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CHESTERIAN AND MORROWAN ROCKS IN THE McALESTER BASIN OF OKLAHOMA

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RICHARD B. LAUDON

ABSTRACT

Outcrops were examined and data from 72 bore holes were evaluated. The Fayetteville shale thickens southwestward and grades into the Caney shale. The Pitkin limestone grades into the upper part of the Caney shale and underlies the Goddard shale. The Goddard shale occurs in subsurface in the western part of the basin, but does not reach outcrop in the Ozark area. In the basin, sedimentation was continuous from the Mississippian into the Pennsylvanian.

INTRODUCTION

The McAlester basin of Oklahoma is bounded on the northwest by a hinge line of basin flexure. North and west of this line marine shales, limestones, and sandstones accumulated in a shelf environment from Chesterian through Desmoinesian time. This shelf environment was highly favorable for the accumulation of petroleum. South of the hinge, within the McAlester basin, a southward thickening wedge of sediments with a maximum thickness in excess of 15,000 feet was deposited. Well control of the Chesterian and Morrowan rocks in the southern part of the basin is limited, because of the great depth of burial and meager petroleum production within the McAlester basin. At the southern boundary of the McAlester basin the rocks of the basin are in fault contact with a sequence of highly siliceous, geosynclinal sediments of the Ouachita facies. It is the writer's opinion that within the basin sedimentation was uninterrupted during Chesterian, Morrowan, and Atokan time in contrast to several small interruptions in sedimentation in the shelf area. Continuous deposition and the failure of the Chesterian and Morrowan rocks to crop out in the basin have caused several terminology, correlation, and boundary problems between the two areas. The subsurface occurrence of the Pitkin limestone between the Goddard shale and the "Mississippian Caney" shale and the apparently Morrow equivalent basal Atoka south of the basin, support the much disputed suggestion that the age of the Stanley and Jackfork formations of the Ouachita Mountains is Mississippian. Sedimentation patterns and formation thicknesses suggest that the rocks of the McAlester basin and those of the frontal Ouachitas were deposited in the same geosyncline, and that the rocks of the frontal Ouachitas have not been transported a great horizontal distance from their site of deposition.

In this study, starting at the outcrops in the southwest flank of the Ozark uplift, the formations enclosing the Mississippian-Pennsylvanian systemic boundary were traced in the subsurface as far south toward the Ouachitas as well control would permit in the hope that some trends or patterns of variation might be discovered, which would permit extrapola-

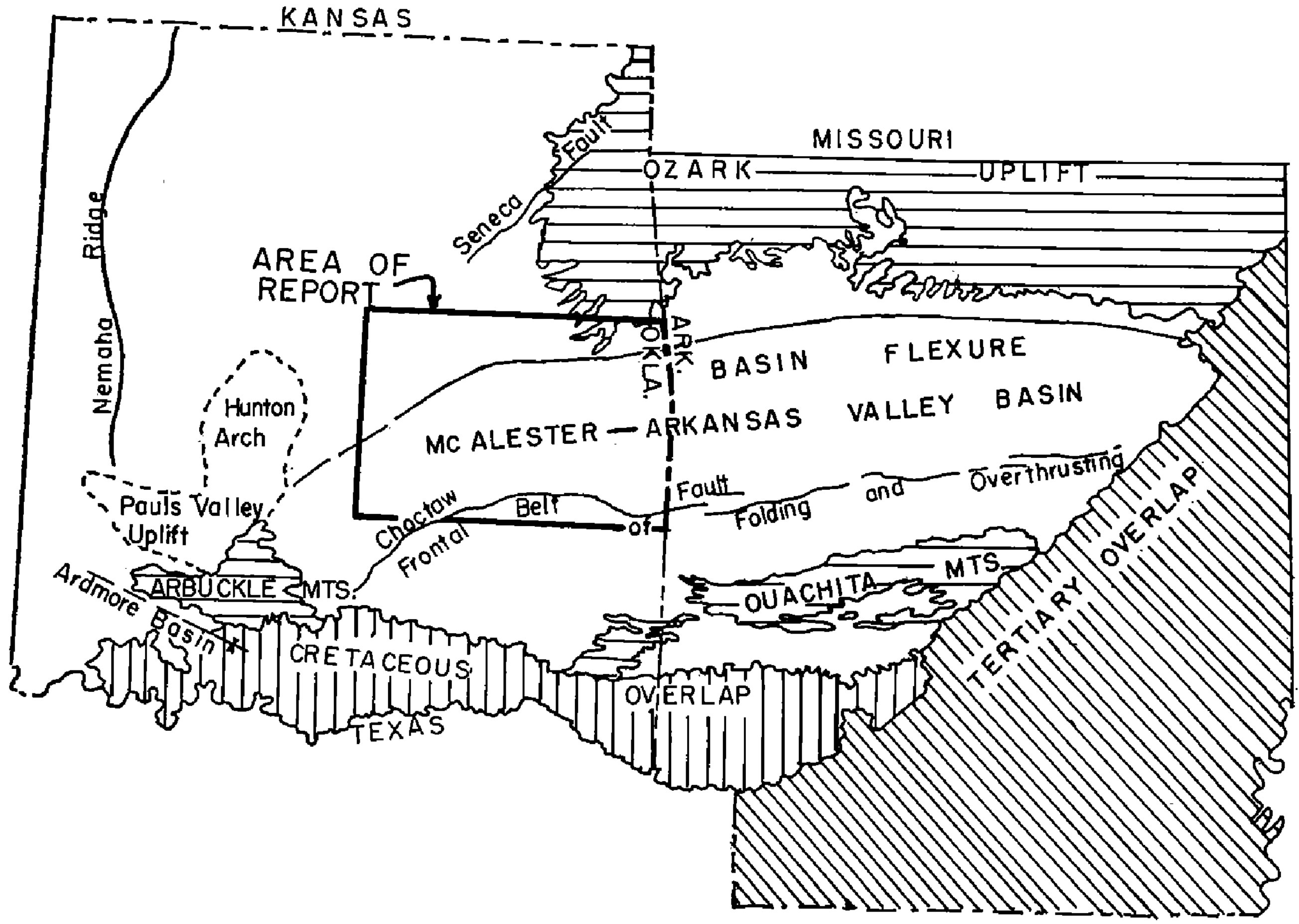

FIGURE 1. *Map showing location of area and major structural features of the region.*

tion into the Ouachitas. Petroleum prospecting in the McAlester basin has been quite unrewarding, with the result that few wells have been drilled to a sufficient depth to encounter rocks of Chesterian and Morrowan age. This is especially true in the southern part of the basin where the Chesterian and Morrowan rocks are deeply buried under rocks of Atokan and Desmoinesian age. In the platform area northwest of the McAlester basin several formations have been highly productive of petroleum and drilling activity has been intense. In the present study all available electrical logs and sample information from the basin proper have been utilized. Within the platform area to the northwest of the basin a density of well control comparable to that available in the basin was employed for the map studies although more records are available in this area. It is anticipated that as more wells penetrate the rocks of the McAlester basin considerably greater accuracy can be applied to studies of this type in areas which are at present rather poorly controlled.

This study is concerned only with the physical rock units. It should consequently be borne in mind that the units under consideration are rock units only and bear no necessary relationship to standard geologic time. Indeed, several formations seem to have variable time value over their areal extent.

TECTONIC SETTING

South of the Choctaw belt of faulting, in the region of the frontal Ouachitas, there is a sequence of rocks in which normal Mid-Continent marine sediments such as limestone, gray shale, and clean quartzose sandstone are subordinate in abundance to some rather unusual siliceous rock types. Sandstones in these formations are generally dirty, poorly sorted subgraywackes. Sedimentation was quite rapid and the Ouachita area was apparently a eugeosyncline in Chesterian, Morrowan and Atokan time. At some horizons the sandstones display load casts, convolute bedding, graded bedding, and other current features which have been described as being typical of turbidity current deposition (Kuenen, 1953). The rocks of the frontal Ouachitas are in fault contact with those of the McAlester basin, which are lithologically more typical of the Mid-Continent region and which are the immediate subject of this investigation.

The McAlester basin (see figure 1) is bounded on the north by a hinge-like line of basin flexure, which had a fairly constant position during all of late Mississippian and early Pennsylvanian time. North and west of the flexure sediments accumulated on a slowly subsiding shelf. Deposition was somewhat erratic in this area as indicated by the irregular thickness patterns of the formations. Across the platform area the Chesterian and Morrowan sedimentary units thin gradually to the north with considerable variation, finally to be truncated by a combination of continuously greater unconformities, decreased deposition, and recent erosion. This area of platform deposition seems to have been especially favorable for the accumulation of petroleum and has been a prolific producing area.

South of the line of basin flexure within the McAlester basin the formations thicken much more rapidly as indicated by the parallelism, uniform spacing, and close spacing of isopach lines (see figures 4, 5, 6 and 7). This "basin" region of deposition subsided with a hinge-like motion

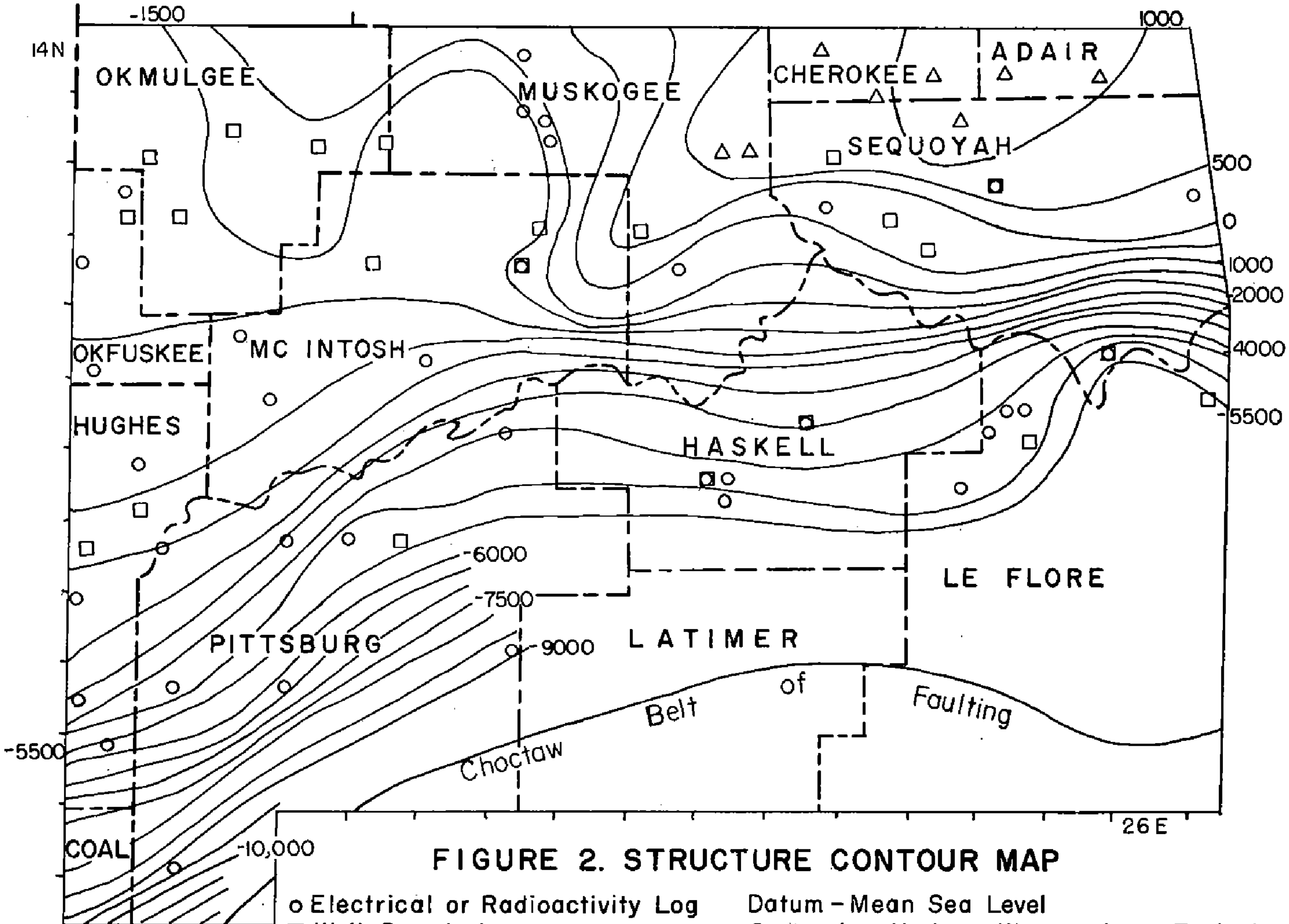

FIGURE 2. STRUCTURE CONTOUR MAP

o Electrical or Radioactivity Log
□ Well Sample Log
△ Outcrop Lithologic Log

Datum – Mean Sea Level
Contouring Horizon – Wapanucka or Equivalent
Contour Interval = 500 feet

and with much greater rapidity than the platform area. This subsidence became much more rapid during Atokan time than it had been during Morrowan time.

