STATE OF ARKANSAS

Arkansas Resources and Development Commission

Wayne C. Fletcher, Executive Director

DIVISION OF GEOLOGY

Harold B. Foxhall, Director

INFORMATION CIRCULAR 12

LOWER CRETACEOUS AND JURASSIC FORMATIONS OF SOUTHERN ARKANSAS

AND

THEIR OIL AND GAS POSSIBILITIES

By

Ralph W. Imlay

Little Rock

1949

Reprinted

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STATE OF ARKANSAS
ARKANSAS GEOLOGICAL SURVEY
ROOMS 443-447 STATE CAPITOL
LITTLE ROCK, ARK.

GEORGE C. BRANNER
STATE GEOLOGIST

July 30, 1940

Hon. Carl E. Bailey,
Governor, State of Arkansas,
Little Rock, Arkansas.

Sir:

I have the honor to submit herewith the report, "Lower Cretaceous and Jurassic Formations of Southern Arkansas and Their Oil and Gas Possibilities," by Ralph W. Imlay.

The formations considered in this report lie within an area of about 9,000 square miles in the southeastern portion of the Gulf Coastal Plain of Arkansas, and, for the most part, are deeply buried. The need for the present study was occasioned by the discovery of oil and gas in formations of Jurassic age in southern Arkansas which began with the discovery of the Snow Hill field in Ouachita County in 1936. This discovery was of importance as it indicated the oil and gas possibilities of beds referred to, at the time, as of Permian age. This led to deep prospecting which was responsible for the discovery of the Schuler field in Union County in 1937, and was followed by the extension of the Rodessa field from Louisiana into Arkansas, and discovery of the Buckner, Magnolia, Village, Atlanta, Lewisville, Dorcheat, Big Creek fields, the Fouke extension and the McKamie field. All of these produce from the formations discussed in this report, and, at present, have a combined daily production of about 49,000 barrels.

The literature bearing on the formations discussed in this report has been relatively meager, and it is believed Dr. Imlay's contribution will add materially to the understanding of the problem of the origin, age, character, distribution, structure and oil possibilities of these formations.

Respectfully submitted,

George C. Branner,
State Geologist.

C O N T E N T S

Page

ILLUSTRATIONS

FOLLOWING TEXT

T A B L E S

LOWER CRETACEOUS AND JURASSIC FORMATIONS OF SOUTHERN ARKANSAS AND THEIR OIL AND GAS POSSIBILITIES

By Ralph W. Imlay

ABSTRACT

Deep drilling in southern Arkansas and adjacent states since 1935 has shown that the Upper Cretaceous system is underlain by thousands of feet of Lower Cretaceous and older Mesozoic rocks that are sources of petroleum. The area favorable for petroleum production, defined on the basis of presence of source and reservoir rocks, is believed to be roughly limited on the north and northeast by a line drawn eastward through the middle of Little River, Hempstead, and Nevada counties, Arkansas, and then southeastward to the western part of Ashley County, Arkansas. Within this area the accumulation of petroleum is apparently controlled by structure and the lenticular nature of the porous beds. Generally, the approximate positions of structures are determined by geophysical surveys. The positions of porous lenses cannot be predicted but the possibility of their occurrence can be indicated after a study of lithologic and stratigraphic features and of regional sedimentary relationships based on well logs and cores. As a beginning of such basic studies, the present paper summarizes existing knowledge concerning the sedimentary rocks and discusses their possible sources, environments of deposition, and probable equivalents elsewhere in North America.

The Lower Cretaceous rocks of southern Arkansas range in thickness from about 600 feet at the outcrop in Sevier, Howard, and Pike counties to over 5,500 feet subsurface in the southwestern corner of the state. These Lower Cretaceous rocks are underlain by Mesozoic (Jurassic) rocks which do not outcrop anywhere in the Gulf region. The Mesozoic rocks range in thickness from about 2,950 feet in Arkansas to over 7,000 feet in northern Louisiana. The Lower Cretaceous and Jurassic formations consist mainly of nearshore, shallow water deposits in Arkansas and of offshore, shallow water deposits in northern Louisiana. The nearshore deposits are characterized by conglomerates, sandstones, red beds, and reef limestones whose deposition was interrupted several times by withdrawals of the Gulf waters. The offshore deposits are characterized by dark shales and thin-bedded limestones the deposition of which was apparently nearly continuous. Anhydrite was formed both nearshore and offshore. The lowest known Mesozoic deposit in Arkansas consists mainly of salt, about 1,000 to 1,300 feet thick, which grades into equally thick red beds.

The major structural features (See Pl. I) of the Lower Cretaceous and older Mesozoic formations of southern Arkansas consist of

(1) a south and southwest inclined monocline on which are superimposed minor anticlinal uplifts and domes that have influenced oil accumulation;

(2) a syncline across southern Miller and Lafayette counties, Arkansas, separating the monocline from the Sabine Uplift of northwestern Louisiana;

