ALGAL REEFS OF THE STANTON FORMATION IN SOUTHEAST KANSAS [FIELD TRIP GUIDEBOOK]

by

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Purpose of Field Trip

The purpose of this one-day trip is to study algal reefs and associated sediments of the Stanton Formation (Pennsylvanian) in Southeastern Kansas.

Stratigraphy

The Stanton Limestone is the uppermost formation of the Lansing Group, which in turn is the uppermost group of the Missourian Stage, Upper Pennsylvanian System.

The Stanton is the top of the undifferentiated "Lansing-Kansas City Lime", an important oil-producing horizon and marker bed in the subsurface of central and western Kansas.

At the surface, the Stanton Formation is divided into five named members (Figure 1), which are extremely persistent in both thickness and lithology for hundreds of miles along the outcrop trend of the formation through Iowa, Missouri, and Eastern Kansas. In the locality of this field trip, however, each of the three limestone members of the Stanton swells abruptly to about ten times its normal thickness to form a series of linear carbonate mounds. These carbonate structures are believed by me to be shoreline-trending algal reefs which grew at the margins of a Late Pennsylvanian epeiric sea.

Overall Geologic Structure and Trend of the Reef Structures

Thickened carbonate lense are present in each of the three limestone members of the Stanton Formation along a rather narrow trend extending from northern Wilson County southwestward to central Montgomery County, a distance of about forty miles. The individual reef bodies are each about one to two miles wide (as measured across the trend) but overlap slightly so the average total width of the reef facies in the Stanton is about five miles.

The limestones thin abruptly and pinch out locally in a west and northwesterly direction along the seaward face of the structures. They also thin rapidly into lagoonal sediments in a shoreward direction. Draping of thick overlying shales at the seaward face of the firmly indurated reefs and differential compaction of thickened interbedded shale members of the Stanton in the lagoonal area causes the limestone bodies to stand as sinuous linear anticlines with shale-filled synclines on both flanks.