On the south the McAlester basin is bounded by the Choctaw belt of faulting and folding. At this fault the rocks of the Ozark and/or Arbuckle facies are in contact with the northward overthrust rocks of the Ouachita facies. The surface rocks of Desmoinesian age immediately north of the fault dip to the north back into the McAlester basin. However, in the wells immediately north of the fault the deeply buried Chesterian and Morrowan rocks of the Ozark facies dip and thicken to the south. Thus the Chesterian and Morrowan rocks of the "basin" are in the form of a wedge, which was deposited on the southward dipping limb of a syncline. If a corresponding northward dipping limb of the McAlester basin exists, it is buried beneath the overthrust rocks of the frontal Ouachitas. The work of C. W. Tomlinson and that of W. D. Pitt (1955) supported by Misch and Oles (1957) strongly indicates that horizontal overthrusting of great magnitude did not occur in placing the rocks of the frontal Ouachitas in their present position. The thicknesses of the "Caney" (Mississippian Caney plus Goddard shale) and the Atoka are only slightly greater in the outcrops of the frontal Ouachitas than they are in bore holes immediately north of the fault. Both the thickness patterns and the lack of dip reversal of the subsurface rocks in the southern part of the McAlester basin suggest that the sediments of the McAlester topographic basin were deposited in the same basin of sedimentation or geosyncline with those of the frontal Ouachitas.

The rocks of the McAlester basin were deposited in a typical miogeosynclinal environment with most of the clastic sediment supplied from the slightly positive continental interior to the north. The rocks of the frontal Ouachitas were deposited farther to the south in what appears to have been the same geosyncline with a tremendous influx of clastic sediments coming from the south. Earlier writers (Miser 1921) visualized a vast rising borderland, Llanoria, which was eroded to supply sediments to the geosyncline. A more modern, and perhaps more accurate, theory envisions island arcs supplying detritus to a eugeosyncline. Recognizable
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pyroclastics, however, are not abundant in the Ouachita region (Honess, 1923). The nature of the source of sediments which lay to the south is not clear.

Some intermixing of sediments from the two sources occurred where the rocks of the frontal Ouachitas were deposited. In the literature, striking differences in the nature of the rocks of the Ouachitas from those of the outcrops in the Arbuckle region and the Ozark uplift have been emphasized (Ulrich, 1927; van der Gracht, 1931). These differences are especially prominent in the pre-Mississippian rocks. In the McAlester basin is found, much as would be expected, a transition, somewhat incomplete, between the Ozark facies and the Ouachita facies. Since this study of the McAlester basin has not shown a complete transition between the facies of the outcrop areas, some explanation for the remaining lithologic change observed on opposite sides of the fault is necessary. Three alternative explanations could account for the lithologic change between the rocks of the Ouachitas and those of the Ozark uplift: (1) The rocks of the Ouachita

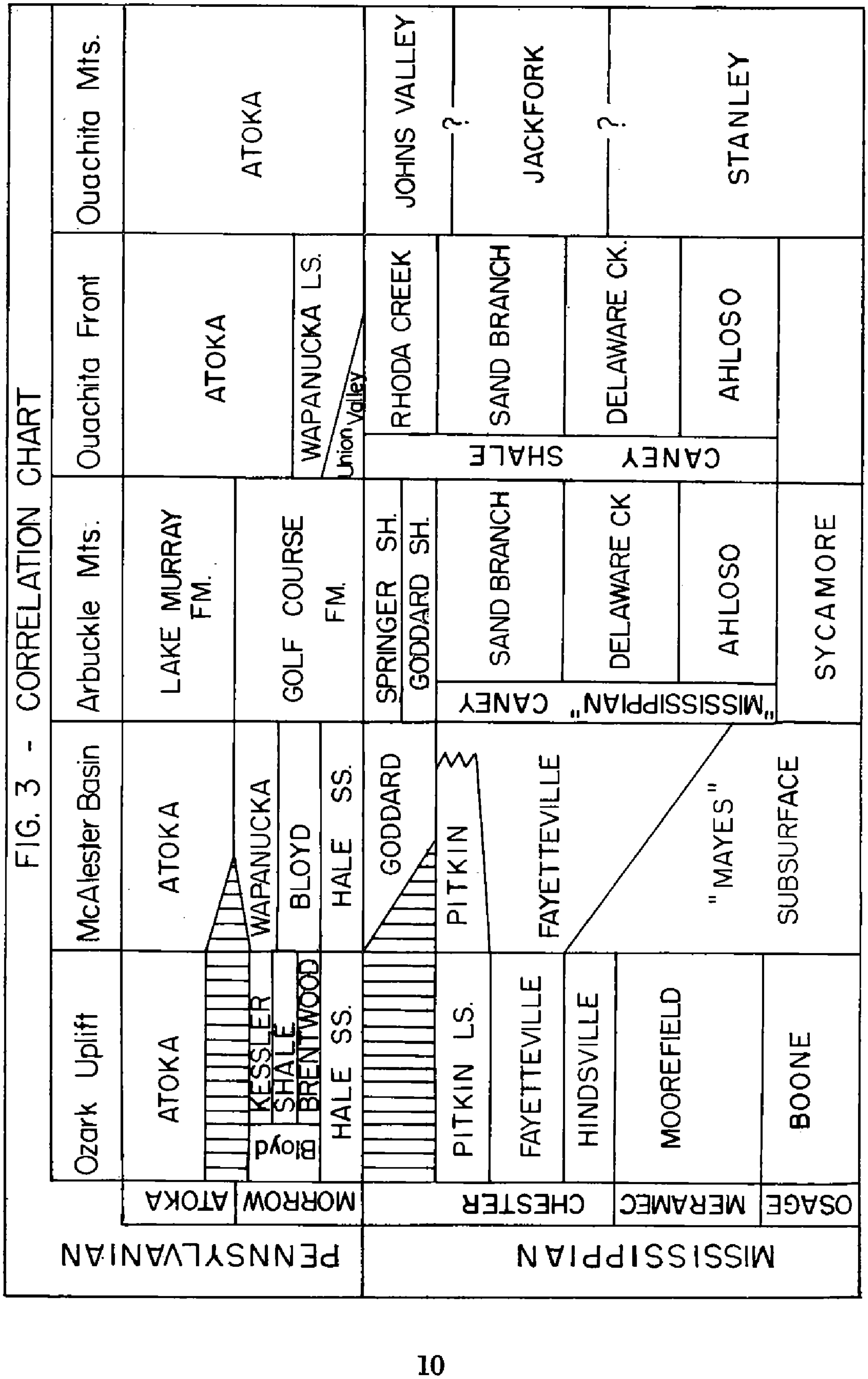

FIG. 3 - CORRELATION CHART

facies have been transported a considerable distance from their depositional site as a thrust sheet (Dake, 1921). The opinion has been expressed that these rocks have been displaced horizontally as much as two hundred miles and that they were originally deposited in a separate basin from those of the McAlester basin (Ulrich, 1927). (2) The facies change between the two rock types was quite sharp at the time of deposition, and the change in sedimentary facies occurred very close to the location of the present trace of the Choctaw belt of faulting. (3) The rocks of the McAlester basin and those of the frontal Ouachitas were very much alike at the time of deposition and the apparent facies difference is largely the result of secondary silicification and metamorphism of the rocks in the Ouachitas (Harlton, 1953).

Deep test wells drilled immediately south of the fault trace would probably penetrate the rocks which were deposited in an intermediate position between those rocks found in wells north of the fault and those rocks which are exposed in the outcrops of the frontal Ouachitas. Several such wells would probably clarify the reason for the lithologic change observed in equivalent rocks on opposite sides of the fault. This "facies problem" is not as serious as it was before subsurface information in the McAlester basin became available, since this area displays a partial transition between the two "facies" in the rocks of Chesterian and Morrowan age.

The theory finally accepted to explain the facies change will undoubtedly contain, to some degree, parts of all three of the above. It seems definite that: (1) the Choctaw belt is thrust faulted from the south; (2) there was a definite lithologic difference between the rocks of the two areas at the time of deposition; and (3) secondary silicification and metamorphism have affected the rocks of the frontal Ouachitas. The question then becomes, to what degree was each effect operative?

ACKNOWLEDGMENTS

Dr. L. M. Cline suggested the problem and gave helpful assistance and consultation in all phases of the investigation. Mr. Ralph A. Brant of the Atlantic Refining Company, and the staffs of the Research Department of the Carter Oil Company and of the Geology Department of the University of Tulsa were consulted and gave assistance in the early stages of this investigation. Many fellow graduate students at the University of Wisconsin gave helpful advice and criticism, and the National Science Foundation gave financial assistance for this investigation. The paper was submitted as a Master of Science thesis at the University of Wisconsin.

STRATIGRAPHY

The "Caney" Formation—A troublesome nomenclatorial problem in eastern Oklahoma has been the use of the term "Caney shale." First described (Taff, 1901) from outcrops in Johns Valley in Pushmataha County, the Caney is readily divisible into at least two distinct lithologic units with a total thickness of 1,600 feet. The lower part is composed of black shales, calcareous gray shales, and limestone lentils. This lower part has higher electrical resisitivy than has the upper part. The upper part of the Caney is composed of dark gray-blue and greenish-blue non-calcareous shale with some sandy members. The Caney has been divided by subsurface stratigraphers into the lower or "Mississippian Caney" and the upper or "Pennsylvanian Caney," but the exact age of these members has long been in doubt.

The use of the systemic designation in a formation name is not acceptable in formal stratigraphic nomenclature. Of greater importance is the fact that the "Pennsylvanian Caney" seems to be of Mississippian age. Considerable confusion could result from the continued use of these subsurface names. It has been proposed (Westheimer, 1956) to restrict the name "Caney" to the previously included beds called the "Mississippian Caney." This is perhaps more desirable than discarding completely the widely used name "Caney." Consequently, in this paper the formation name "Caney" will be restricted to the lower part of Taff's original Caney formation. Although the Fayetteville shale seems to be laterally continuous with the Caney (see figures 11, 12 and 13), the lithologies are sufficiently different to justify the use of two separate formational names in different parts of the basin. Elias (1956) suggested a division of the "Mississippian Caney" into three members: Ahloso, Delaware Creek, and Sand Branch in the area adjacent to the Arbuckles. The writer was unable to recognize these members in the subsurface of the McAlester basin.