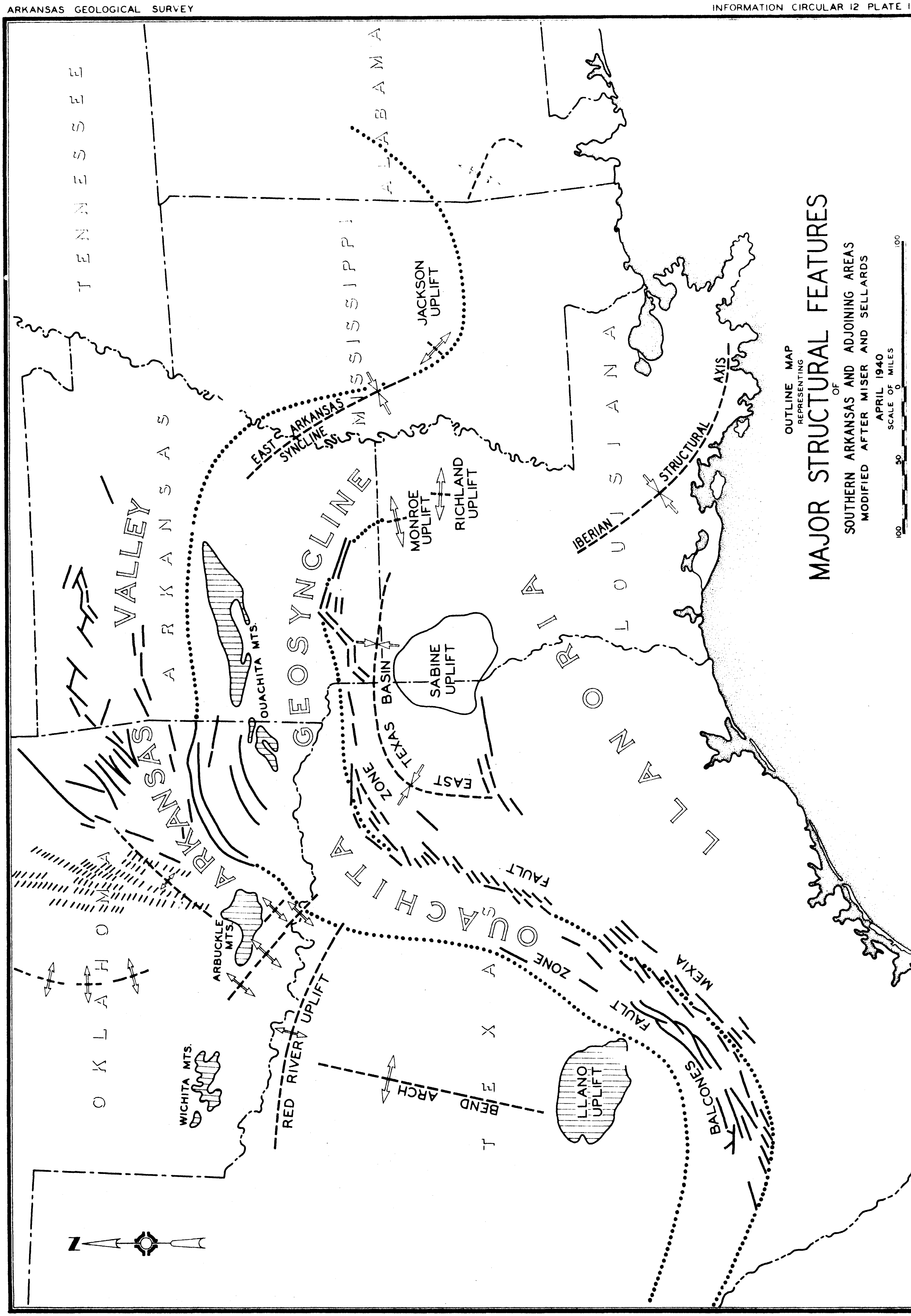
(3) an east-west trending zone of normal faulting which is arcuate toward the north and has displacements of 400 to 1,200 feet in Lower Cretaceous rocks;

(4) a flexure in the basement rocks, apparently paralleling and bordering the southern margin of the Ouachita Mountain folds.

Extensive revision of current ideas concerning the geological history of the Gulf

Coastal region during the Mesozoic era has been made herein. The evidence shows that the Ouachita peneplain, developed during early Mesozoic time, was tilted southward and submerged beneath the ancestral Gulf of Mexico during middle Mesozoic time. Intermittent upward movements in the region of the Ouachita Mountains tended to influence the character of the Gulf deposits and to cause shifting of the strand line. The seas oscillated across the bordering lowlands many times, but, in general, successive transgressions extended farther and farther northward. South of the region of the Ouachita Mountains the floor of Paleozoic and older rocks sank to great depths but was covered so rapidly by sediments that the sea always remained fairly shallow. During Lower Cretaceous time a total thickness of about 13,000 feet of sediment accumulated in some places. At the end of Lower Cretaceous time the entire region was uplifted from the sea; the sedimentary rocks of southern Arkansas were tilted strongly to the southwest; a zone of normal faulting, arcuate toward the north, developed across the southern part of the state, and local domes and anticlinal uplifts were formed. Then the entire region was eroded extensively before being covered by an early Upper Cretaceous sea.

The minor anticlines and domes developed by regional warping at the end of Lower Cretaceous time have greatly influenced the accumulation of petroleum. They constitute the principal factor controlling oil accumulation in most of the oil fields of southern Arkansas.