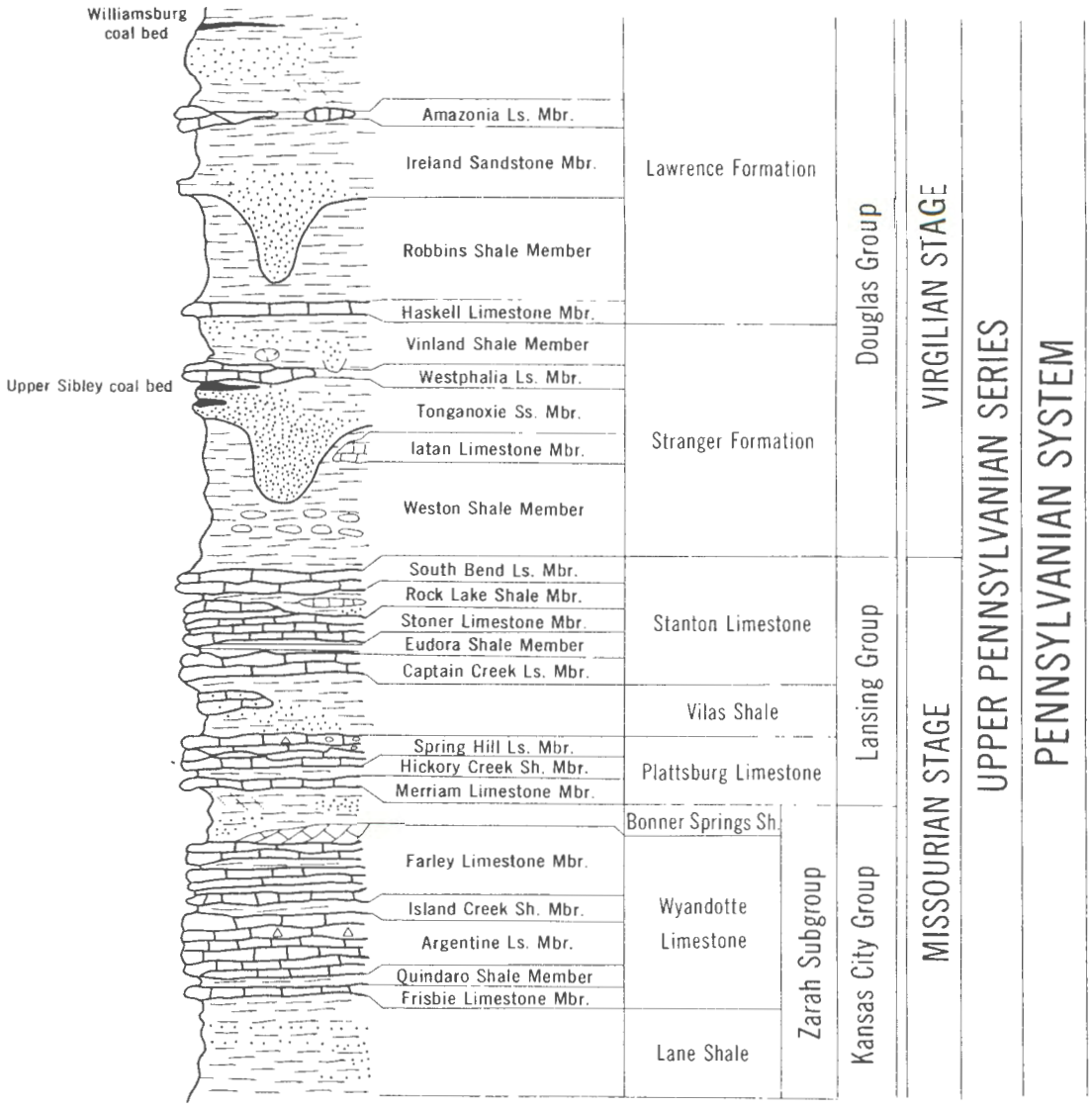

Williamsburg coal bed
Amazonia Ls. Mbr.
Ireland Sandstone Mbr.
Robbins Shale Member
Haskell Limestone Mbr.
Lawrence Formation
Vinland Shale Member
Westphalia Ls. Mbr.
Upper Sibley coal bed
Tonganoxie Ss. Mbr.
Iatan Limestone Mbr.
Weston Shale Member
Stranger Formation
South Bend Ls. Mbr.
Rock Lake Shale Mbr.
Stoner Limestone Mbr.
Eudora Shale Member
Captain Creek Ls. Mbr.
Stanton Limestone
Vilas Shale
Spring Hill Ls. Mbr.
Hickory Creek Sh. Mbr.
Merriam Limestone Mbr.
Plattsburg Limestone
Bonner Springs Sh.
Farley Limestone Mbr.
Island Creek Sh. Mbr.
Argentine Ls. Mbr.
Quindaro Shale Member
Frisbie Limestone Mbr.
Wyandotte Limestone
Lane Shale
Douglas Group
Lansing Group
Zarah Subgroup
Kansas City Group
VIRGILIAN STAGE
MISSOURIAN STAGE
UPPER PENNSYLVANIAN SERIES
PENNSYLVANIAN SYSTEM

Figure 1

The general trend of the thickened limestone bodies through the field-trip area is north 20° east-south 20° west. This corresponds closely to the strike of the outcrop which may have been influenced by the erosion-resistant limestones. Most of the less resistant lagoonal and nearshore sediments have been eroded along the back of the structures in Wilson and northern Montgomery counties, but occasional outliers of thick shale (locally called "mounds") mark the trend of the backreef peripheral syncline.

Immediately north of Elk City Reservoir, in northwest Montgomery County, the reefs swing sharply to the west across the trend of the Stanton outcrop, and the lagoonal and nearshore sediments are preserved in the region south of this area to the Oklahoma line. The cross-section (Figure 2) shows the north-south facies relationships of the Stanton in this region.

Carbonate mounds are present in each of the limestone members of the Stanton in the vicinity of Elk City, but each thins abruptly to the southward into dense, sponge-bearing limestones of the lagoonal facies. Further southward, the limestone members change to fossiliferous calcarenites and oolites of the nearshore environment. Near the Oklahoma line, these strata change to lime-cemented orthoquartzites and are eventually lost in the sandstone-shale facies of the Barnsdall and Wann Formations of Oklahoma. Local unconformities which are marked by conglomerates and erosion of previously deposited sediments, are noted at the bases of nearshore equivalents of each of the limestone members near the state line.

The interbedded shale members are thin or absent in the carbonate mound area but each thickens abruptly in the lagoonal area. Local lenses of sandstone (which may be longshore bar deposits), and southward thickening tongues of sandstone of probable deltaic origin are present in the shale members near the Oklahoma-Kansas state line. Much of the previously deposited Stanton section was eroded prior to deposition of deltaic sediments of the Rock Lake sequence in the area immediately north of Tyro and Caney. These features are cited as evidence of a low land mass near the state line during Stanton times.

Interpretation of Physical Stratigraphy

The results of detailed stratigraphic studies of the Stanton Formation in Wilson and Montgomery counties were the subject of an unpublished thesis by this writer (Wilson, 1957a) in which the thickened limestone bodies were interpreted as barrier reef and reef-associated deposits formed under organic (probably algal) influence. Identification of these structures as barrier reefs was based on the physical characteristics of the thickened limestones, the linear disposition of the limestone lenses, and the presence of lagoonal