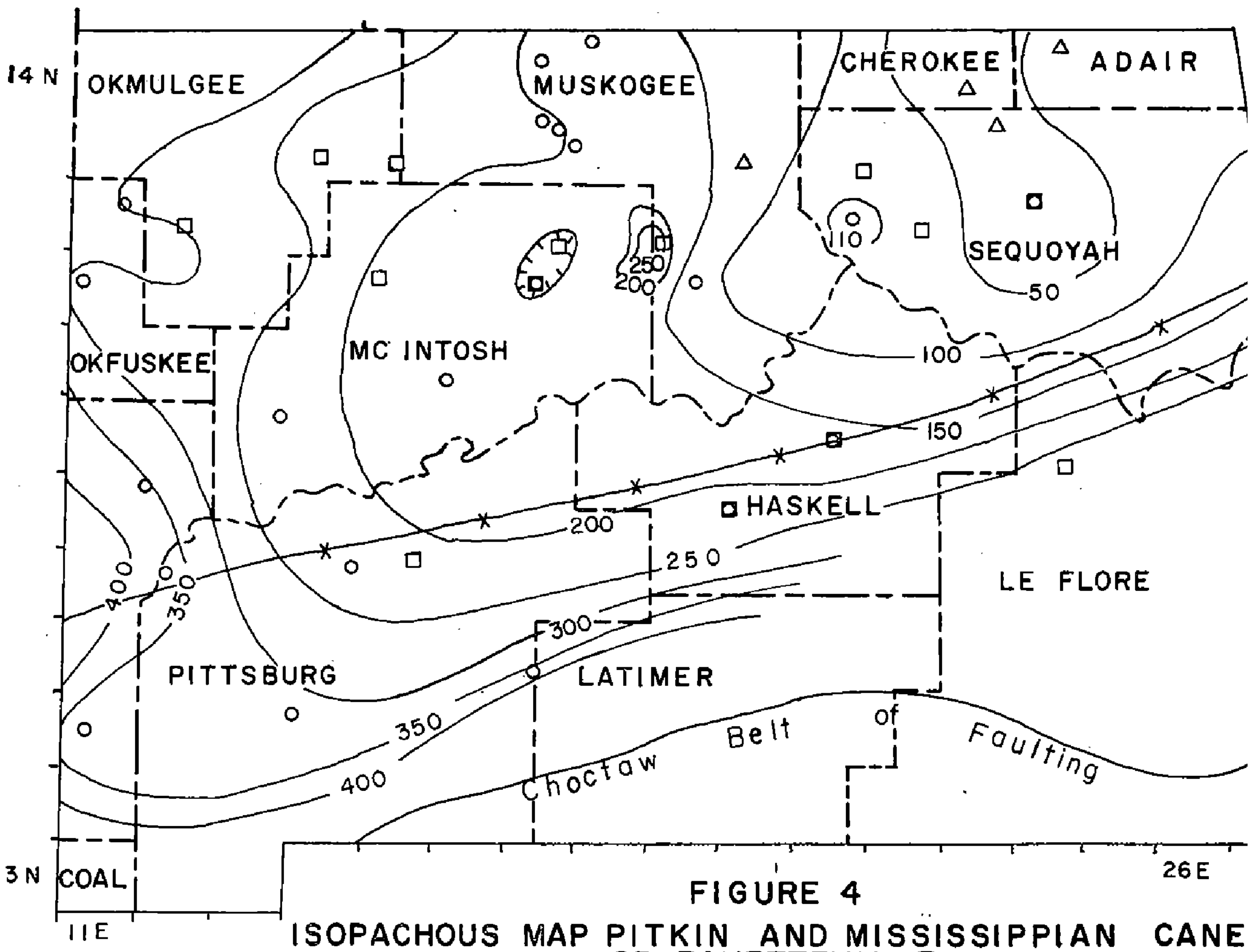

FIGURE 4

ISOPACHOUS MAP PITKIN AND MISSISSIPPIAN CANE OR FAYETTEVILLE

Isopach Interval = 50 feet —x— Approximate Line of Basin Flexu

Fayetteville and "Mississippian Caney" Shales—The Fayetteville shale was first described (Simonds, 1891) from outcrops near Fayetteville, Arkansas, as a black fissile to gray clay shale with local limestone units near the top. In its typical outcrop development on the south-west flank of the Ozark uplift, the Fayetteville is about 90 feet thick. Its thickness increases in the subsurface (see figure 4), and its variability is dependent upon how far laterally the name "Fayetteville" is maintained. To the south and west of the outcrop area the Fayetteville thickens and becomes progressively more calcareous, grading laterally into the Caney shale. The upper part of the Caney (Mississippian) in the subsurface of the McAlester basin is bluish-gray, slightly calcareous, uniformly fine-grained, fissile shale. The lower, very calcareous part of the Caney is the "Ada Mayes" of earlier reports. This black, granular limestone closely resembles the underlying "Mayes" limestone, a relationship which was especially deceptive to early drillers in Seminole district of Oklahoma. The "Ada Mayes" is completely gradational with the overlying, less calcareous part of the Caney. In the subsurface of the McAlester basin of Oklahoma the Caney is underlain conformably by the "Mayes" formation. The type Mayes was described (Snider, 1915) from outcrops in Mayes County, north of the McAlester basin. In its type area the Mayes is younger than the "Mayes" of the subsurface (Selk, 1948). Regardless of whether or not the "Mayes" of the McAlester basin has legitimate standing as a formal stratigraphic term, its top forms a recognizable, persistent lithologic horizon immediately below the Caney. The base of the Caney formation apparently is progressively older to the south and west. In the Arbuckle Mountains the base may be as old as late Osagean.

On the southwest flank of the Ozark uplift the Fayetteville shale is divided into two parts by the Wedington sandstone member. The Wedington seems to have been deposited near shore on the flank of the uplift and is not recognized in the McAlester basin.

Pitkin Limestone—The Pitkin limestone was originally described (Adams and Ulrich, 1904) from outcrops near the village of Pitkin, Arkansas. The formation is characteristically a light to dark blue-gray, fine-textured, massive, oolitic limestone with an argillaceous to granular zone at the top. In its typical outcrop development on the southwest flank of the Ozark uplift the Pitkin is about fifty feet thick. In the McAlester basin the Pitkin thickens to a maximum of about ninety feet and becomes gradually more argillaceous before losing its identity upon grading into the top part of the Caney (see figure 11). In the outcrop area and in most of the platform area to the north of the basin the Pitkin is unconformably overlain by the Hale sandstone. South of the basin flexure the Pitkin is overlain by an increasingly thicker section of Goddard shale (see figure 5). This relationship is extremely important in establishing the geologic age of both the Caney and the Goddard. The Pitkin and Goddard formations are both present in only a relatively narrow zone in the subsurface, bounded on the north by the zero thickness edge of the Goddard and on the south by merging of the Pitkin with the top part of the Caney.

Because of its uniform thickness and lithology, the writer believes that the Pitkin was deposited at essentially the same time over its entire extent.

The Pitkin is the youngest Chesterian formation in the outcrops around the Ozark dome, and it is observed underlying the Goddard (Pennsylvanian Caney) and overlying the Caney (Mississippian Caney) in the subsurface (see figure 10).

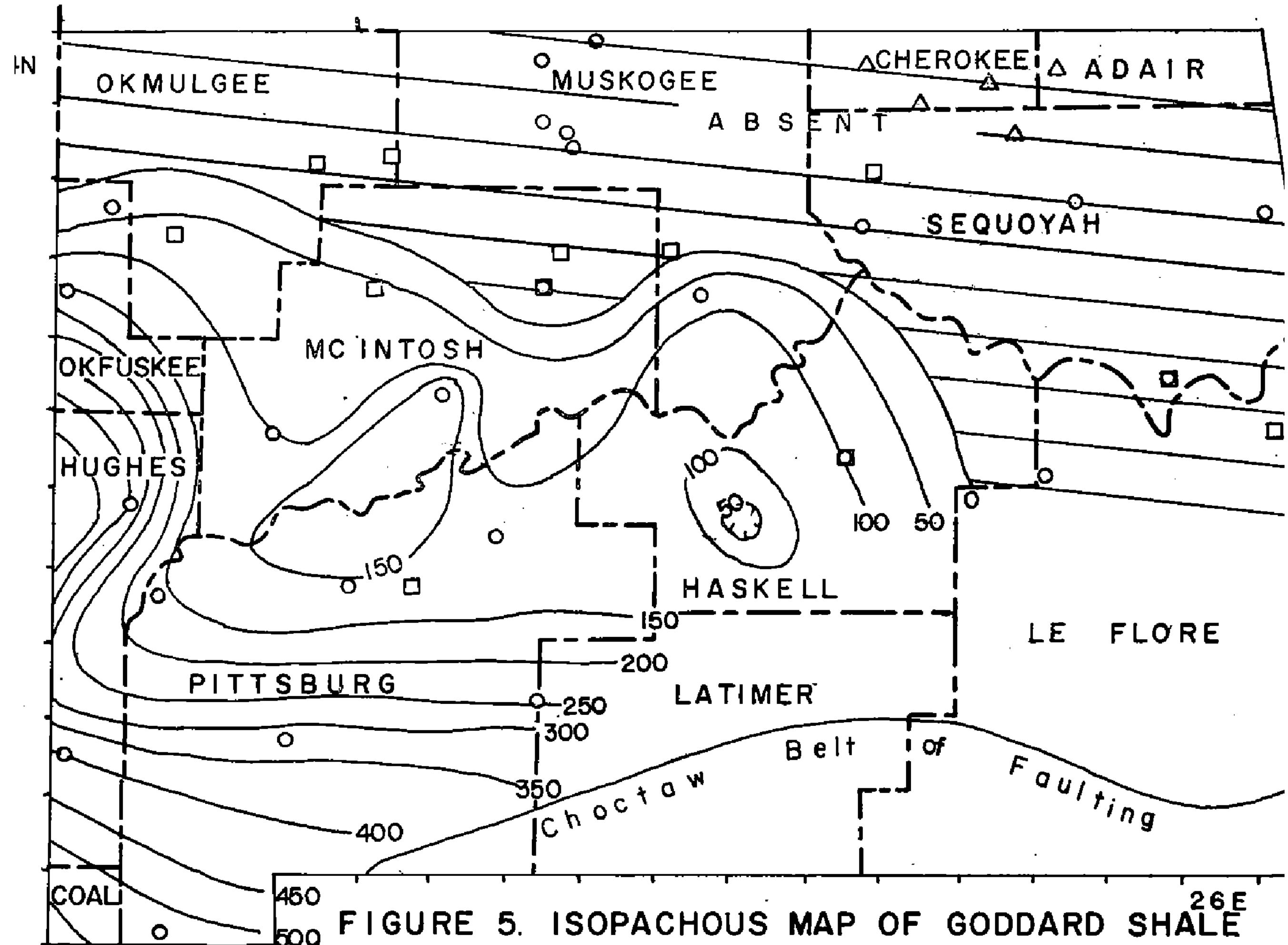

FIGURE 5. ISOPACHOUS MAP OF GODDARD SHALE

Isopach Interval = 50' ○ Electrical or Radioactivity Log
□ Well Sample Log △ Outcrop Lithologic Log

Goddard Shale—The subsurface term "Pennsylvanian Caney" is still widely in use, but as previously mentioned, the writer thinks that it should be replaced, at least for the purposes of formal stratigraphic nomenclature, with a more suitable name. The Goddard shale as described (Westheimer, 1956) from outcrops on the Goddard Ranch in Johnston County, Oklahoma, is composed of dark gray, soft, clayey, non-calcareous shale. The underlying Caney (Mississippian) is a black, tough and brittle, calcareous shale formation. The Goddard has a much lower electrical resistivity than the underlying calcareous Caney. At the type section the Goddard is 2,850 feet thick. On the basis of the cephalopod fauna Elias (1956) assigned the Goddard to the Chester series. The Goddard is similar to the "Pennsylvanian Caney" of the McAlester basin both in lithology and in stratigraphic position. The writer believes the two to be physically continuous, and as such they constitute a single formation. In the McAlester basin this formation thins and finally wedges out entirely. In the remainder of this paper the name "Goddard" will be used to replace "Pennsylvanian Caney."