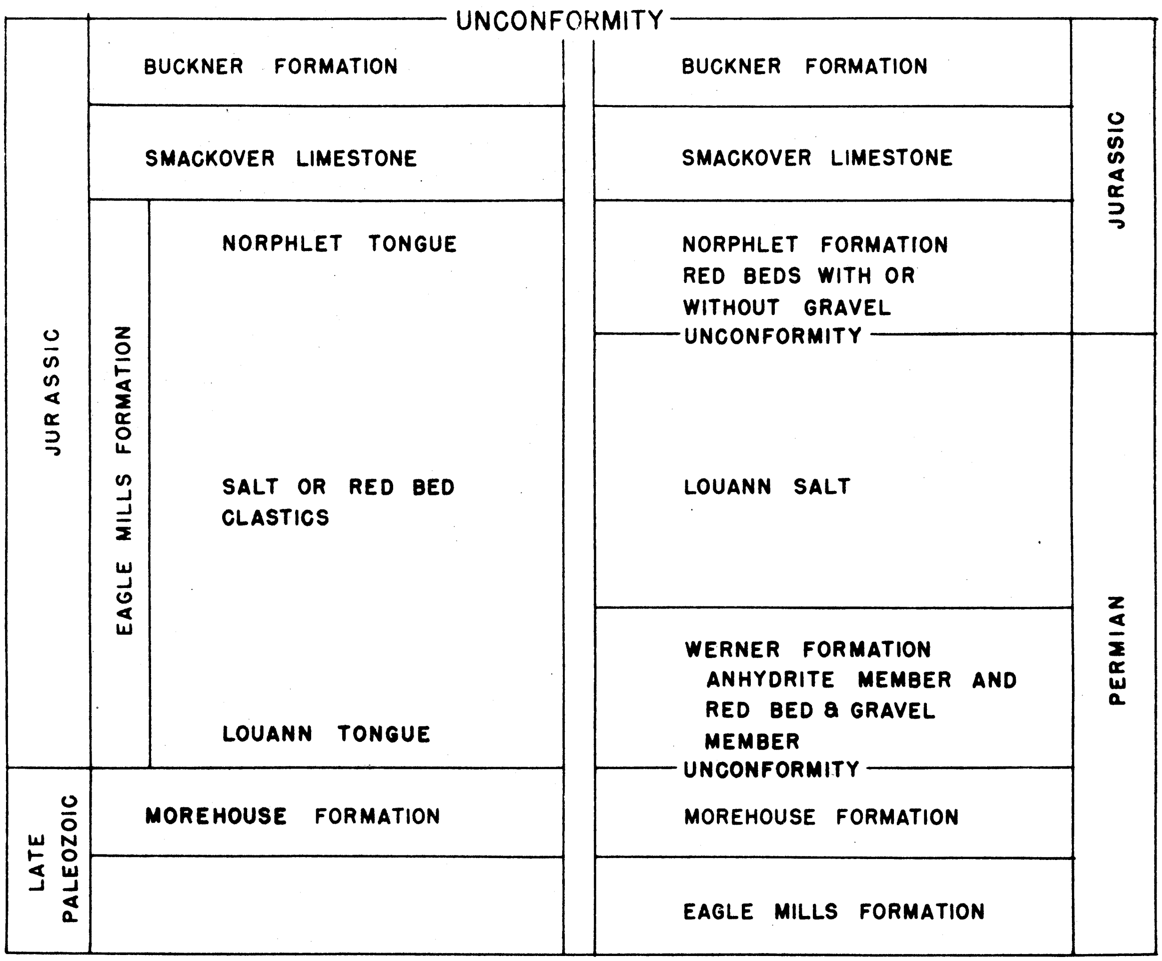

OUTLINE MAP
REPRESENTING
MAJOR STRUCTURAL FEATURES
OF
SOUTHERN ARKANSAS AND ADJOINING AREAS
MODIFIED AFTER MISER AND SELLARDS
APRIL 1940
SCALE OF MILES
100 50 0 100
TENNESSEE
ALABAMA
MISSISSIPPI
ARKANSAS
LOUISIANA
OKLAHOMA
TEXAS
JACKSON UPLIFT
EAST ARKANSAS SYNCLINE
MONROE UPLIFT
RICHLAND UPLIFT
IBERIAN STRUCTURAL AXIS
ARKANSAS VALLEY
OUACHITA MTS.
GEOSYNCLINE
SABINE UPLIFT
EAST TEXAS BASIN
LLANORIA
ARBUCKLE MTS.
OUACHITA
ZONE
FAULT
MEXIA FAULT ZONE
WICHITA MTS.
RED RIVER UPLIFT
BEND ARCH
LLANO UPLIFT
BALCONES
N

JURASSIC AND PERMIAN SECTION IN SOUTH ARKANSAS
According to Hazzard, Blanpied and Spooner
1945

Below is shown the latest published interpretation of stratigraphic relations of the Jurassic and Permian in this area. Information obtained from deep wells drilled in south Arkansas, northeast Texas, and North Louisiana since the publication of Information Circular 12 indicates that the Louann Salt, Werner, Morehouse, and Eagle Mills are separate formations of probable Permian age.

IMLAY'S INTERPRETATION OF STRATIGRAPHIC SEQUENCE

HAZZARD, BLANPIED AND SPOONER INTERPRETATION OF STRATIGRAPHIC SEQUENCE



This information is an extract from: "Notes on the Stratigraphy of the Formations Which Underlie the Smackover Limestone in South Arkansas, Northeast Texas, and North Louisiana" which is included in Volume II of "1945 Reference Report on Certain Oil and Gas Fields of North Louisiana, South Arkansas, Mississippi, and Alabama" and is here reproduced through the courtesy of the Shreveport Geological Society.

LOWER CRETACEOUS AND JURASSIC FORMATIONS OF SOUTHERN ARKANSAS AND THEIR OIL AND GAS POSSIBILITIES

By Ralph W. Imlay

INTRODUCTION

During the last few years hundreds of wells have penetrated to depths below four thousand feet in southern Arkansas and bordering states and have revealted the presence of thick rock layers whose existence, composition, and structure could not have been predicted from surface observations. The drilling was accompanied by careful studies of cuttings, cores, electrical logs, and drillers' time logs. These studies have resulted in a large mass of detailed information which is gradually being interpreted in terms of regional stratigraphy and structure and applied toward the finding of oil deposits.