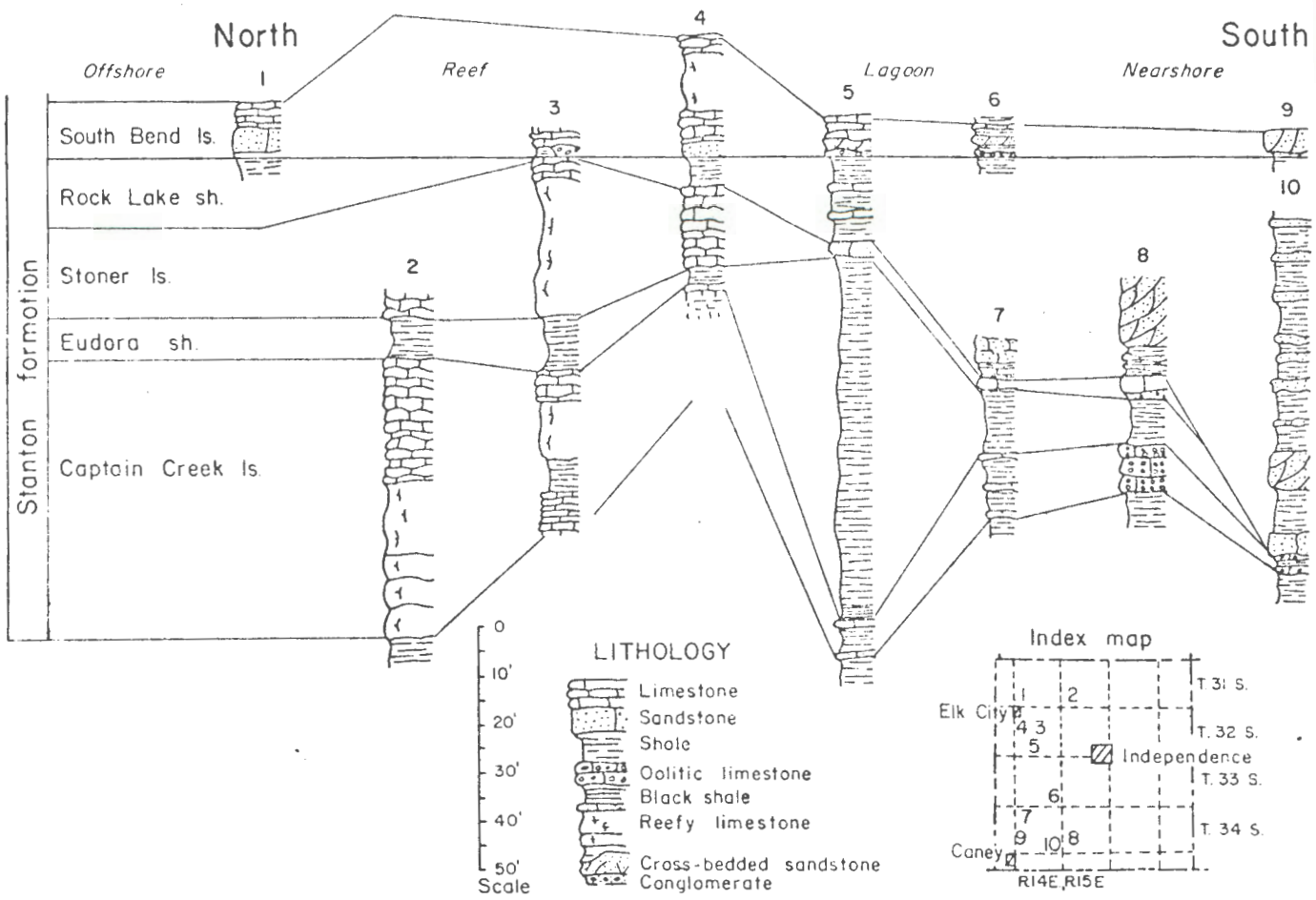


Fig. Sections showing facies in the Stanton formation in southern Kansas.

Figure 2

sediments between them and the shoreline. Deposition of black shale, calcarenite, and oolite in the lagoon and nearshore environments supported the theory that the reefs were indeed physical barriers to free circulation of normally saline marine waters.

The pinching-out of forereef sediments along a line of steep dips at the seaward face of the structures and observation of large blocks of limestone detached from the reefs and enclosed in shale at lower elevations than the general level of the base of the reefs suggested that the structures formed at the edge of a submerged shelf near the margins of a shallow Pennsylvanian sea.

The Stanton shoreline, as indicated by the trend of linear reefs in the field trip area, matches closely the inferred shoreline of a Late Pennsylvanian epeiric sea as determined more recently by others (Figure 3).

A Discussion of the Origin of the Stanton Reefs

Algal stromatolites comprise the first form of carbonate deposition at many exposures along the rear of the line of reefs in Wilson County.

Stromatolites are laminated calcareous structures of various sizes and shapes which are formed by the trapping of wave-suspended limy silt or other detritus in the dense gelatinous or filamentous mat that comprises the growth form of many types of blue-green algae. Intricate patterns of superposed laminae are often discernable on weathered or etched surfaces of these structures, but microscopic examination seldom reveals evidence of the algal filaments which once were present. The external shape of stromatolites may vary from simple encrustations to massive, cauliflower-shaped heads. In the past, genera and species names were assigned to these various shapes, but studies of Recent stromatolites indicate that typical shape is determined by environmental conditions rather than the genera or species of algae involved.

Although the use of stromatolites as indicators of ancient environment is still debated by experts, studies of Recent marine stromatolites suggest that they are best developed in the intertidal zone where they are intermittantly exposed at low tide. The heights of cauliflower- or dome-shaped stromatolites are thought to record the tidal range at the point in the neritic zone where the structures were located.