The Goddard thins to the north and disappears in the subsurface south of the outcrop belt of the Ozark uplift (see figure 5). This thinning was caused by slower sedimentation to the north at the time the formation was deposited. The area around the Ozark dome was quite stable and trapped almost no sediment while the McAlester basin was subsiding with a hinge-like movement and trapping progressively more sediment to the south. In the outcrop area the Pitkin and Hale are in unconformable contact, and it might be inferred that the Goddard was truncated by this erosional unconformity. Such is not the case to any appreciable degree. In figures ten and eleven it can be observed that a few thin horizons near the top of the Goddard have higher resistivities than the rest of the formation. These more highly resistant horizons are found near the top of the formation over the entire area of investigation. This would not be the case if the formation had been uniformly deposited and subsequently tilted and truncated. The predominant cause of convergence of the Goddard must have been a differential rate of sedimentation over the area at the time of deposition.

At the time this study was undertaken (June of 1956) the placement of the Mississippian-Pennsylvanian boundary in the McAlester basin was problematical. The age of the Morrow group of the Ozark uplift was held in dispute for many years. This group of rocks with unconformities at both the top and base in its type area lies between typical Mississippian and typical Pennsylvanian of the upper Mississippi River Valley. It has been accepted by most writers that the Morrow is the earliest major division of the Pennsylvanian system (Mather, 1915; Moore, 1947). The Hale formation overlying the Goddard in the McAlester basin is, by definition, the oldest formation of the Morrow group. In this study it was found that the Pitkin limestone, which is of Mississippian age, underlies the Goddard, where both formations are present. The boundary between the two systems in the McAlester basin, therefore, was known to lie between the base and the top of the Goddard, or at one of these boundaries.

Neither had the time equivalent of the Goddard in the Ouachita Mountains been positively established at the time this study was undertaken. A Caney (Mississippian) fauna occurs in the Johns Valley shale overlying the Jackfork formation. The Johns Valley is famous for the erratic boulders of older formations which it contains. It has been held that the Caney fauna is not indigenous to the Johns Valley formation but is actually in Caney erratics which are contained within the Johns Valley. If this were the case, the Johns Valley would be older than the Caney and the Jackfork would be largely of Pennsylvanian age. On the other hand there is evidence that the Caney fauna, which occurs in limestone concretions, is in place in the Johns Valley formation (Cline, 1956). Thus the lower part of the Johns Valley formation would be of Mississippian age, as would be the underlying Jackfork and Stanley. The convergence pattern of the Morrow group in the McAlester basin and the corresponding Wapanucka formation of the frontal Ouachitas suggests that the basal part of the Atoka formation is at least partially equivalent to the Morrow of the Ozark uplift. Within the frontal Ouachitas the base of the Atoka apparently continues to become older to the south (Cline, 1956). If this trend continues into the central Ouachitas, the Johns Valley must be at least partially equivalent to the Goddard. This correlation would date the underlying Stanley and Jackfork formations as Mississippian in age, which supports Cline's correlation. This is contrary to the present majority opinion of geologists familar with the problem, which places the Stanley and Jackfork in the Pennsylvanian (Pennsylvanian subcommittee of the National Research Council Committee on Stratigraphy, Moore et al., 1944).

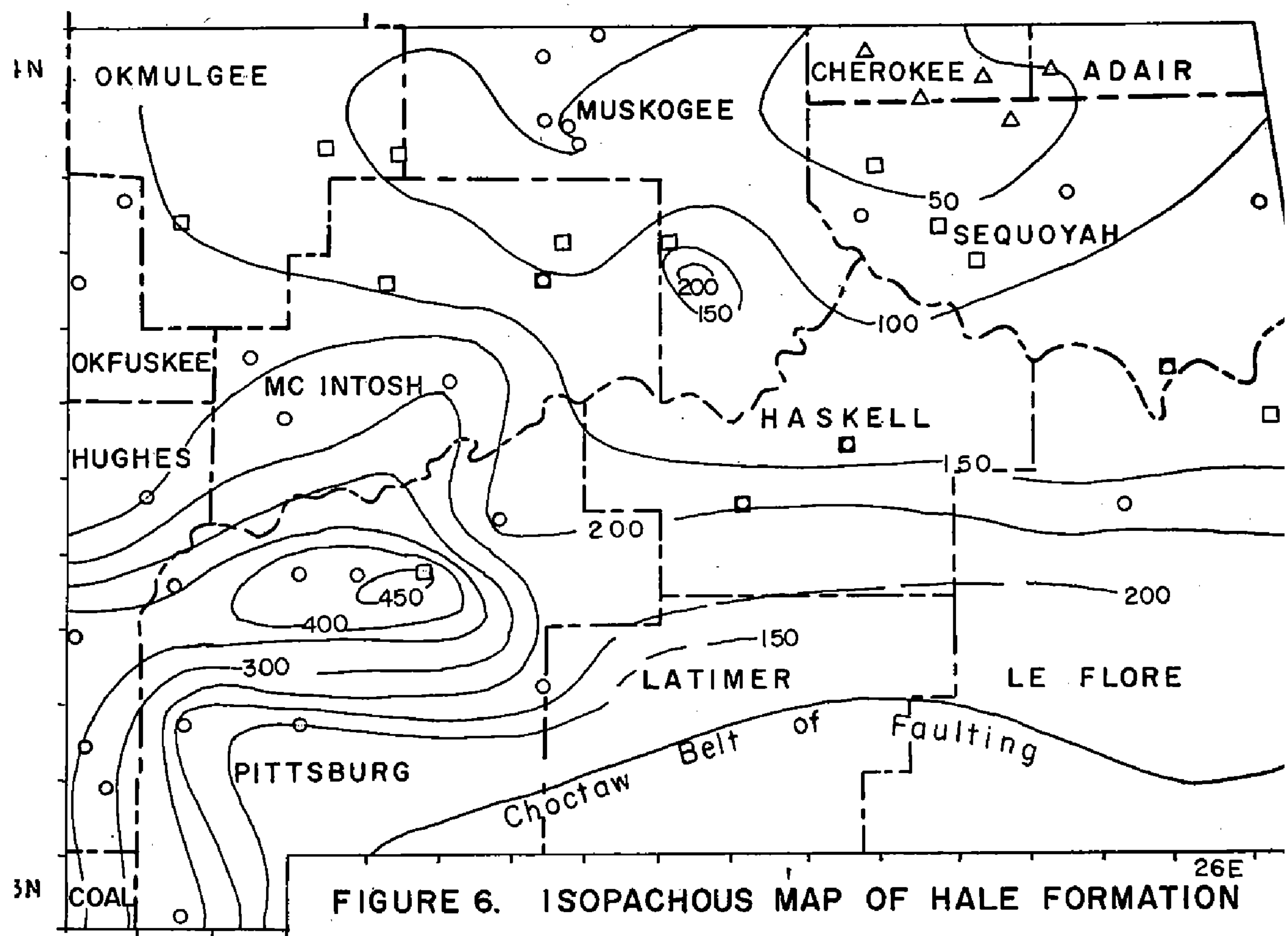

FIGURE 6. ISOPACHOUS MAP OF HALE FORMATION

Isopach Interval = 50 feet
□ Well Sample Log
o Electrical or Radioactivity Log
△ Outcrop Lithologic Log

This position seems to have been influenced by a report of erratic boulders from the Wapanucka formation in the Johns Valley shale (Ulrich, 1927). Obviously Wapanucka erratics could not have been deposited in the Johns Valley formation before Wapanucka time. On this basis the Johns Valley shale would be equivalent to the lower part of the Atoka of the frontal Ouachitas; and the Jackfork and perhaps the Stanley would be of Pennsylvanian age. Subsequent workers, however, have not recognized Wapanucka erratics in the Johns Valley shale.

HALE FORMATION

The Hale formation was originally described (Taff, 1905) from outcrops on Hale Mountain above the village of Morrow, Arkansas (northeast end of cross section, figure 13). In the type area the Hale is a calcareous, cross-bedded sandstone with a few thin shale and limestone beds with a total thickness of about 125 feet. The formation varies laterally in outcrops from a massive sandstone containing little calcareous material to a massive sandy limestone. These changes occur within short distances horizontally and identification of the Hale from one outcrop to the next is difficult. From studies of the outcrops of Washington County, Arkansas, Henbest (1953) suggested a division of the Hale into the lower or Cane Hill member and the upper or Prairie Grove member. Huffman (1958) suggests a tentative correlation of the Cane Hill with the upper part of the Springer of the Ardmore Basin. If this correlation were correct, the Mississippian-Pennsylvanian boundary would fall within the Hale formation, which was defined as basal Morrowan. The silty shale of the Cane Hill member is not recognized in the McAlester basin of Oklahoma. In the outcrops on the flank of the Ozark uplift the Hale overlies the Pitkin with a slight erosional disconformity which dies out in the McAlester basin. Locally the basal Hale is observed to contain reworked pieces of Pitkin limestone (Henbest, 1953; Moore, 1947). The formation thickens in the subsurface to a maximum in the area of this investigation of 450 feet and is called the Cromwell sand by most subsurface operators. This name was taken from the Cromwell field in Seminole County, where the formation is a prolific oil producer.

In the platform area of sedimentation to the northwest of the McAlester basin the Hale contains five recognizable units. A thin sandstone unit at the base is followed above by a dark gray to black, hard, calcareous shale. The overlying third unit is a white, fine-grained, pyritic, slightly calcareous sandstone. The third and fourth units are separated by an unconformity, which seems to be largely responsible for changes in thickness of the formation. This unconformity is of short time duration and dies out basinward. The fifth unit is a non-persistent, gray to brown, arenaceous, medium-crystalline, fossiliferous limestone. The basal part of the fifth unit is transitional with the underlying fourth, sandstone unit. This limestone is called the "Union Valley" by many subsurface stratigraphers. The Union Valley formation was described (Hollingsworth, 1933) from outcrops near the Union Valley Schoolhouse in Pontotoc County as a 250-foot thick member of the Wapanucka formation. Hyatt (1936) observed that the Union Valley typically consists of a sandstone member and an upper limestone member and that the sandstone member is the lateral equivalent of the Cromwell (Hale). It seems clear that the "Union Valley" limestone should not be assigned formational rank in the McAlester basin and adjacent shelf area.

