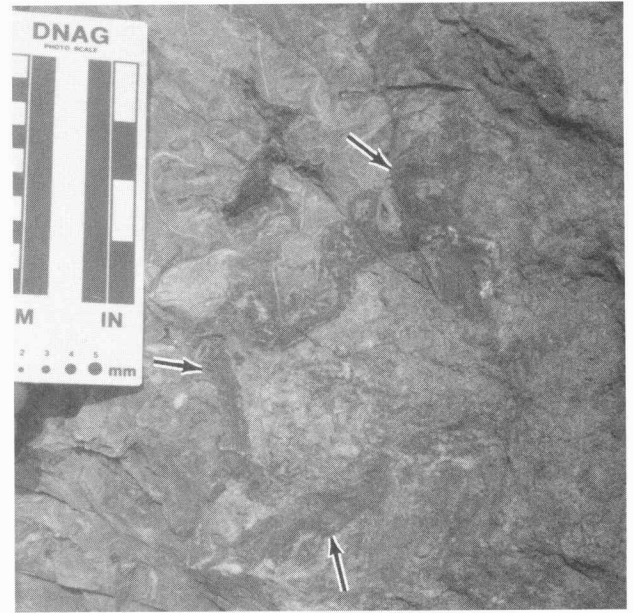


C





A



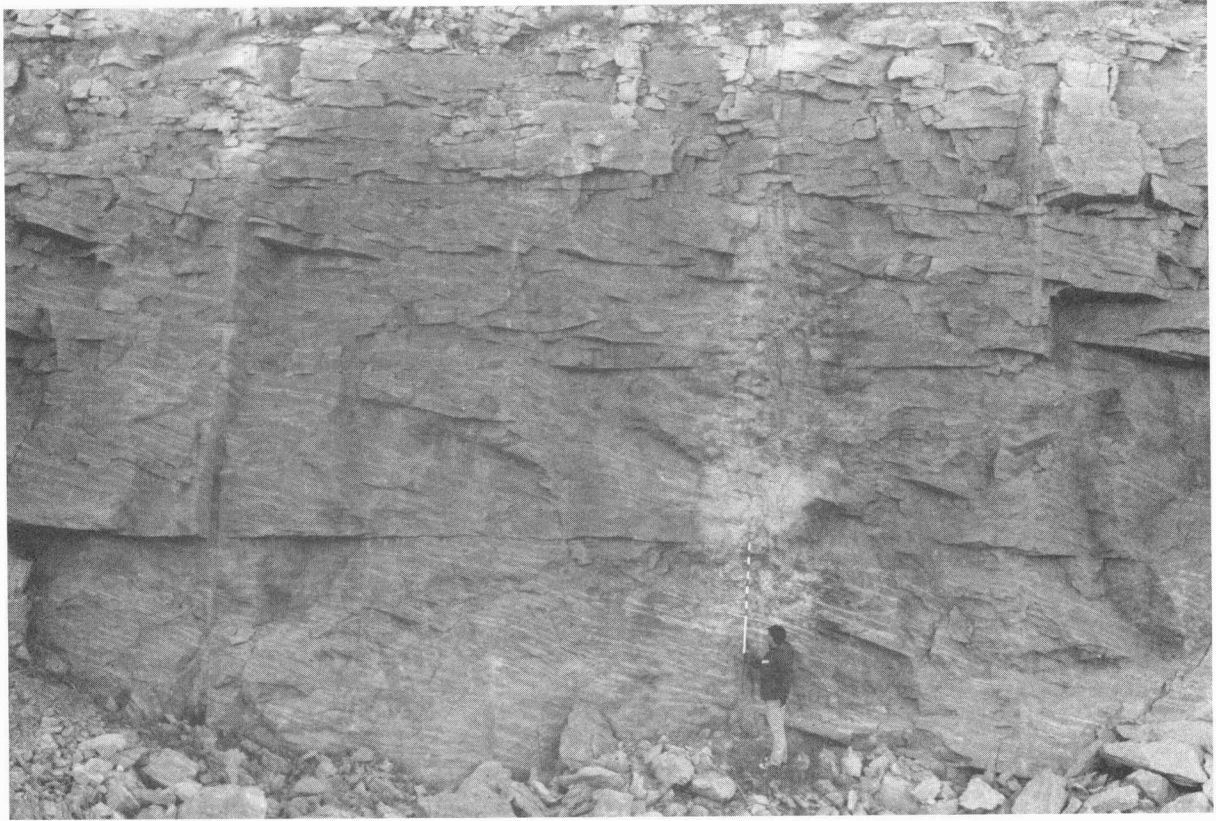