An important thing to remember about stromatolites is that the individual layers of limy sediment are rapidly indurated. Investigations of Recent stromatolites showed

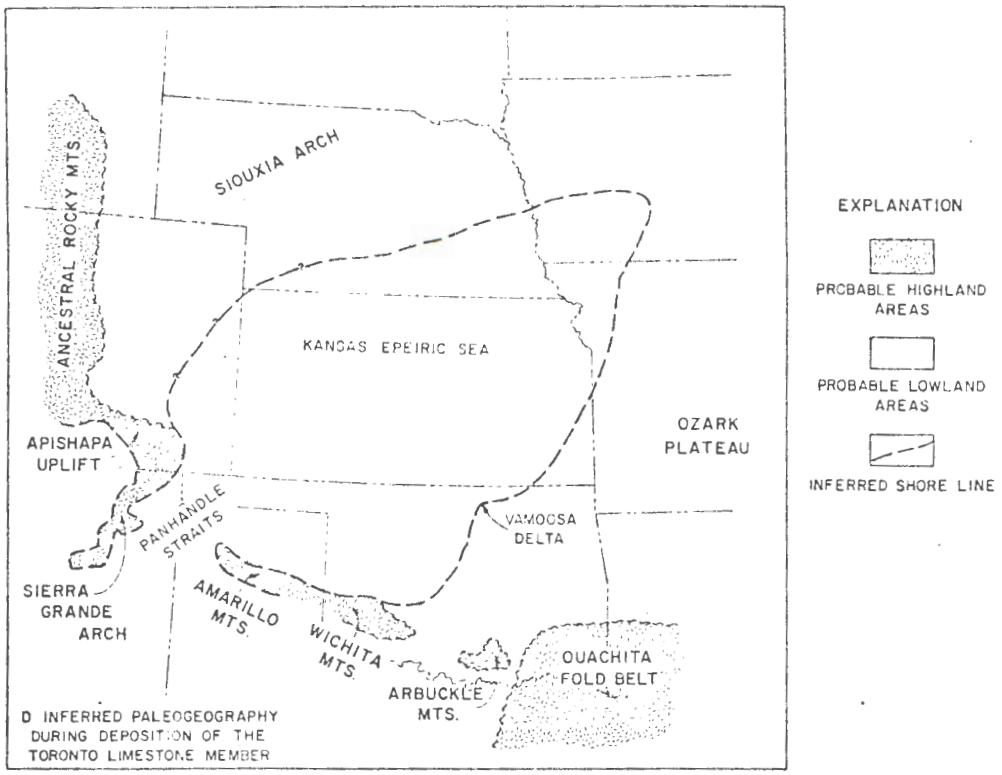


FIGURE 11.—Inferred facies patterns after transgression of Toronto sea *(A-C)* (Fig. 13), and general paleogeographic setting during phase of inundation *(D)*.

Kansas Geol. Survey Bull. 197, 1969

Troell—Depositional Facies of Toronto Limestone Member, Subsurface Marker Unit in Kansas

Figure 3

that sediment immediately below the outer sheath of live algae was firmly indurated within a few days after deposition.

Well-developed stromatolites occur at the bases of the Captain Creek Limestone and South Bend Limestone Members at a number of locations in Wilson County. Nearly every type of stromatolite has been noted, ranging from simple saucer-like caps to large and complex toadstool or cauliflower-shaped heads several meters in diameter. These structures are believed by me to be important keys to understanding the origins of the Stanton reefs.

It is readily apparent at most localities that the stromatolites formed initially as limy caps on slightly higher areas of the shale (mud) bottom. In many instances these limy caps were smothered by subsequent inundations of mud and are now preserved within the shale at that stage of development. Where the encrusting blue-green algae were not smothered by mud, the subsequent development of the structures indicates that they grew in fairly shallow water, probably in the intertidal zone which was subject to tidal scour. The limy caps protected the high areas of the mud bottom from current scour which was thus concentrated in the channels or deeper areas of the bottom between the algal caps (Figure 4). In some instances, tidal currents eroded to depths of five or six feet and stromatolite-sheathed pinnacles of shale with almost vertical sides were preserved. In other places, the currents undercut the limy caps to form toadstool or club shaped structures. Many of the latter structures are enclosed in current-bedded oolite and fossiliferous calcarenite, further evidence that stromatolites of high relief developed in a high energy environment, probably in the intertidal zone.

Field evidence suggests that subsequent development of the reef structures was influenced by a relative rise in sea level (either due to sinking of the bottom or eustatic rise in water level). As the stromatolites became entirely submerged but still remained above wave base, they were encrusted by firmly attached layers of red alga (Archeolithophyllum lamellosum) which seemingly preferred and probably required a firm, limy substrate. Because these stromatolite- and red algae-encrusted higher areas of the sea floor received a greater increment of sunlight (required for algal growth) and were swept clean of detrital debris by wave action, they became accelerated centers of growth for all types of attached marine organisms, especially calcareous algae. Algal growth was discouraged in the former surge channels and depressed areas of the sea floor by debris which was swept into them from the higher areas. Accelerated organic growth and deposition over stromatolite-protected high areas of the bottom resulted in the local lenslike thickening of sediments or "hummicky bedding" which is typical of such deposits.

viewed parallel to shoreline, tidal currents toward and away from observer.