BLOYD FORMATION

The Bloyd formation was described (Purdue, 1907) from outcrops on Bloyd Mountain, nine miles south of Fayetteville, Arkansas. The Bloyd is composed predominantly of dark gray, micaceous shale with interbedded limestone and local sandstone. In the outcrop area the limestones are sufficiently well developed to be assigned lentil names. The lower or Brentwood limestone lentil is composed of variously cross-bedded, lenticular, and unevenly bedded limestones, occasionally sandy and laterally intertonguing and intergrading with dark shale. Although the lower part of the Bloyd is composed predominantly of limestone, the individual limestone

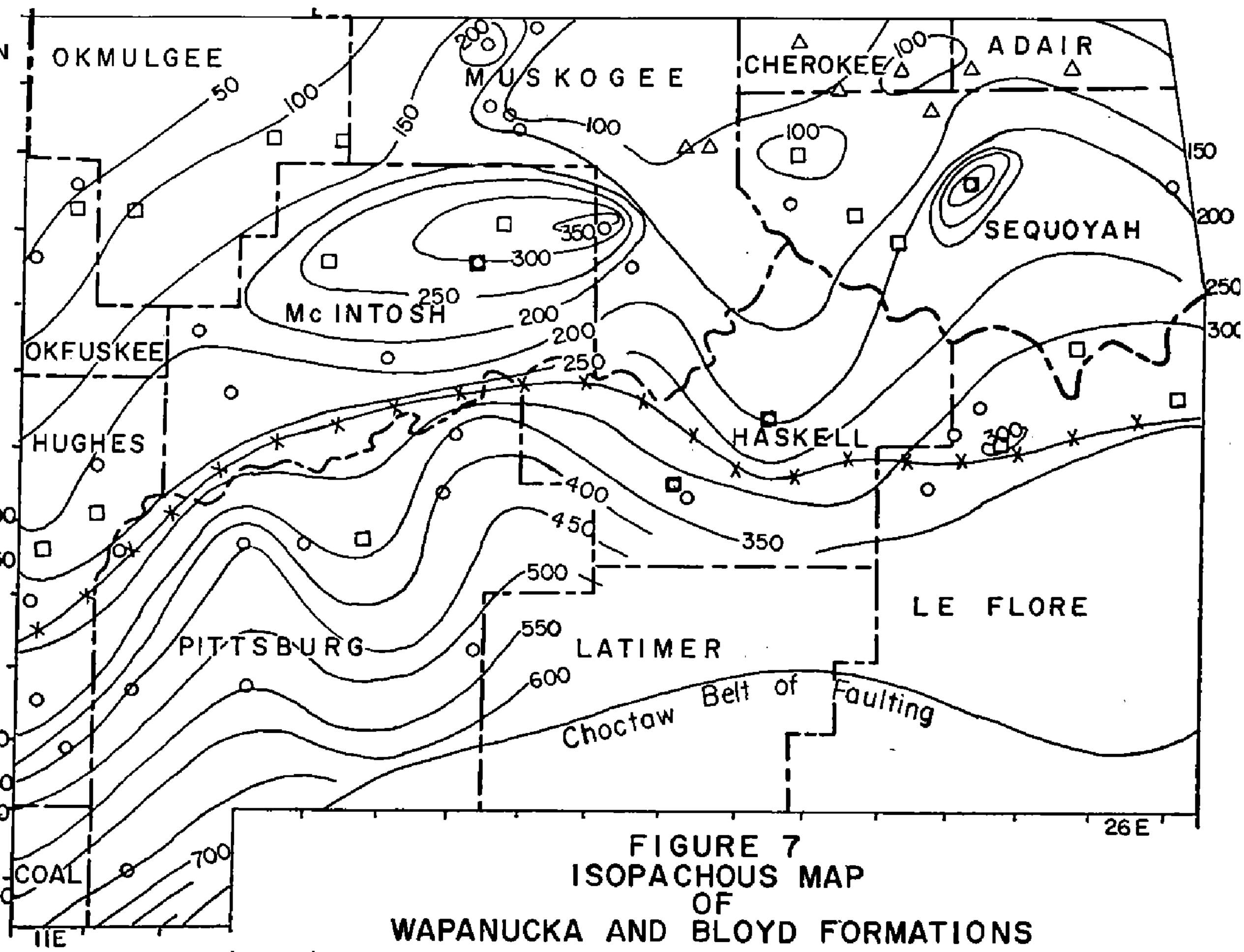

FIGURE 7
ISOPACHOUS MAP
OF
WAPANUCKA AND BLOYD FORMATIONS

Isopach Interval = 50 feet —×—× Approximate Line of Basin Flexure
○ Electrical or Radioactivity Log □ Well Sample Log
△ Outcrop Lithologic Log

beds have little lateral continuity. The middle part of the Bloyd is dark gray shale with local development in Arkansas of a coal called the Baldwin and a continental shaly siltstone and conglomerate named the Woolsey (Henbest, 1953). Neither the Woolsey nor the Baldwin was observed in the McAlester basin of Oklahoma. This is to be expected, since terrestrial beds could not have been deposited except on the uplifted area. The upper part of the Bloyd has been designated the Kessler limestone lentil. It consists of shales interbedded with a series of light gray to buff, finely crystalline, fossiliferous, oolitic limestone beds, which become sandy locally.

The Kessler is truncated in the outcrop area by the pre-Atoka unconformity, and its extension into the subsurface and probable continuance with the Wapanucka has not been firmly established.

The Bloyd in the outcrop area is truncated to the north, varying from zero to a maximum of about 250 feet in thickness. It continues to thicken in the subsurface (see figure 7, 11, and 12) to an observed maximum of almost 400 feet exclusive of the Wapanucka. In the northwest corner of the area of this investigation the erosion at the pre-Atoka unconformity completely removed the Wapanucka and cuts into the Bloyd, thinning the formation to less than thirty feet.

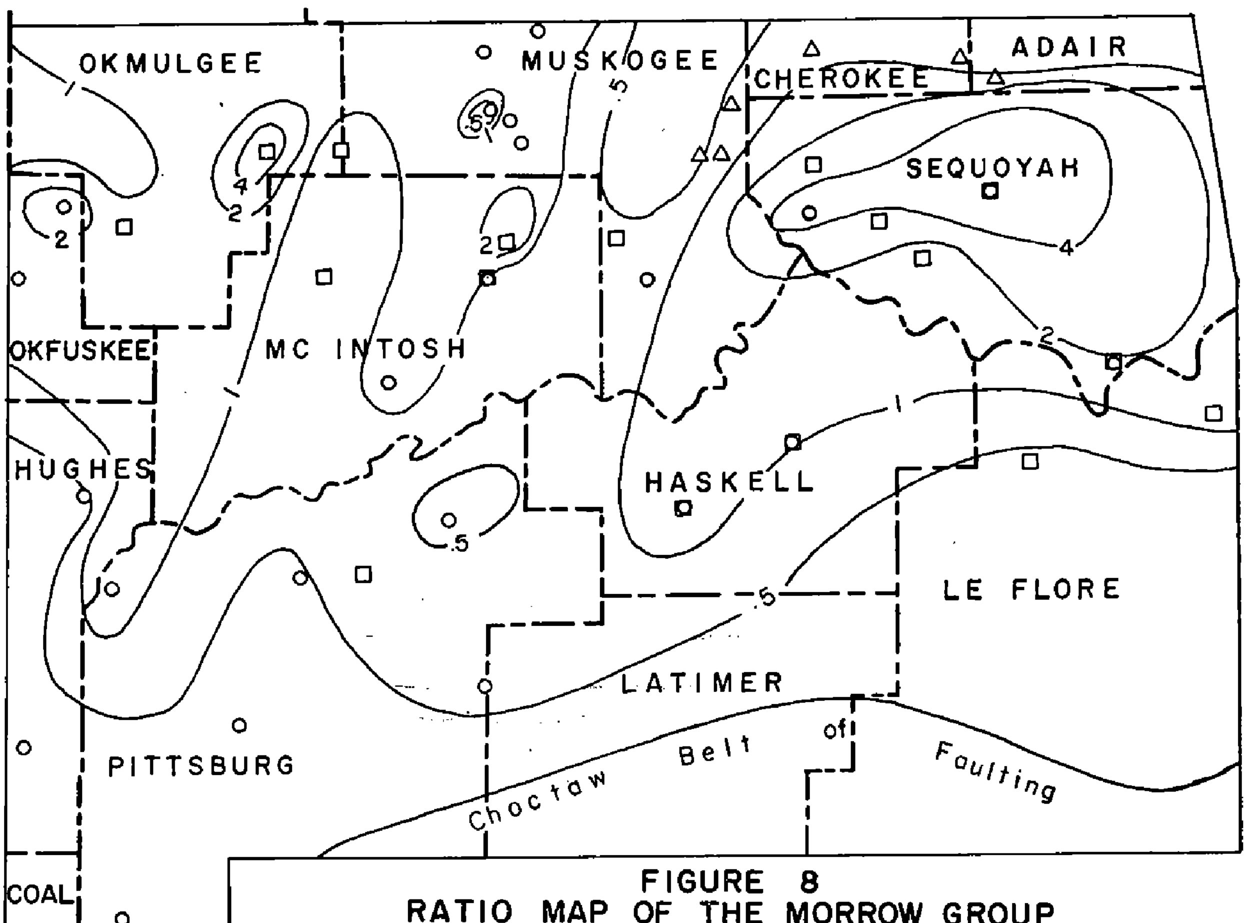

FIGURE 8
RATIO MAP OF THE MORROW GROUP
SANDSTONE AND LIMESTONE
SHALE
Geometric Ratio .25, .5, 1, 2, 4
o Electrical or Radioactivity Log □ Outcrop Lithologic Log
△ Well Sample Log

Wapanucka Limestone—In the subsurface of the McAlester basin a limestone formation which is not present in the truncated outcrops of the Ozark uplift, occurs above the Bloyd. This gray to brown, coarsely crystalline, compact, locally sandy limestone or its partial lateral equivalent crops out in the Ouachitas. From these outcrops the Wapanucka was originally described (Taff, 1901) as a massive, white to brown limestone containing shale and sandstone with local chert; the formation lying conformably above the "Caney" (Goddard) and below the Atoka.

The Wapanucka of the McAlester basin overlies the Bloyd, which overlies the Hale. All three formations thicken southward. In the most southerly well in the area of this investigation (section 34, T. 3 N., R. 12 E.) the Wapanucka is 250 feet thick and the Bloyd and Hale have a combined thickness in excess of 600 feet. Thus the Morrow group at this location is more than 850 feet thick. The Wapanucka as originally defined by Taff would seem to be equivalent to the entire Morrow group, yet this formation in the frontal Ouachitas is described as being typically about 300 feet thick (Gould, 1925). Since the rocks of the frontal Ouachitas were deposited farther basinward than the rocks of the McAlester basin, by extrapolation it seems that the Wapanucka of the frontal Ouachitas should be at least 850 feet thick. One possible explanation for the commonly observed 300-foot thickness of the Wapanucka is that this formation was thinned by a pre-Atoka unconformity. This seems improbable because of the apparent basinward position of the frontal Ouachita rocks relative to those of the McAlester basin. The pre-Atoka unconformity of the platform area dies out southward on the north edge of the McAlester basin, and no evidence of a pre-Atoka unconformity has been reported from the frontal Ouachitas, though such an unconformity may exist in the central Ouachitas.

Perhaps the simplest explanation of the anomalous thickness of the Wapanucka of the frontal Ouachitas is that the base of the Atoka formation becomes older in this area and the lower part of the Atoka formation is partially equivalent to the upper part of the Morrow of the McAlester basin and Ozark uplift. This would be caused by a sandy, Morrow equivalent facies on the south, not by overlap. This possibility is strengthened by the existence of a Morrow fauna in the lower Atoka of the frontal Ouachitas (Mather, 1917). Harlton (1938) suggested the separation of the Barnett Hill formation containing an "unquestionable Morrow fauna" from the Atoka. The formation has an observed 500 foot maximum thickness and is predominantly sandstone interbedded with shale. The Barnett Hill has been included in the Wapanucka, but lithologically it is almost inseparable from the overlying Atoka, and for this reason its status as a separate formation is open to criticism. Subsequent workers have not separated the Barnett Hill from the Atoka. Regardless of the status of the Barnett Hill as a formation, the existence of Morrow equivalent rocks in the formation above the Wapanucka provides a simple explanation for the unexpectedly thin Morrow group. Apparently during upper Morrowan time arenaceous clastics were transported from the south and were deposited to form the lower Atoka of the frontal Ouachitas. This Atoka sandstone overlies the Wapanucka in the frontal Ouachitas, but is equivalent in part to the Wapanucka of the McAlester basin. This relationship is of considerable interest because it means that the Morrowan and Atokan series partially overlap in time in their type areas.

ATOKA FORMATION

The Morrow group of the Ozark uplift and the platform area northwest of the McAlester basin is overlain unconformably by the Atoka sandstone. This unconformity dies out basinward, and the Atoka is apparently conformable with the Wapanucka in all observed sections south of the hinge line of basin flexure. It should be noted, however, that the absolute continuity of beds at any given geologic horizon can nowhere be proven. If evidence for the existence of an unconformity at a horizon is lacking, it is assumed that none exists.