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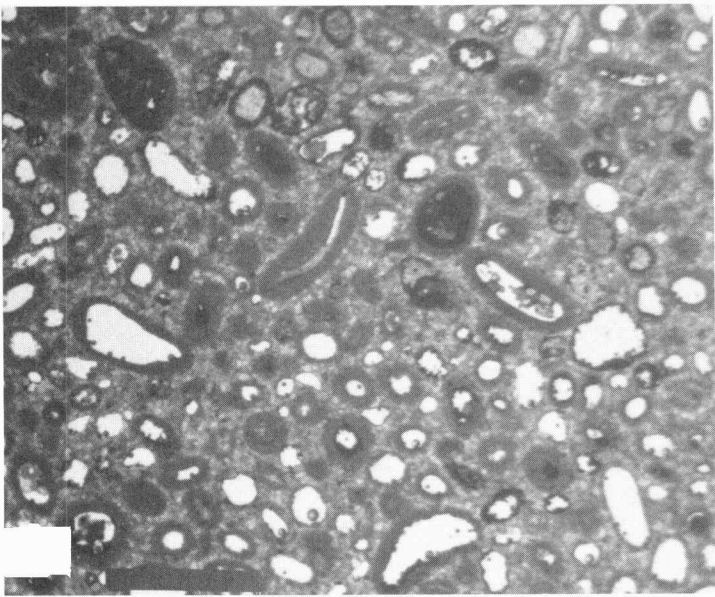
C