In the following pages the writer will discuss the information obtained in recent years by deep drilling and will deal with the Lower Cretaceous and older Mesozoic sedimentary rocks of southern Arkansas. The report may be considered as supplementary to th the volume, "Oil and Gas Geology of the Gulf Coastal Plain in Arkansas," by W. C. Spooner. Most of the information presented herein was not available to Mr. Spooner in 1935 when his work was published. The main purpose of this report is to describe the broader subsurface geological features in southern Arkansas.

ACKNOWLEDGMENTS

This report was prepared for the Arkansas Geological Survey under the direction of George C. Branner, State Geologist, who conceived the plan and scope of the report and assisted actively in its preparation.

The writer is greatly indebted to Warren B. Weeks, of the Phillips Petroleum Company, El Dorado, Arkansas, and Roy T. Hazzard, of the Gulf Refining Company, Shreveport, Louisiana, for many fruitful discussions concerning the geology of the older Coastal Plain beds and for permission to obtain necessary data from the files of their companies. Both men spent considerable time helping the writer obtain the most pertinent information of the large mass available. They later contributed more time checking the maps and structure sections and commenting upon the manuscript. Without their aid the present report would not have been possible.

Other individuals with whom the writer has discussed the general geological problems or who have contributed important information are G. D. Thomas, W. S. Adkins, and Miss Anna Minkofsky, of the Shell Petroleum Company; C. L. Moody, of the Ohio Oil Company; M. N. Broughton, of the Texas Company; Joseph Purzer, of the Phillips Petroleum Company; Merle Israelsky, of the Union Gas Company; H. J. Morgan and H. H. Trager, of the Atlantic Refining Company; and A. F. Crider, consulting geologist.

Lastly, the writer wishes to emphasize that he is serving merely as a medium of expression for facts and ideas that are already known to most of the petroleum geologists active in southern Arkansas and northern Louisiana. Although many of the facts presented in this paper have not been published previously, very few of the facts or ideas are original to the writer. Most of them have been acquired through discussions with the individuals mentioned above. The few original ideas presented in this report are in matters of interpretation and are possibly erroneous.

PREVIOUS WORK

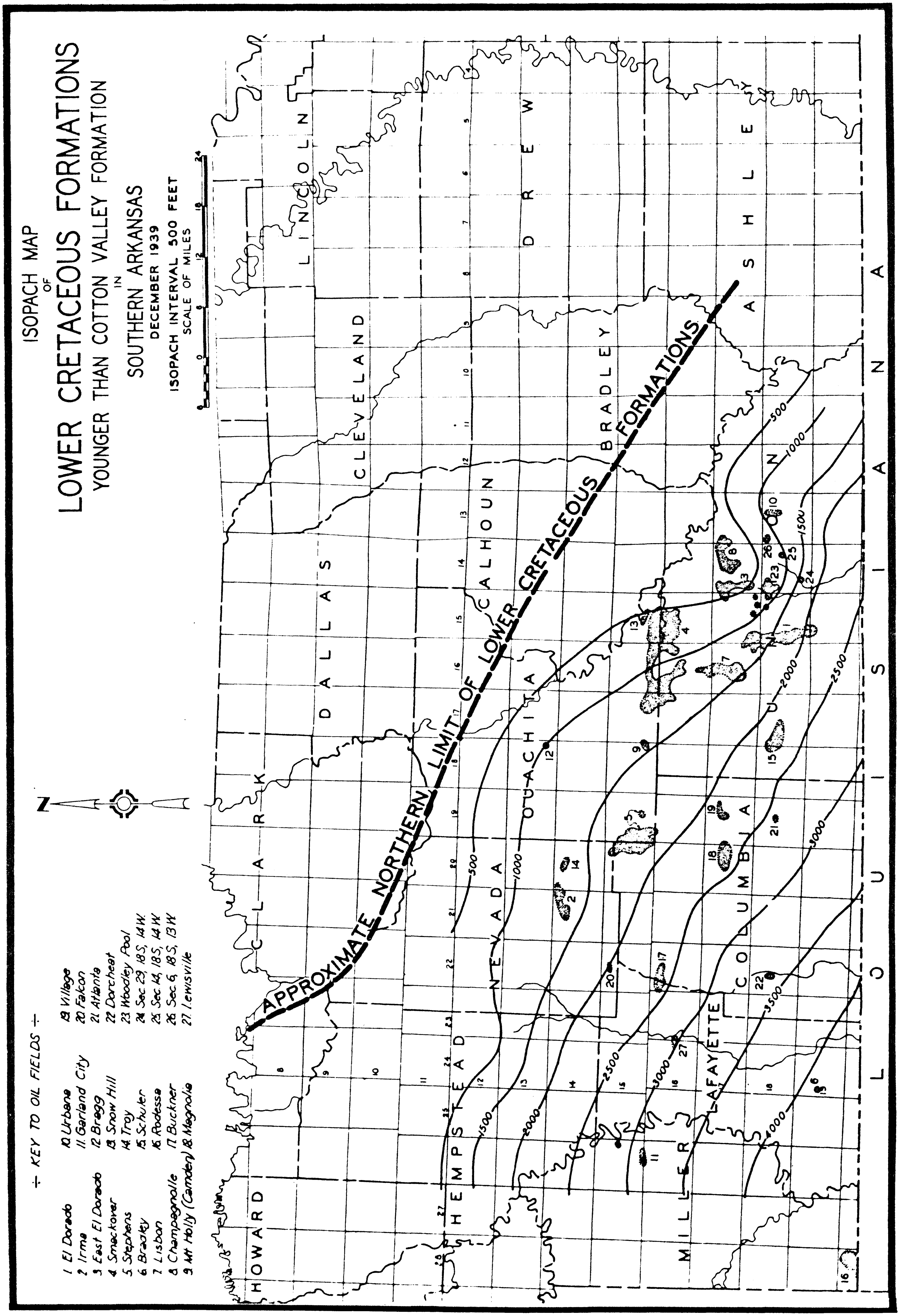
Spooner (44, p. 2, 3) discussed geologic publications concerning the Gulf Coastal Plain of Arkansas and listed the more important contributions to the year 1933. Since that time only a few writers have dealt with the Lower Cretaceous and Mexozoic rocks of southern Arkansas. The most important contribution is by Warren B. Weeks (51) who presents a geologic map and sections of the pre-Upper Cretaceous formations. A valuable work by Roy T. Hazzard (18) discusses the changes in lithology from Arkansas into Louisiana and the evidence for the age of the various formations of pre-Upper Cretaceous age. The writer has drawn heavily on the information presented by Mr. Weeks and Mr. Hazzard. A number of brief summary papers concerning the geology of southern Arkansas appeared in the Guide Book of the Shreveport Geological Society for 1939. The oil developments in southern Arkansas are generally discussed annually in the Bulletin of the American Association of Petroleum Geologists. These various papers are referred to in the text and are listed at the end of the report (p.62).