The Atoka formation was originally described (Taff and Adams, 1900) from outcrops at Atoka, Oklahoma, and was subsequently redefined as a 7,000-foot shale formation with thin ledges of brown sandstone. The Atoka is composed of sandstone a few tens of feet thick in the outcrops on the southwest flank of the Ozark uplift in Cherokee and Adair Counties. During Atokan time the downward flexing of the McAlester basin was especially strong, allowing the accumulaton of a tremendous thickness of clastic sediments increasing progressively to the south. In the extreme southern part of the McAlester basin the Atoka is composed almost entirely of shale with a thickness in excess of 6,000 feet. In the frontal Ouachitas, still farther south, the Atoka again contains prominent sandstone beds. These sandstones seem to represent the northern edge of the wedge of arenaceous clastics supplied from the source area to the south.

The apparent transgression of time of the Atoka lithology has already been commented upon.

SUMMARY

The late Mississippian and early Pennsylvanian rocks of the McAlester basin were probably deposited in the same geosyncline with those of the Ouachitas.

The pre-Morrowan and pre-Atokan unconformities, occurring in the platform area and the uplifted area north of the basin, die out basinward, and within the basin proper there was continuous sedimentation from Mississippian into Pennsylvanian time.

The northward convergence of the Goddard shale was caused predominantly by a differential subsidence rate over the basin of deposition at the time the Goddard was being deposited, rather than by the truncating erosion of a pre-Pennsylvanian unconformity.

The base of the Atoka formation seems to become older to the south, and the lower part of the Atoka of the frontal Ouachitas seems to be a time equivalent of the upper part of the Morrow of the Ozark uplift.

The Goddard shale is a partial time equivalent of the Johns Valley shale.

The Stanley and Jackfork formations are of Mississippian age.

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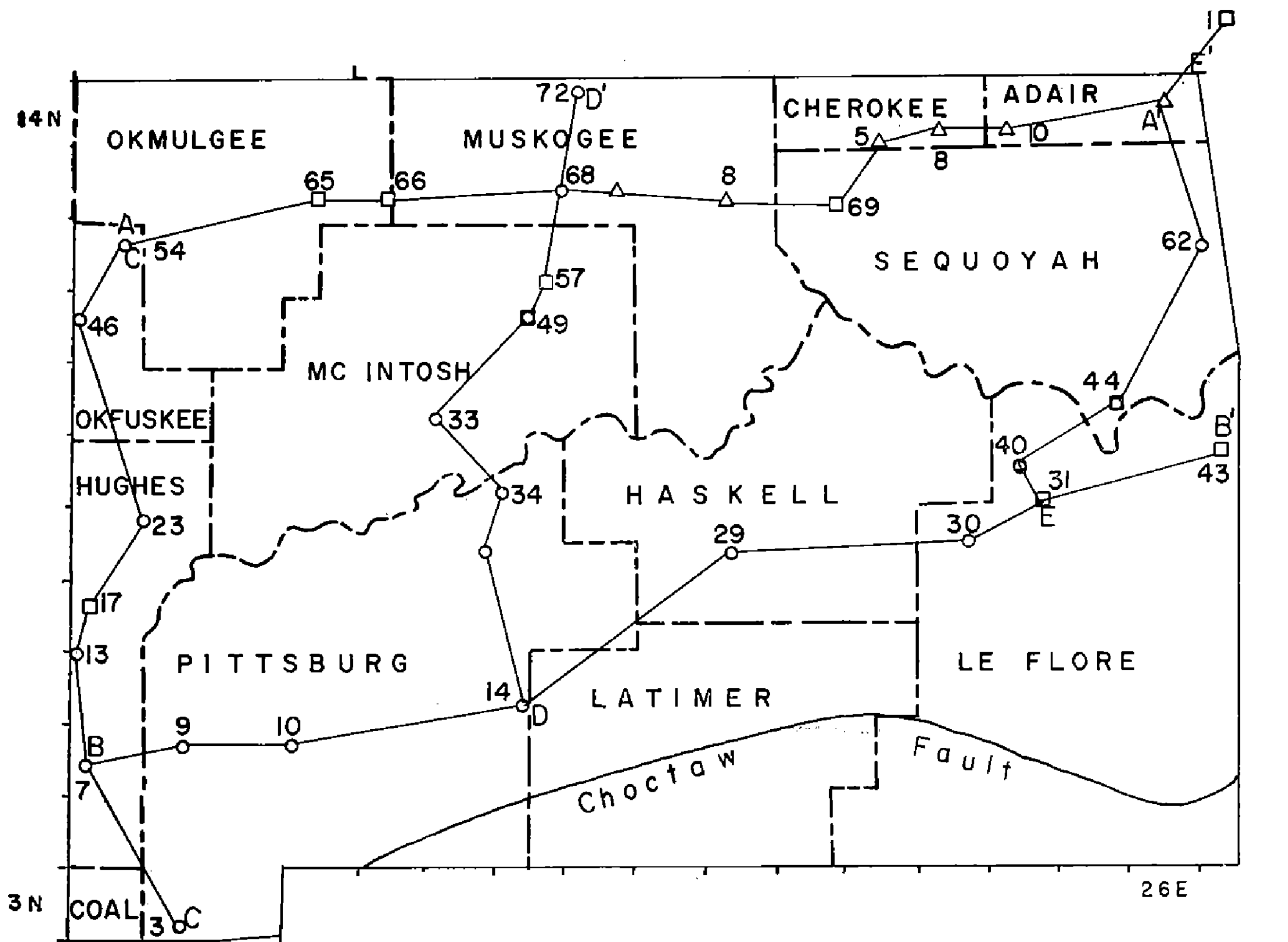


FIGURE 9. MAP SHOWING LOCATION OF CROSS SECTIONS

o Electrical or Radioactivity Log
□ Well Sample Logs
Δ Outcrop Lithologic Log
5 Number of Wells (See Appendi)

APPENDIX

	Company	*Well*	*Location*	*Sec.*	*Twp.*	*Rge.*
1.	Delhi Oil Corp.	Claud Mowdy # 1	SE NE SE	10	2N	11E
2.	Southwest Exploration	Hoeman # 1		16	2N	14E
3.	Superior Oil Co.	Little # 1	SE NW SE	34	3N	12E
4.	O. N. Sellers	Jones # 1	C NW NE	30	3N	22E
5.	Pure Oil Co.	Scullion # 1		3	4N	11E
6.	Sunray Oil Corp.	Mullens # 1	C SE SW	29	4N	14E
7.	Magnolia Petroleum	McKoy Heirs # 1A	SW SW SE	16	5N	11E
8.	Fleet Drlg. & Stanolind Oil Cos.	Patterson # 1		21	5N	11E
9.	Phillips Petroleum	Bowlby # 1	NE NW NE	4	5N	12E

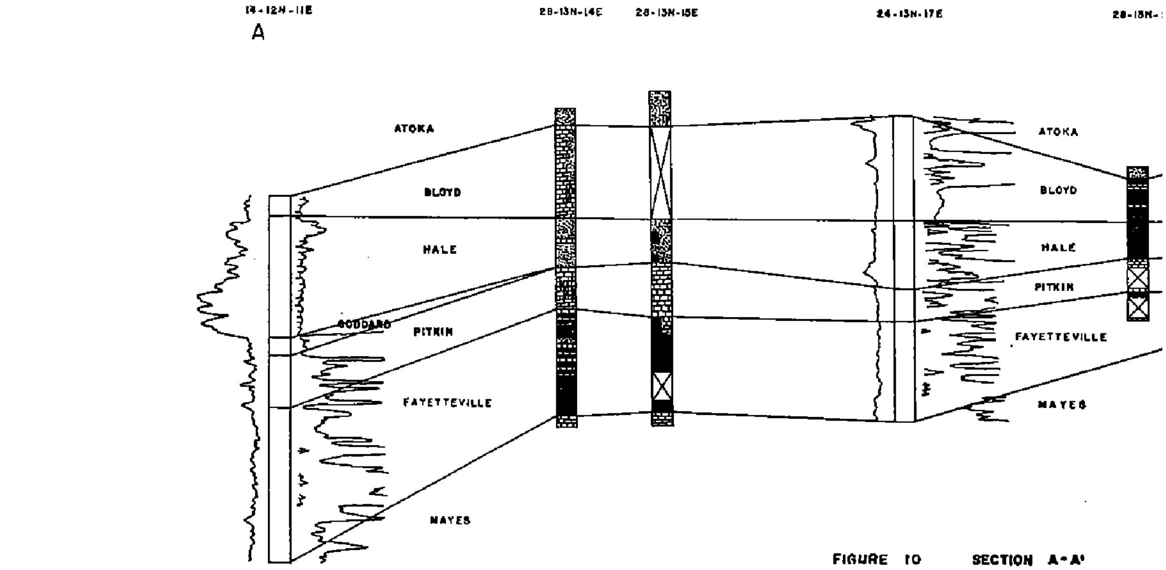
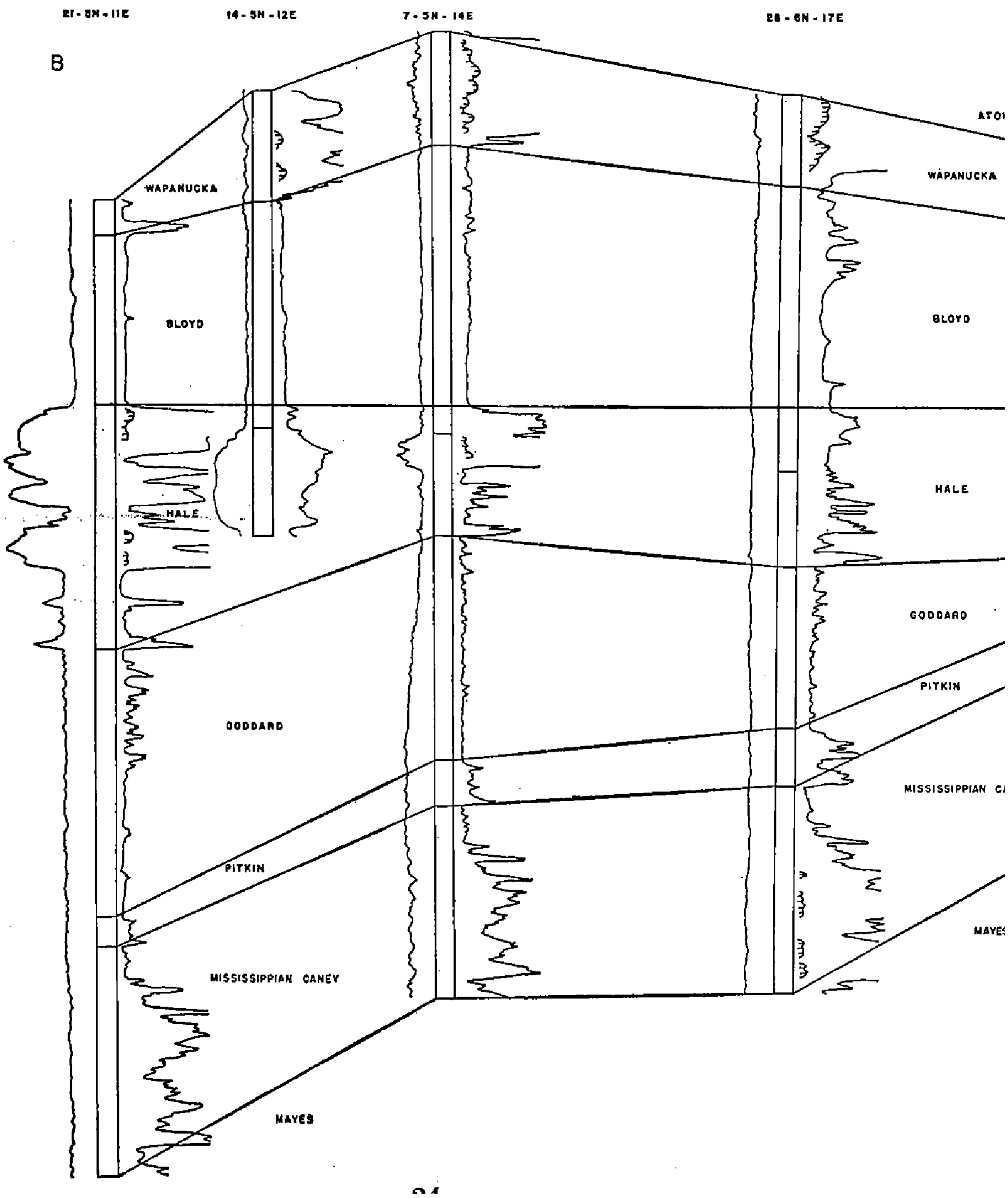
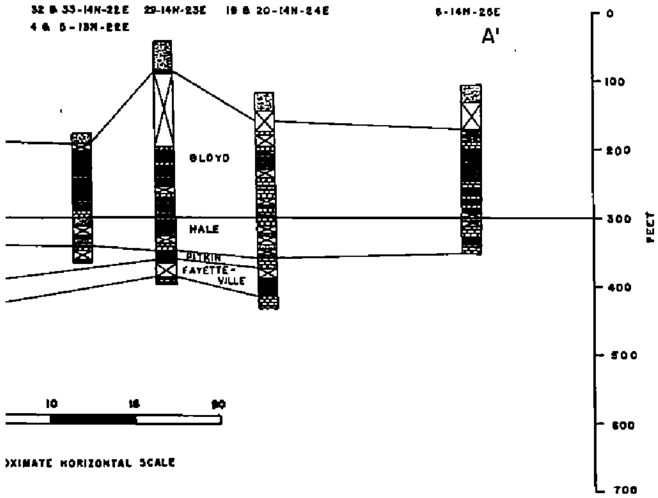