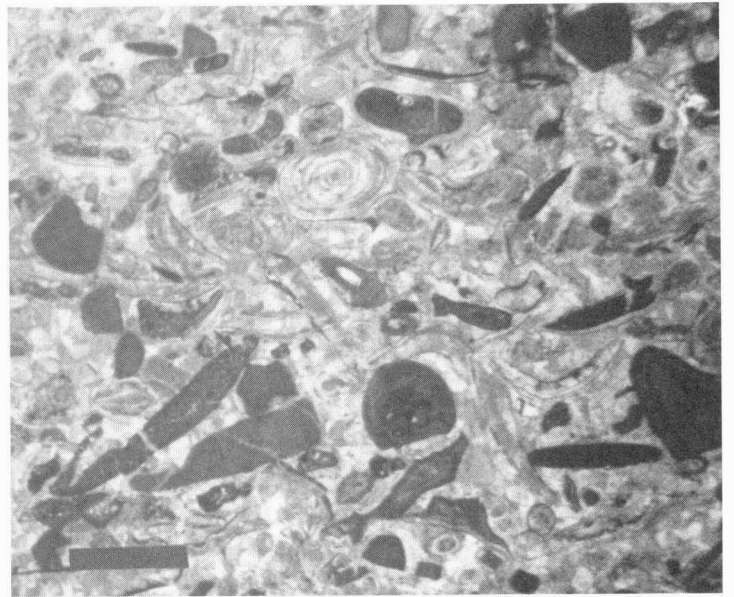
D



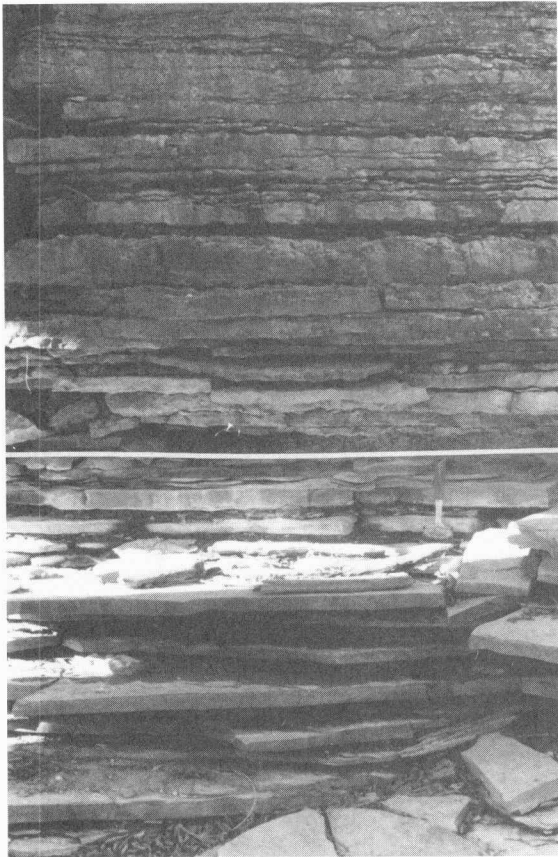
A



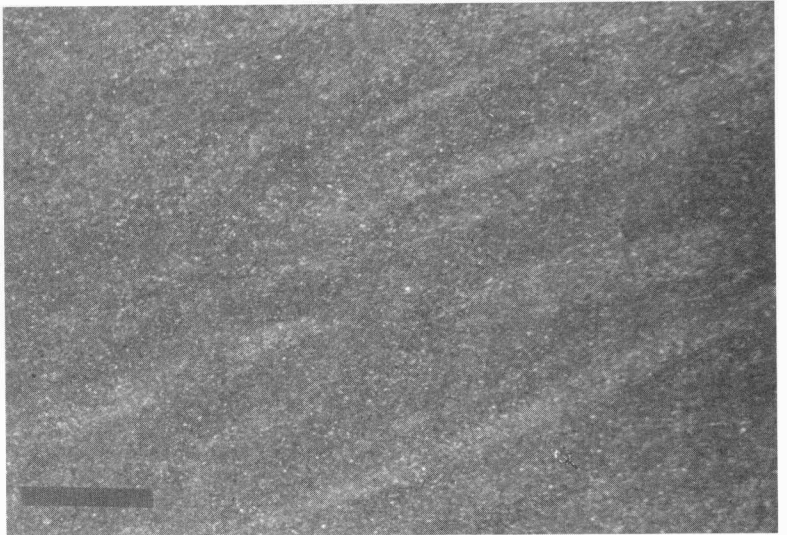
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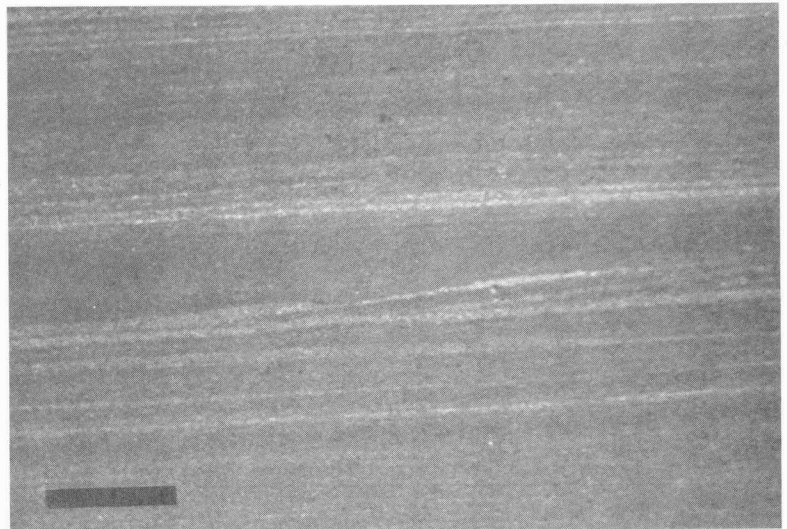
C



A



B



C