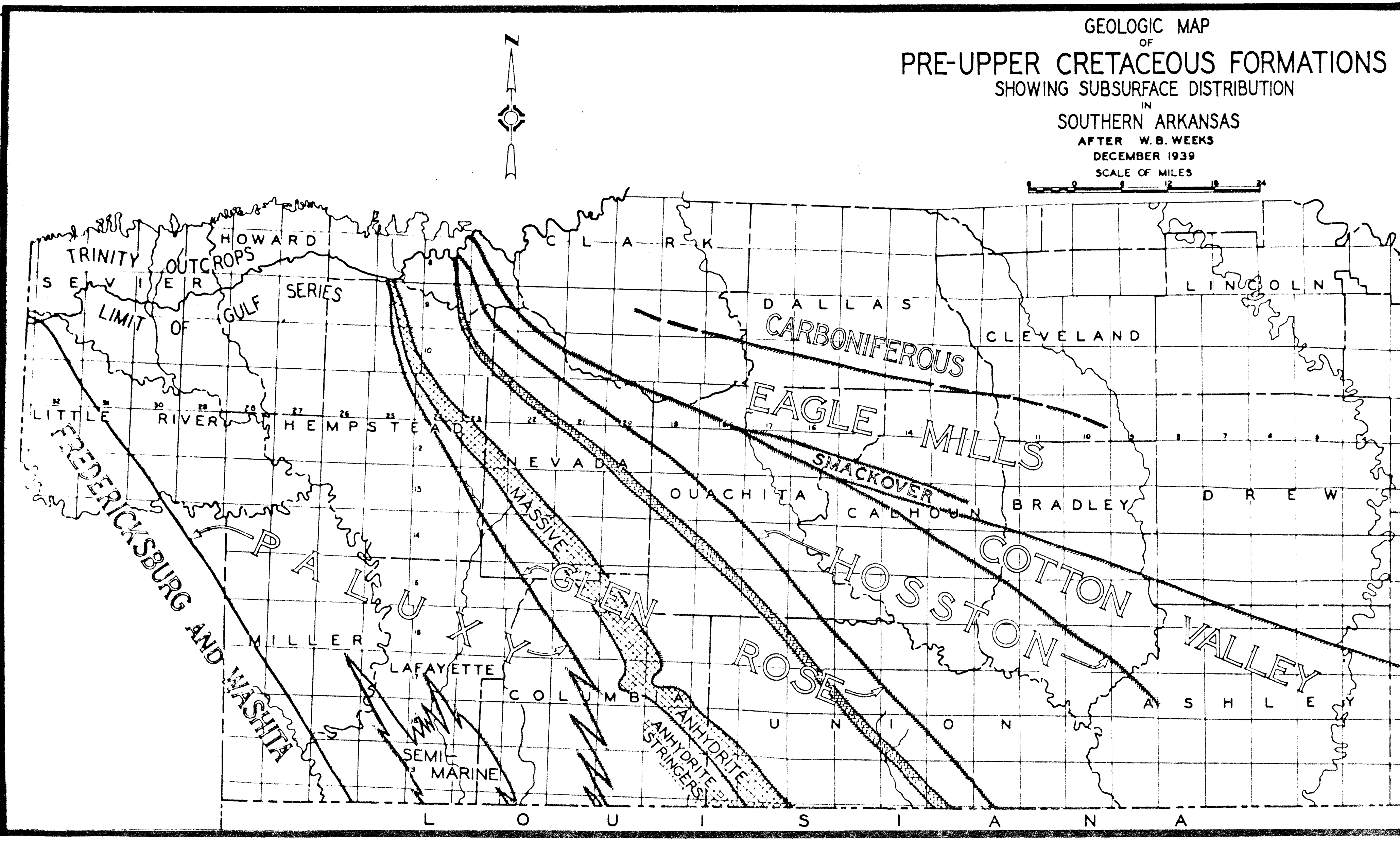
REGIONAL STRATIGRAPHY

Lower Cretaceous outcrops in Little River, Sevier, Howard, and Pike counties, Arkansas, have been known for some years and have been described in considerable detail (30; 33, p. 79-86; 44, p. 29-32; 50, p. 1069-1094). Summary descriptions of them are given in this report under the stratigraphy of Sevier, Howard, and Pike counties. During recent years deep drilling in southern Arkansas and bordering states has shown that these Lower Cretaceous outcrops are the shoreward edges of extensive formations which thicken southward, and that the older Mesozoic formations of the Gulf Coastal region do not outcrop. Thousands of feet of older sediments which are definitely of Lower Cretaceous and Jurassic age lie beneath the Upper Cretaceous sediments of southern Arkansas, northern Louisiana, eastern Texas, and west-central Mississippi. Formations of Lower Cretaceous age, from youngest to oldest, include the Kiamichi, Goodland, Walnut, Paluxy, Glen Rose equivalents (Mooringsport, Ferry Lake, Rodessa, Pine Island, and Sligo), and Hosston. An isopach map of the Lower Cretaceous formations younger than Cotton Valley in southern Arkansas is shown in Plate II. Fossil evidence indicates that the underlying Cotton Valley and Buckner formations are of Upper Jurassic age. The Smackover limestone is definitely of Jurassic age and is not older than Middle Jurassic. The lowest Mesozoic rocks penetrated by drilling are not older than Jurassic. The distribution of these formations is shown in Plate III. The formations and their approximate thicknesses are set forth in Table 1.

Table 1. Thicknesses in feet of Lower Cretaceous and Jurassic formations in southern Arkansas and northern Louisiana

	Arkansas		Louisiana
	Surface	Subsurface	Subsurface
Lower Cretaceous			
Undifferentiated beds of Washita age		100+	100+
Kiamichi shale	20)	300	400
Goodland limestone	50)		
Walnut formation	)		
Paluxy formation	160 - 270	1,200)	1,600
Mooringsport formation	30 - 75	730)	
Ferry Lake anhydrite	3 - 14	500	500
Rodessa formation	150 - 340	500	500
Pine Island formation	50 - 200	280	500