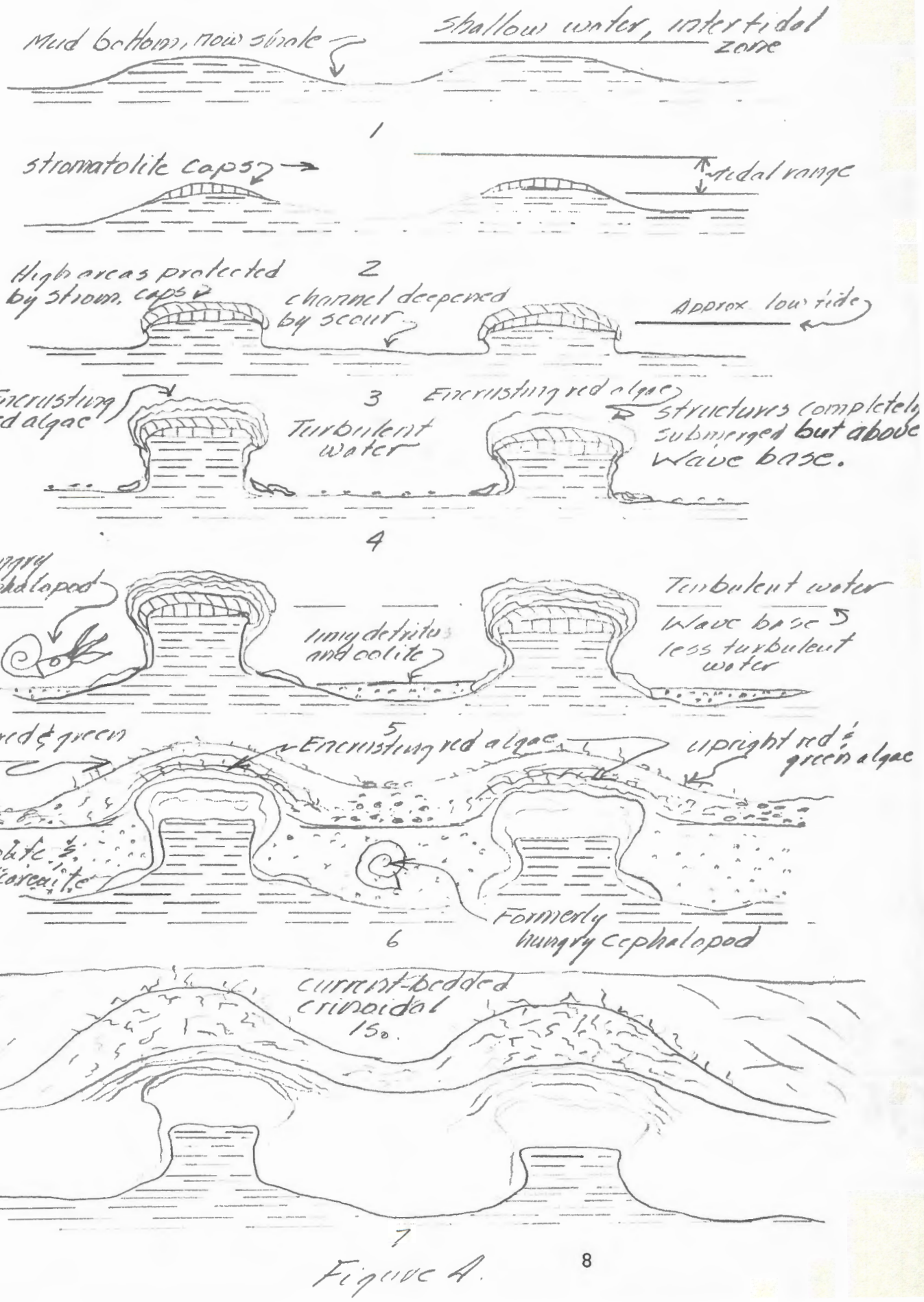


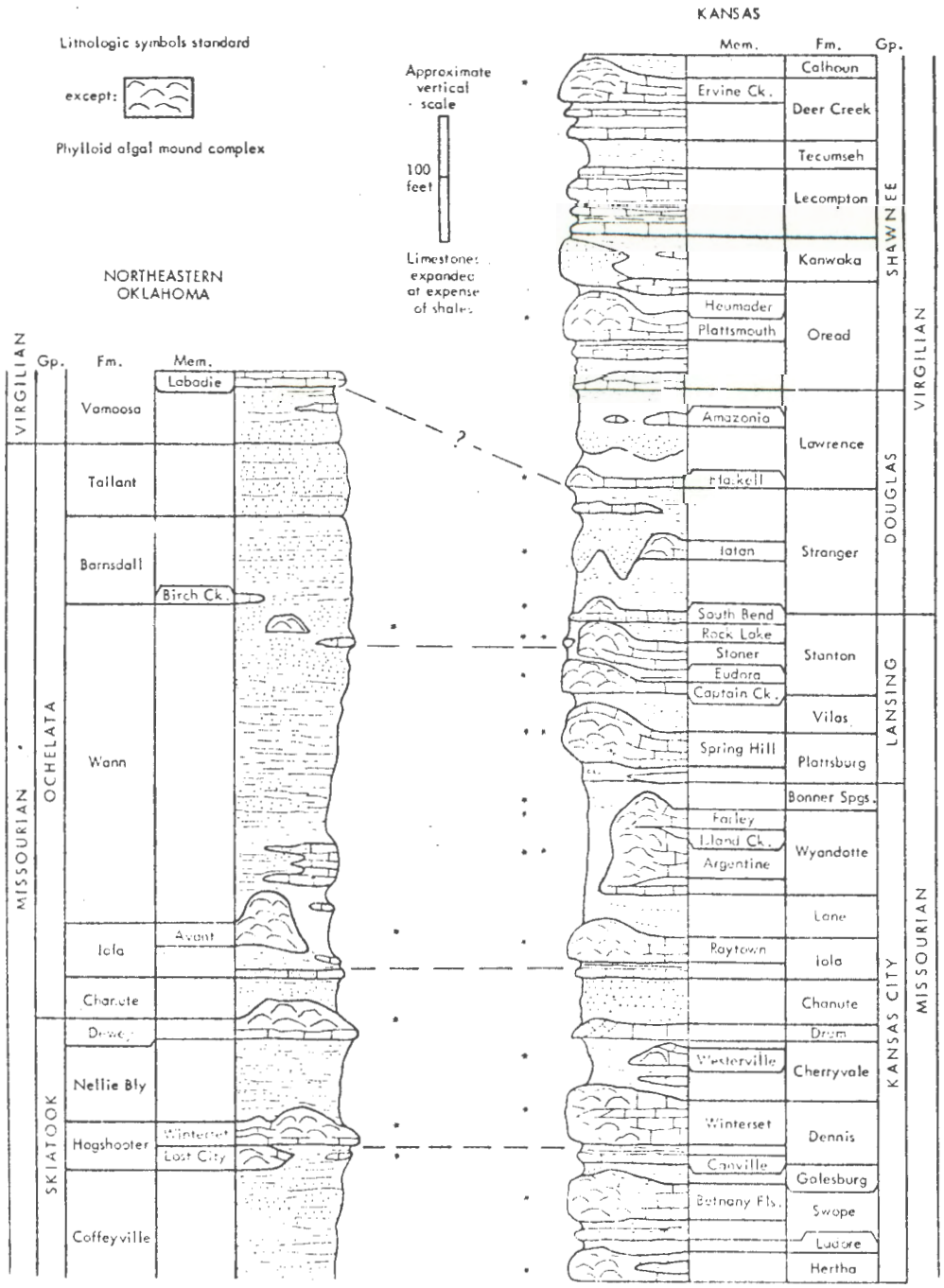
Figure 4.