FIGURE 10 SECTION A-A'





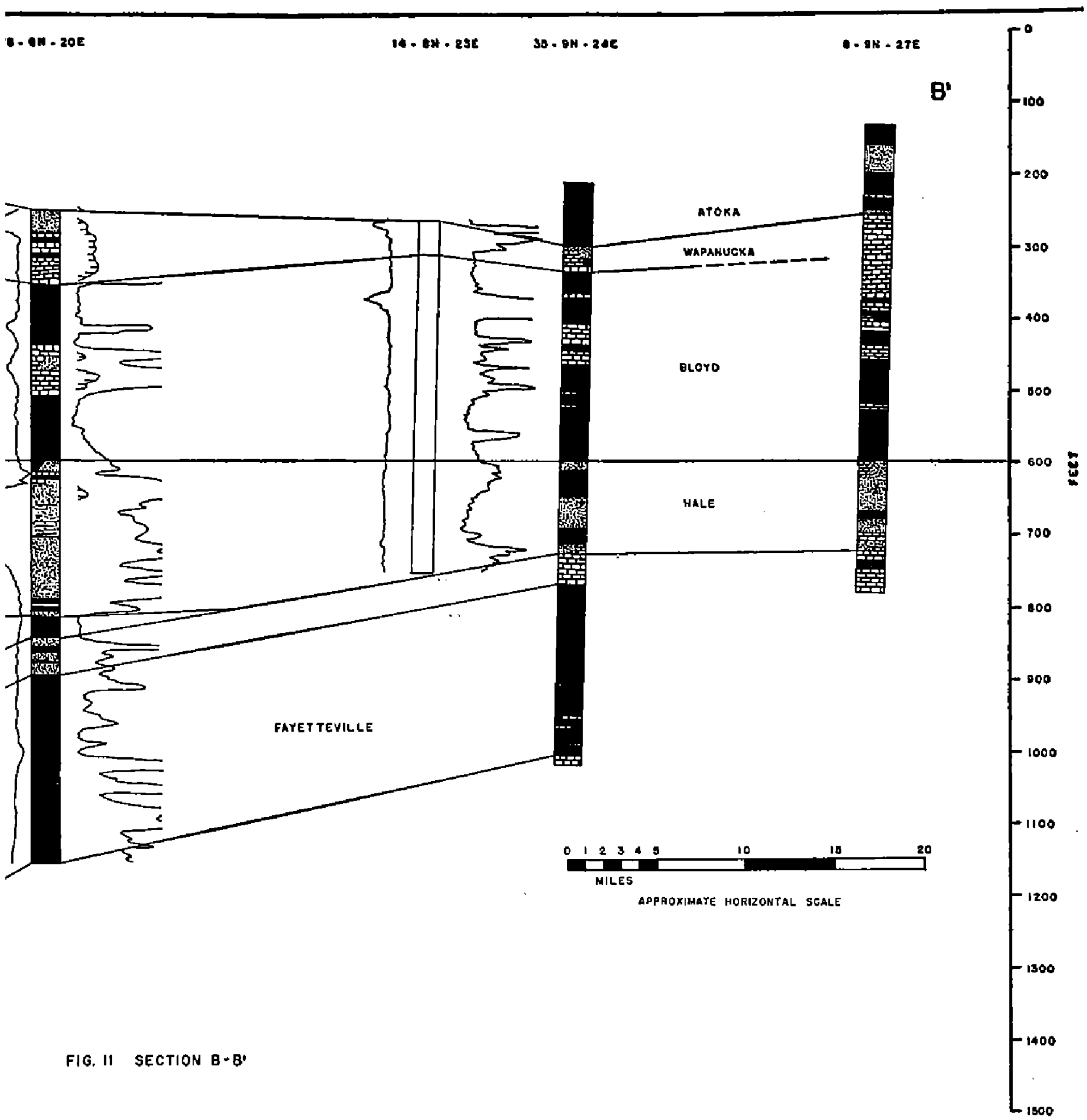


FIG. 11 SECTION B-B'

Company	Well	Location	Sec.	Twp.	Rge.
10. Wood Oil & Continental Oil Cos.	Childers # 1		7	5N	14E
11. Clark & Co.	Wilson # 1		15	5N	18E
12. R. M. Akers	Utah Gray # 1		17	5N	19E
13. Gulf Oil Corp.	B. E. Trumbo # 1	SE SE SW	6	6N	11E
14. Magnolia Petroleum	Manschreck # 1	C SE NE	28	6N	17E
15. LeFlore County Gas & Electric Co.	R. O. 53 McFerran	C S½ S½	2	6N	22E
16. Sonac	Rose # 1		17	7N	10E
17. Rock Oil Corp. & Burke-Greis	Sanders # 1	C NE SE SE	17	7N	11E
18. Otha Grimes	Gilcrease # 1	SW SE SE	16	7N	12E
19. American Oil & Refining	Beeler # 1	NE NE SW	7	7N	14E
21. Phillips Petroleum	Lytle # 36-12	SW NE SW	12	7N	14E
22. Liebmann Prod. Co.	Hubacher # 1	C NW NE	11	7N	15E
23. Stanolind	Lowrey # 1		35	7N	23E
24. Newman	Robison # 1	SW SE SE	7	8N	12E
25. Phillips Petroleum	Barnett # 2	SE NW NW	31	8N	12E
26. Superior Oil Co.	Parsons # 1		24	8N	16E
27. Superior Oil Co.	Pixler Unit # 1		14	8N	20E
28. Superior Oil Co.	Gordon # 1	NW NW SE	16	8N	20E
29. Superior Oil Co.	Allred # 73-18	NW SE SE	18	8N	20E
30. Arkansas & Oklahoma Gas Co.	Drain # 1		21	8N	20E
31. Athletic Mining & Smelting Co.	Phillips # 1	SW SE NW	14	8N	23E
	Hickman # 1		17	8N	25E
32. Continental Oil Co.	C. L. Follansbee # 1	SE SE SW	13	9N	13E
33. Carter Oil Co.	Graham # 1		3	9N	16E
34. Carter Oil Co.	Pratt # 1		30	9N	17E
35. Phillips Petroleum	Sammon # 1		22	9N	21E
36. LeFlore County Gas & Electric Co.	Stigler # 2		32	9N	21E
37. Arkansas & Oklahoma Gas Co.	Weitz-Harvey # 1		14	9N	24E
38. Arkansas & Oklahoma Gas Co.	Paschall # 1	50′ E 50′ S of C	16	9N	24E
39. Redbank	Fee # 1	SE SW NW	23	9N	24E
40. Arkansas & Oklahoma Gas Co.	Rabon # 1	SW SW NE	30	9N	24E
41. Athletic Mining & Smelting Co.	Dunn # 1		35	9N	24E
42. Gibralter Oil Co.	Welch # 1	C SW NE	16	10N	13E
43. LeFlore County Gas & Electric	Cedars # 7		8	9N	27E
44. Arkansas & Oklahoma Gas Co.	Brant # 1		24	10N	25E
45. Texas	Cowan # 1	SW SW SW	5	11N	10E
46. Nadel & Gussman	Parson # 1	NE NW SE	18	11N	11E
47. Wigdon	Koch # 2	NW SE NE	15	11N	15E
48. Texola Drilling Co.	Cannon # 1		7	11N	17E
49. Phillips Petroleum	Williams # 1		16	11N	17E
50. Johnstone & Nylen Petroleum Co.	Escoe # 2		16	11N	17E
51. Akins, Potter & Seiber	Matthews # 1	NE NE NE	15	11N	19E
52. O. P. Leonard	Ed Highfill # 1		5	11N	21E
53. Diamond Drilling Co.	Mullens # 2		5	11N	23E
54. Sam King	Pharoah # 1	SW NW NW	14	12N	11E
55. Pure	Rentie # 1	SE NW NE	26	12N	11E
56. Dixie	Gibson # 1	NE NE SW	27	12N	12E
57. Oklahoma Oil	Coffey (J. Wolfe)	SE SW SE	35	12N	17E
58. Lester	Rogers # 1		31	12N	19E
59. O. P. Leonard	Smith # 1		23	12N	21E