Sligo formation		160	300
Hosston formation		800 - 1,600	2,300
Jurassic			
Cotton Valley formation		1,400 - 2,275	3,175
Buckner formation and equivalents		100 - 275	495
Smackover limestone and equivalents		450 - 900	1,200
Eagle Mills red beds and equivalent salt		1,000 - 1,200	1,250
Morehouse formation			1,190
Total in feet	393 - 969	3,750 -10,020	13,510


ISOPACH MAP
OF
LOWER CRETACEOUS FORMATIONS
YOUNGER THAN COTTON VALLEY FORMATION
IN
SOUTHERN ARKANSAS
DECEMBER 1939
ISOPACH INTERVAL 500 FEET
SCALE OF MILES
0 6 12 18 24
KEY TO OIL FIELDS
1 El Dorado
2 Irma
3 East El Dorado
4 Smackover
5 Stephens
6 Bradley
7 Lisbon
8 Champagnolle
9 Mt Holly (Camden)
10 Urbana
11 Garland City
12 Bragg
13 Snow Hill
14 Troy
15 Schuler
16 Rodessa
17 Buckner
18 Magnolia
19 Village
20 Falcon
21 Atlanta
22 Dorcheat
23 Woodley Pool
24 Sec 29, 18S, 14W.
25 Sec 14, 18S, 14W.
26 Sec 6, 18S, 13W.
27 Lewisville
APPROXIMATE NORTHERN LIMIT OF LOWER CRETACEOUS FORMATIONS
HOWARD
CLARK
DALLAS
CLEVELAND
LINCOLN
DREW
HEMPSTEAD
NEVADA
OUACHITA
CALHOUN
BRADLEY
ASHLEY
MILLER
LAFAYETTE
COLUMBIA
UNION
LOUISIANA
500
1000
1500
2000
2500
3000
3500
4000


GEOLOGIC MAP
OF
PRE-UPPER CRETACEOUS FORMATIONS
SHOWING SUBSURFACE DISTRIBUTION
IN
SOUTHERN ARKANSAS
AFTER W. B. WEEKS
DECEMBER 1939
SCALE OF MILES
N
TRINITY OUTCROPS
LIMIT OF GULF SERIES
FREDERICKSBURG AND WASHITA
PALUXY
GLEN ROSE
MASSIVE
ANHYDRITE
ANHYDRITE STRINGERS
SEMI-MARINE
HOSSTON
COTTON VALLEY
SMACKOVER
EAGLE MILLS
CARBONIFEROUS
HOWARD
SEVIER
LITTLE RIVER
HEMPSTEAD
NEVADA
CLARK
DALLAS
CLEVELAND
LINCOLN
OUACHITA
CALHOUN
BRADLEY
DREW
MILLER
LAFAYETTE
COLUMBIA
UNION
ASHLEY
LOUISIANA

From Arkansas southward into Louisiana and southwestward into east Texas, the Lower Cretaceous and Jurassic formations change from littoral and nearshore, shallow water deposits into offshore, shallow water deposits. The former are characterized by conglomerates, sandstones, red beds, and reef limestones and the latter by dark shales and thin-bedded limestones. Anhydrite and salt represent deposition both nearshore and offshore. Nearly all deposits grade into red beds shoreward.