After encrusting organisms built the wave-fronting portion of the reef upward to the surface of the sea, upright and less-firmly attached forms of leafy red and green algae (Archeolithophyllum missouriense, Anchicodium, etc.) thrived in the sheltered water at the back of the reef. The flat upper surface of the reef (behind the wave-fronting rampart), was exposed during low tide and probably was the site of flat-lying stromatolitic deposition. These laminated deposits grew upward from limy fragments of leafy algae and other debris. Limy mud which was trapped and bound into the filamentous layers of the algal mat are now represented by micrite which is attached to upper surfaces of phylloid algal crusts. These flay-lying deposits were sometimes disturbed by heavy surf to produce the voids which are now partially filled by sparry calcite. Much of the micrite which is considered by others to have been soft limy mud, is thought by me to be of stromatolitic origin and to have been rather firmly indurated at the time of burial.

It seems probable that most of the deposits which we now observe in the thickened limestone mounds are reef platform and backreef sediments.

Until Wray (1964) identified the predominant calcareous alga in the Stanton mounds as Archeolithophyllum, the frame-building potential of the known organisms was subject to question. Because of this, Harbaugh (1959, 1960, 1962, 1964, 1965) believed that the structures were not firmly indurated reefs but were initally soft banks of skeletal debris and limy mud deposited (somehow) by currents on high areas of the sea floor and stabilized there by a loose mat of algal fronds. He postulated that the gross initial porosity of these deposits (perhaps 40% to 60%) which is now represented by large masses of brownish sparry calcite and partially filled vugs, was due to the sheltering effect of the algal fronds which caught limy mud on their upper surfaces and prevented it from filling the open space beneath.

Wilson (1962) pointed out that deposition of loose, limy debris and lime mud on high areas of the open sea floor which were exposed to currents or waves was not adequately explained. If the sediments were analogous to existing bank deposits, all but the coarsest debris would be swept into adjacent depressions in the sea bottom. Any fine material remaining on the banks would logically be expected to be found under the sheltering detritus rather than on it. He also questioned how crusts of crystalline calcite 0.15 to 0.7 mm. thick, whose other dimensions ranges up to several hundred times this figure could maintain a gross open porosity of 40% to 60% under even the slightest load of overlying sediment. These objections are less critical if much of the micrite is considered to be of stromatolitic origin. This would also explain the presence of [redacted] micrites on the upper surfaces of [redacted] algal crusts.



Phylloid Algal-Mound Complexes in Outcropping Upper Pennsylvanian Rocks of Mid-Continent[1]

PHILIP H. HECKEL[2] and J. M. COCKE[2]

The American Association of Petroleum Geologists Bulletin
V. 53, No. 5 (May, 1969), P. 1058-1074, 12 Figs.