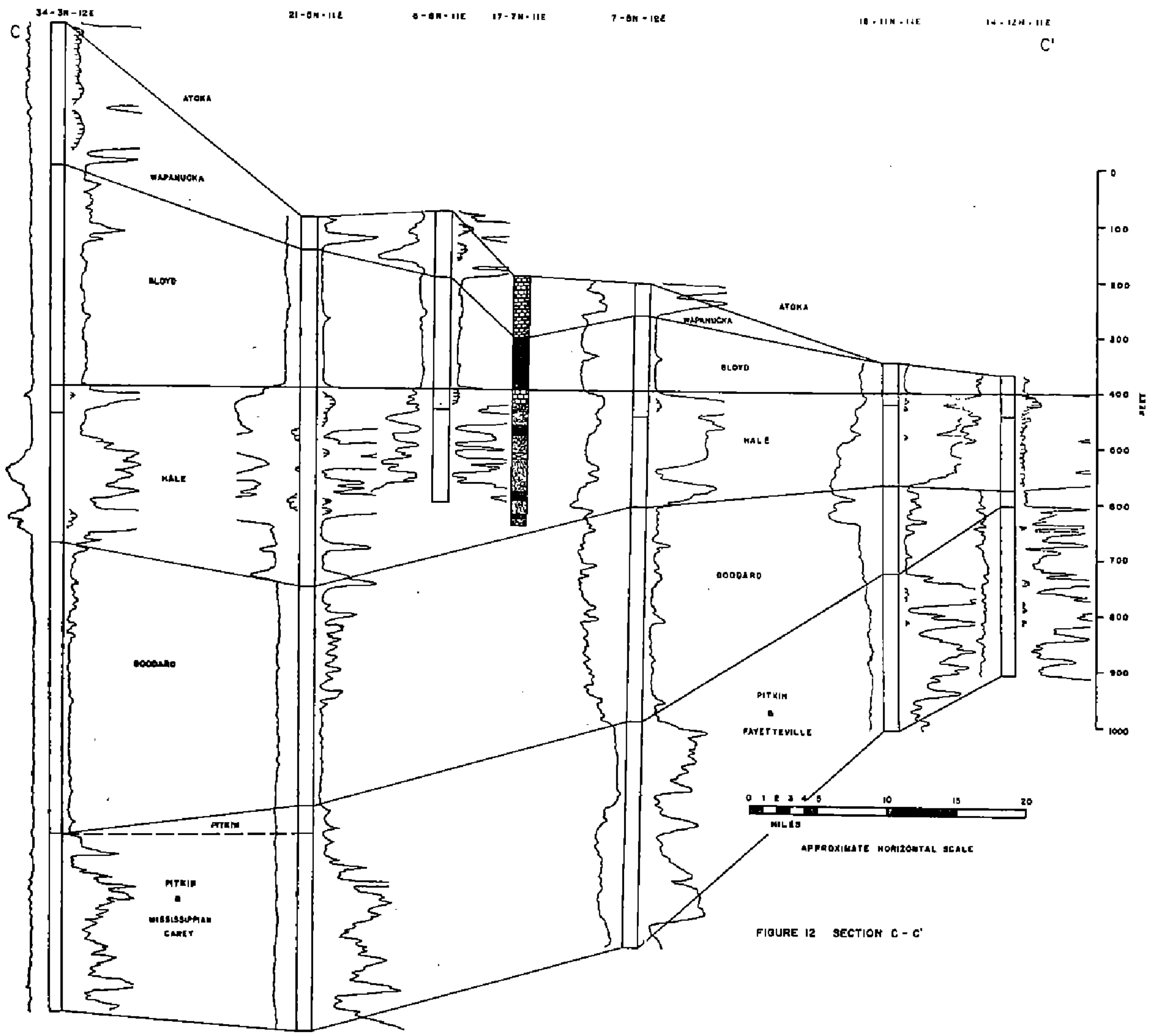


FIGURE 12 SECTION C - C'

	Company	*Well*	*Location*	*Sec.*	*Twp.*	*Rge.*
60.	Cobb-Bennett	Haraway # 1		26	12N	22E
61.	Lohmann-Johnson Drilling	Cook # 2	C SW NE	8	12N	24E
62.	Carter Oil Co.	Olil Cates # 1	C NW SE NW	18	12N	27E
63.	Texas	Patterson # 1	NE NW NE	31	13N	12E
64.	Evans et. al.	Hardridge # 1	SE SE NW	20	13N	13E
65.	Gledoil	Baker # 9		28	13N	14E
66.	Wynne	Hutton # 1	SE NE NE	28	13N	15E
67.	Beckman Inc.	Holland # 1		14	13N	17E
68.	W. B. Pine	Coffee # 1		24	13N	17E
69.	Bennett-Cobb	Wilson # 1		36	13N	21E
70.	W. H. Pine	Cable # 6	NW SW NE	16	14N	17E
71.	V. L. Crowell	Crowell-Thurber		21	14N	19E
72.	W. H. Pine	Rooney # 2	SW SW NW	6	14N	18E

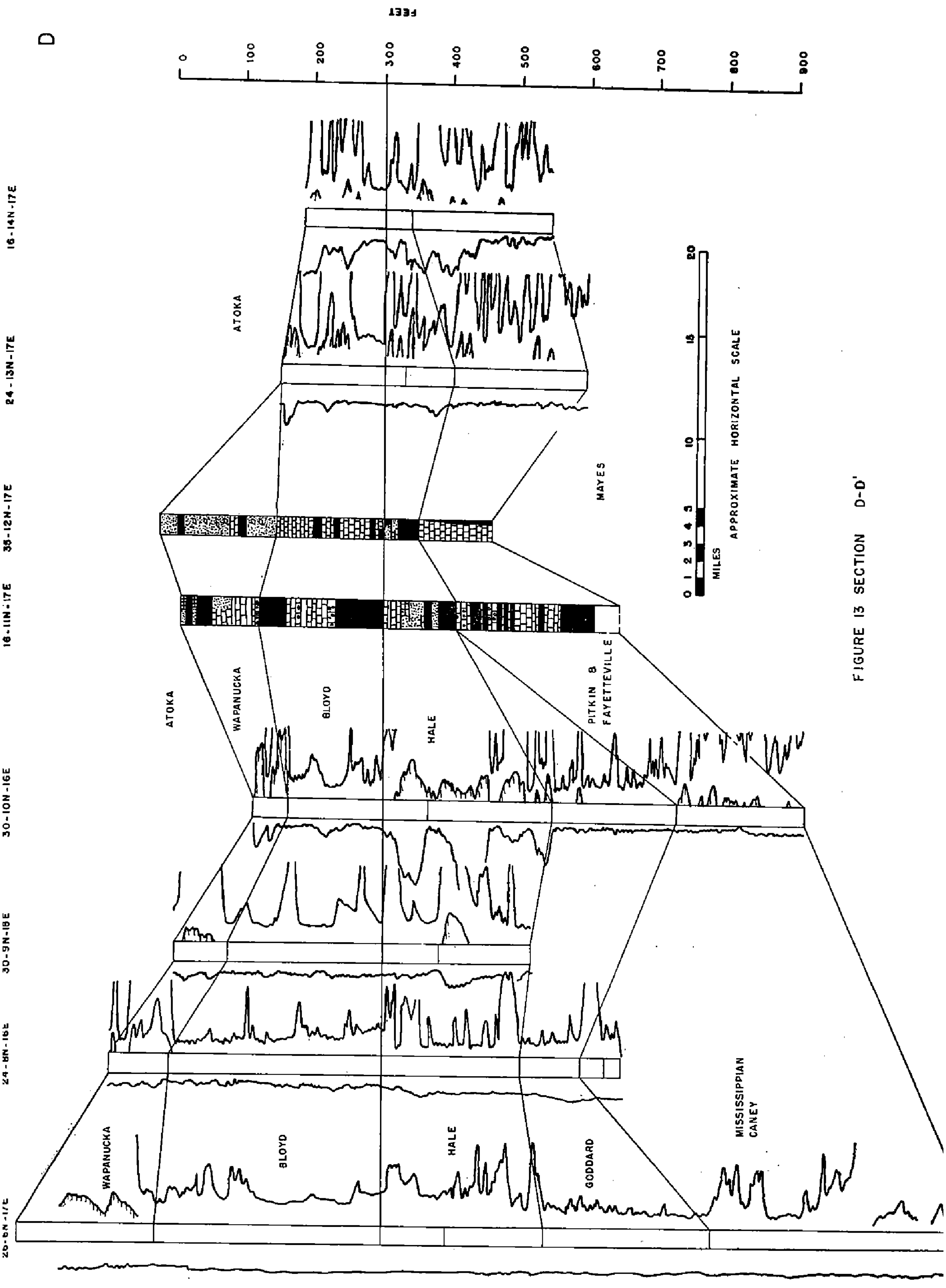


FIGURE 13 SECTION D-D'

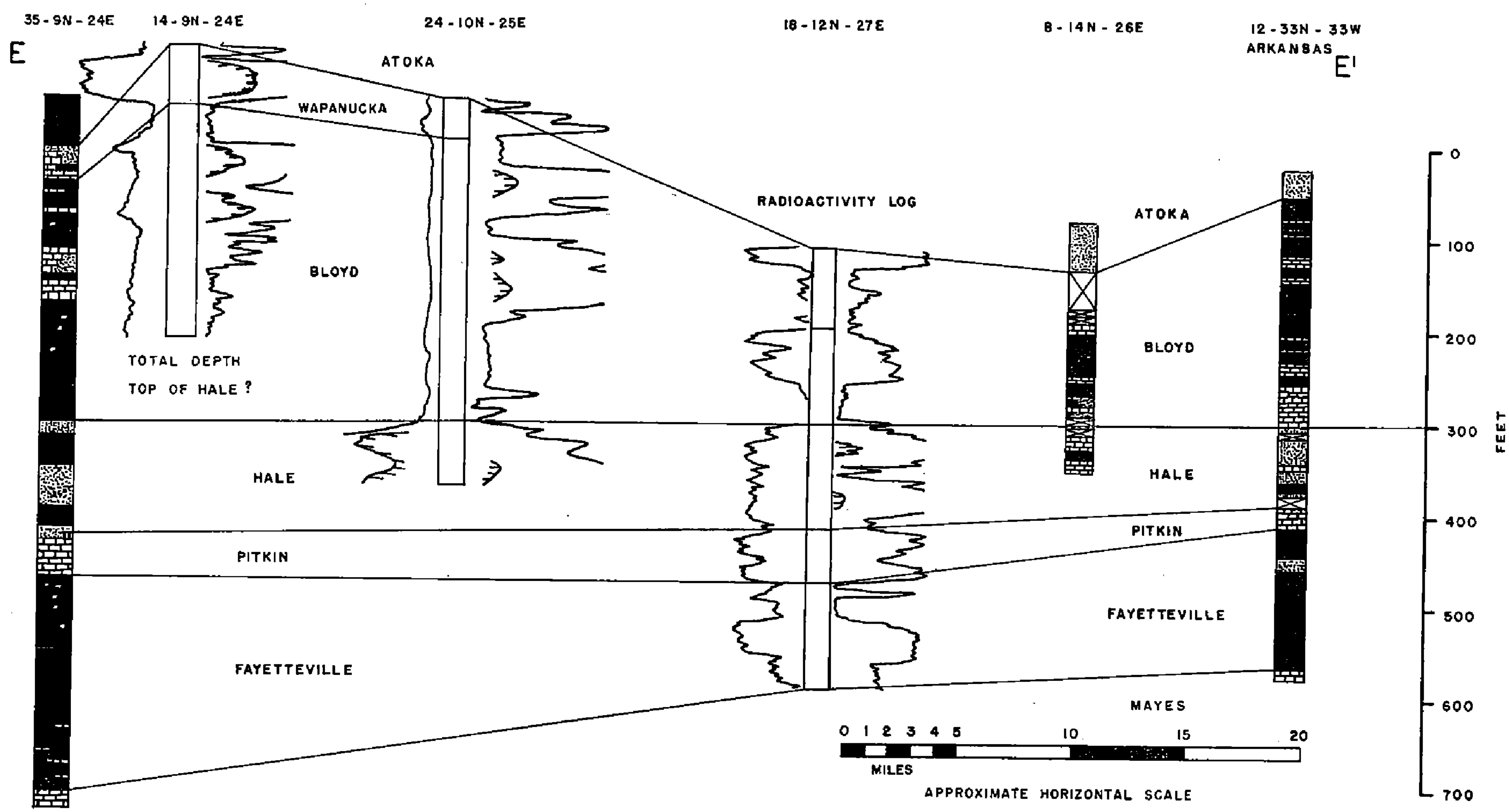


FIGURE 14 SECTION E-E'

Measured Sections from Carl A. Moore, The Morrow Series of Northeastern Oklahoma : Oklahoma Geological Survey Bulletin # 66, 1947

1. Hale Mountain	12	33N	33W	Arkansas
2. Greenleaf Dam	2	13N	20E	Oklahoma
3. McClain	28	13N	20E	Oklahoma
4. Linder Creek	3	13N	21E	Oklahoma
5. Blackgum	32 & 33	14N	22E to	
	4 & 5	13N	22E	Oklahoma
6. Quarry Mountain	14	13N	23E	Oklahoma
7. Elk Creek	23	14N	23E	Oklahoma
8. Terrapin Creek	29	14N	23E	Oklahoma
9. High Mountain	2, 3, 10, & 11	14N	24E	Oklahoma
10. Bunch Mountain	15	14N	24E	Oklahoma