Accompanying the southward change in facies is a marked increase in thickness of deposits. Thus the Lower Cretaceous formations at the outcrop in Arkansas are about 700 feet thick and are over 6,000 feet in northern Louisiana where they do not outcrop. The subsurface Jurassic formations range in thickness from about 3,000 feet in Arkansas to over 7,000 feet in northern Louisiana. The greater thickness of sediments in Louisiana than in Arkansas can be explained only by progressively greater subsidence of the sea floor toward the south. Apparently most of the sinking occurred south of a hinge-line marked at present by a zone of faults which extends eastward across southern Arkansas in an arcuate plan roughly parallel to the trend of the Ouachita Mountain folding. North of this hinge-line, subsidence was not great as is shown by marked thinning of the formations. Uplifts of the land masses north of the hinge-line interrupted subsidence many times and resulted in the withdrawal of the sea southward. Minor withdrawals of the sea occurred at the ends of Buckner, Cotton Valley, and Paluxy times when the shoreline must have been near the present Arkansas-Louisiana boundary. A major withdrawal of the sea occurred at the end of the Lower Cretaceous when much of the Gulf region of the United States was uplifted and eroded. In northwestern Louisiana subsidence was so much greater than in Arkansas that deposition was continuous from the beginning of Eagle Mills time to the end of the Lower Cretaceous period. Six sections have been prepared to show the changes in lithology and thickness of the various formations in southern Arkansas and northern Louisiana. The locations of these sections are shown on Plate IV and the sections themselves on Plates V, VI, VII, VIII, IX and X. The time relations of the various lithologic facies are shown diagrammatically in Table 2. Correlations of the Lower Cretaceous and Jurassic formations of southern Arkansas with those of Louisiana, Texas, and northern Mexico are shown in Table 3. A summary of the regional stratigraphy of the various formations, from oldest to youngest, follows.

The Morehouse formation consists mainly of gray to black shales and siltstones and contains minor amounts of sandy shales, sandy limestones, and red shales. The Morehouse formation is known only from northeastern Louisiana where it is at least 1,190 feet thick. It was deposited in normal marine waters probably during Jurassic time and is slightly older than the Eagle Mills formation.

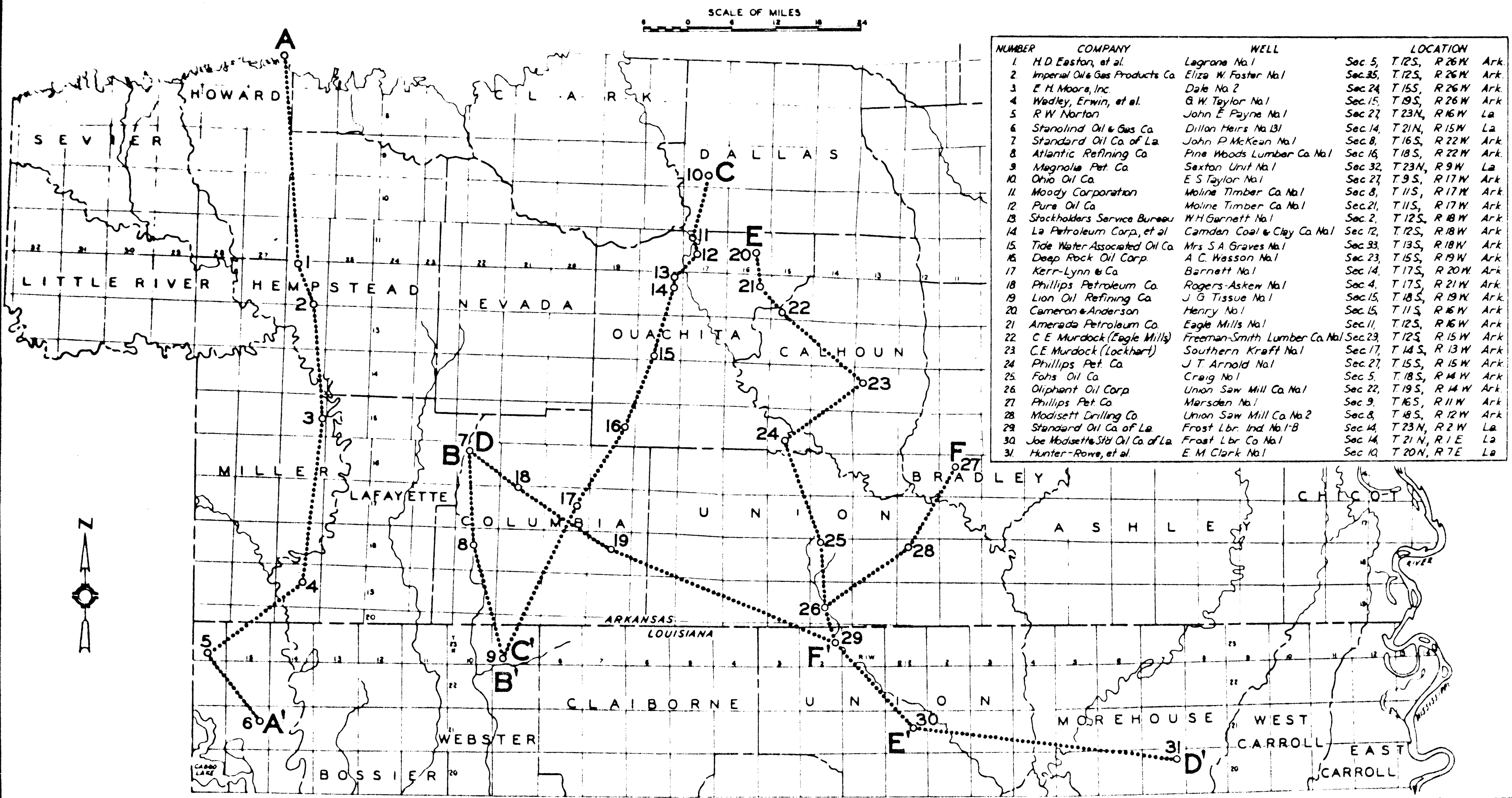
The Eagle Mills formation comprises two lithologic facies; namely, red beds and anhydrite shoreward, and salt and anhydrite basinward. These facies grade into each other along a transition zone which apparently passes through southern Bradley and Calhoun counties, central Ouachita and Nevada counties, and southern Hempstead County. Thicknesses range from 1,000 to 1,250 feet. The formation in Arkansas overlies Upper Paleozoic shale and slate with marked angular unconformity and underlies the Smackover limestone and shale with apparent conformity. In northeastern Louisiana, the Eagle Mills formation rests conformably above the Morehouse formation. The Eagle Mills formation was deposited in an Upper or Middle Jurassic sea at a time of great aridity.