Figure 5

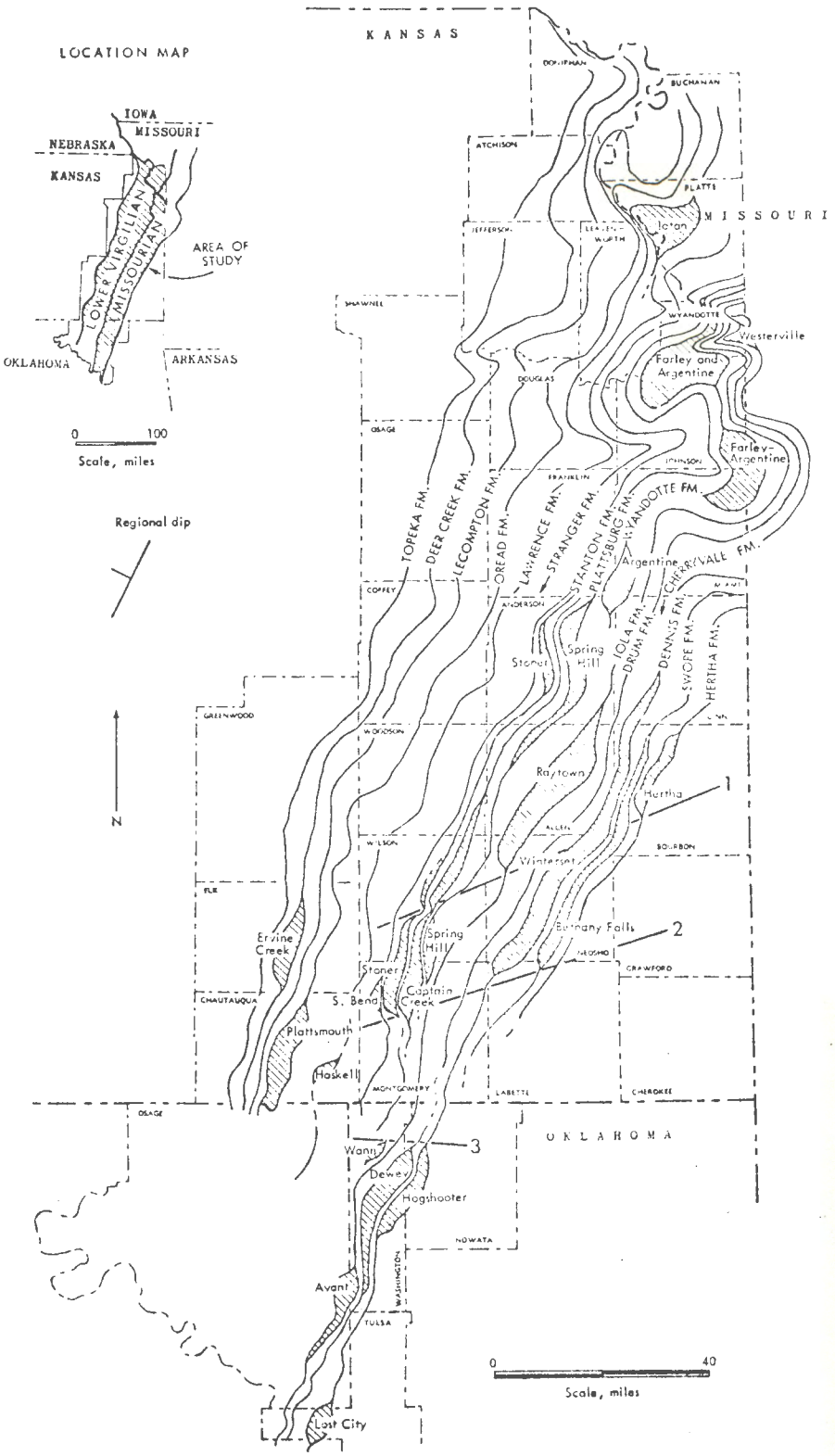

LOCATION MAP
IOWA
MISSOURI
NEBRASKA
KANSAS
OKLAHOMA
ARKANSAS
LOWER VIRGILIAN
MISSOURIAN
AREA OF STUDY
0 100
Scale, miles
Regional dip
N
KANSAS
MISSOURI
OKLAHOMA
TOPEKA FM.
DEER CREEK FM.
LECOMPTON FM.
OREAD FM.
LAWRENCE FM.
STRANGER FM.
STANTON FM.
PLATTSBURG FM.
VANDOTTE FM.
Argentine
CHERRYVALE FM.
DENNIS FM.
SWOPE FM.
HERTHA FM.
IOLA FM.
DRUM FM.
Stoner
Spring Hill
Raytown
Hertha
Winterset
Burnany Falls
Ervine Creek
Captain Creek
S. Bend
Plattsmouth
Haskell
Wann
Dewey
Hogshooter
Avant
Lost City
Westerville
Farley and Argentine
Farley-Argentine
Iatan
1
2
3
0 40
Scale, miles

Figure 6

The presence of Archeolithophyllum in both its firmly encrusting lamellar form and free or attached forms supports the reef theory. Archeolithophyllum is a curiously advanced red alga having characteristics of both the solenaporaceae, a major Paleozoic reef alga, and the corallinaceae, which are probably more important than corals in the formation of Mesozoic and more recent reefs, including those of the present day. Archeolithophyllum lamellosum with its firmly attached, superimposed, multilayered, encrusting, growth form certainly was capable of building a wave-resistant structure. Archeolithophyllum missouriense which is believed by Wray to have been firmly attached in early stages of growth and locally attached or entirely free in later stages of development, is also considered capable of trapping and binding the reef sediment into a rigid, coherent mass. It should be recognized that the framework does not necessarily or even characteristically comprise the bulk of the reef but merely serves to hold it together. Modern reefs have been described as extremely porous sponges of finely crystalline fossiliferous limestone containing numerous voids that may be empty or partially filled with organic or inorganic debris and chemically precipitated calcite.

Economic Significance of the Stanton Structures

Abrupt thickening of the limestone portions of the geologic section and southward change of facies is not restricted to the Stanton Formation alone. At various other places in southeastern Kansas most of the other Upper Pennsylvanian limestone formations display similar southward sequences of facies change (Figs. 5 & 6). Although detailed studies of the depositional environments of the other limestone formations have not been made, it seems probable that the general model for the Stanton Formation can be applied to these formations as well. If this reasoning is correct, it suggests that conditions favorable to the formation of shoreline-trending carbonate reefs and associated structures existed during most of the Late Pennsylvanian, and that similar structures probably formed around the margins of all positive land areas in existance of that time (Fig. 7).

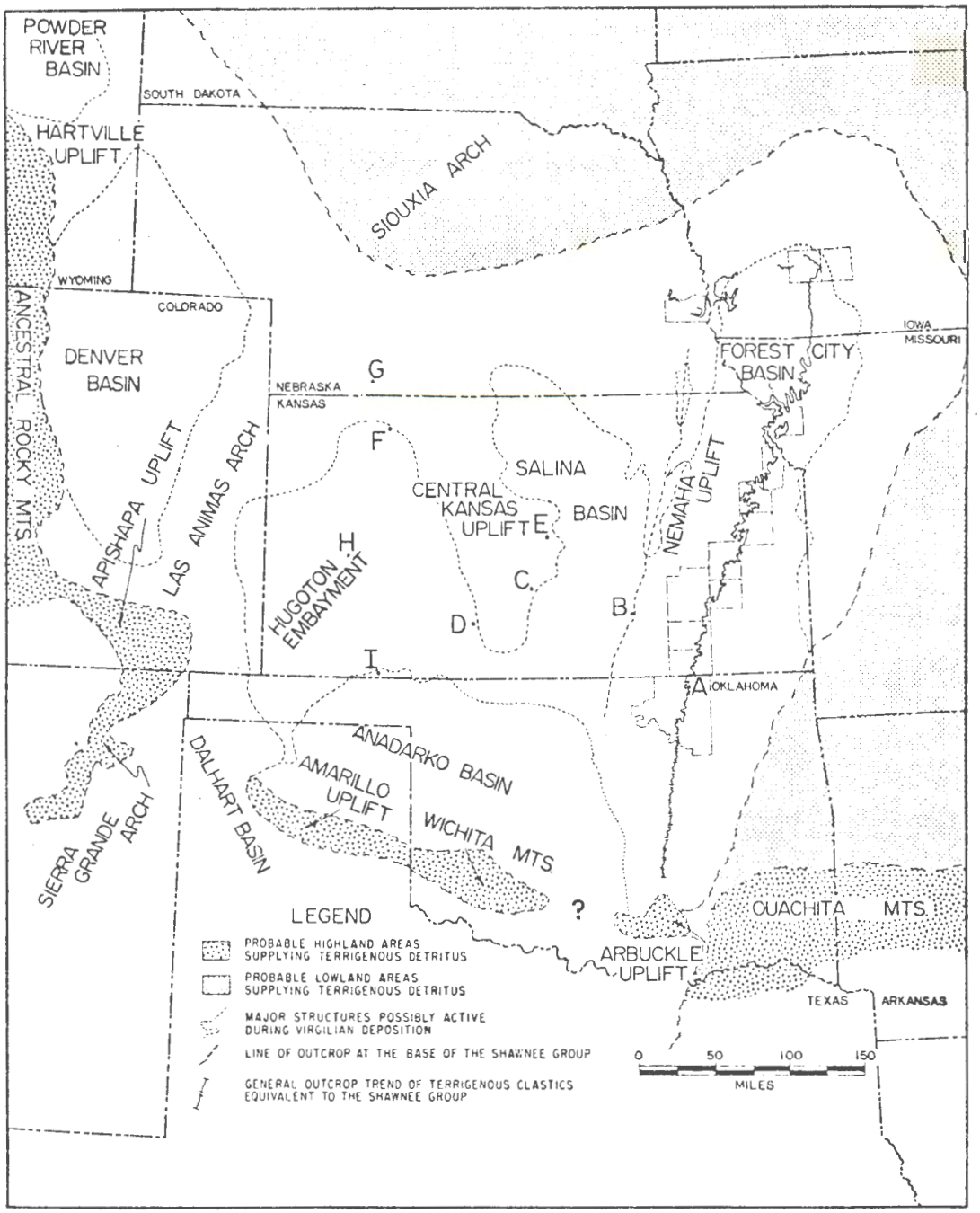


FIGURE 3.—Major paleotectonic features in Kansas and surrounding states during Virgilian time [modified from *Tectonic Map of the United States*, Am. Assoc. Petrol. Geol., 1944, and state geologic maps of Oklahoma (1954), Kansas (1964), Missouri (1939), Nebraska (1950), and Iowa (1937)]. Letters indicate boreholes to which subsurface correlations of Oread Limestone have been made.

Troell, Depositional facies of Toronto Limestone Member, Subsurface marker unit in Kansas: Kansas Geol. Survey Bull. 197, 1969

Figure 7

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NOTES