The Smackover formation of Arkansas is comprised of two members. The upper member consists of oölitic to chalky limestone and the lower or dense limestone with dark argillaceous bands. These limestone facies grade southward in northwestern Louisiana into dark shales and limestones, and in northeastern Louisiana into limestones, sandstones, and dark shales. The thickness increases toward the south from about 450 to 900 feet. Equivalent shaly beds in northwestern Louisiana are over 1,200 feet in thickness. The limestone facies is overlain conformably by the Buckner anhydrite and red beds, or locally disconformably by the Cotton Valley formation. The lower member is probably partly of chemical origin and the upper member of reef origin. The Smackover formation is of Middle or Upper Jurassic age.

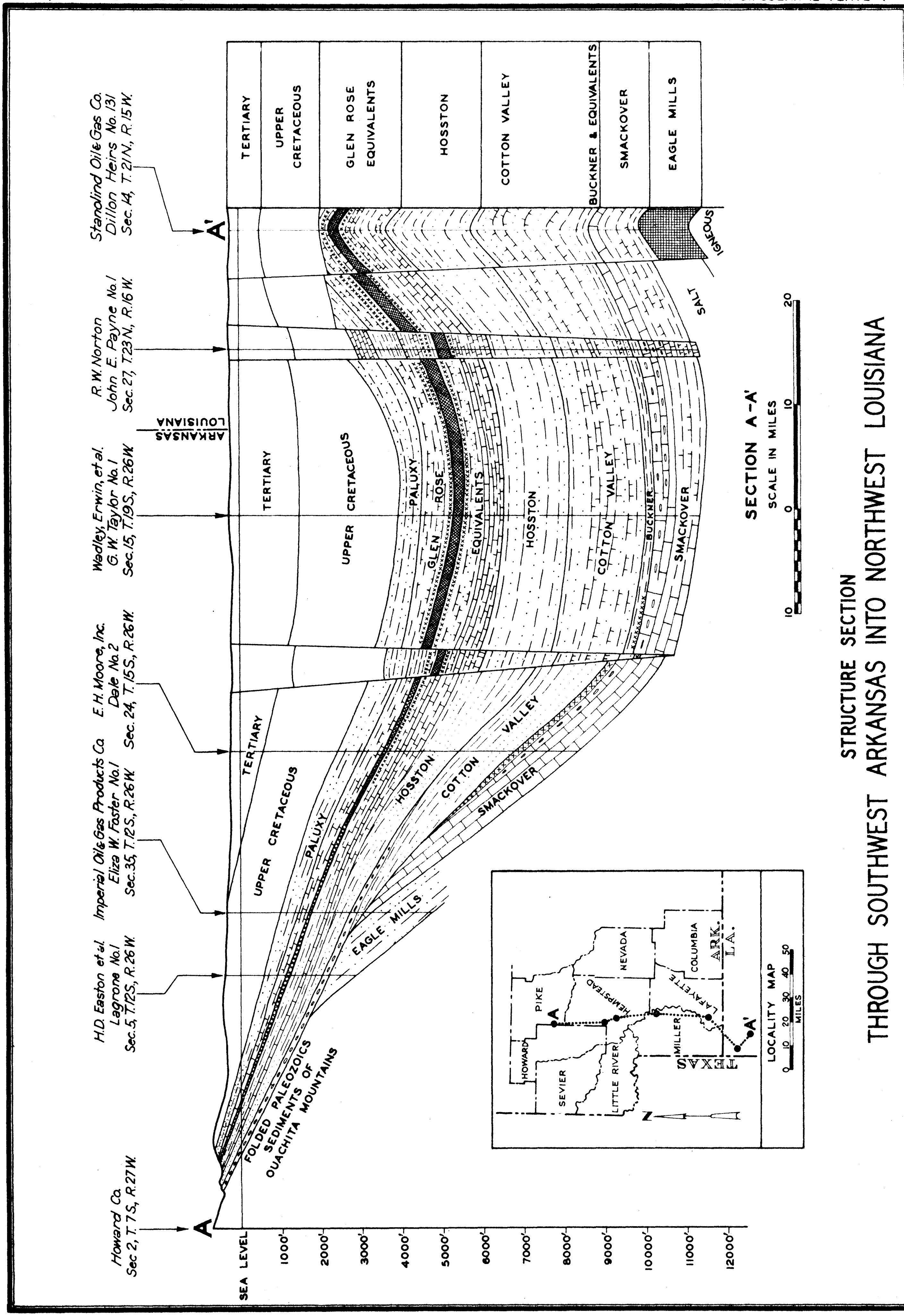
INDEX MAP

SHOWING

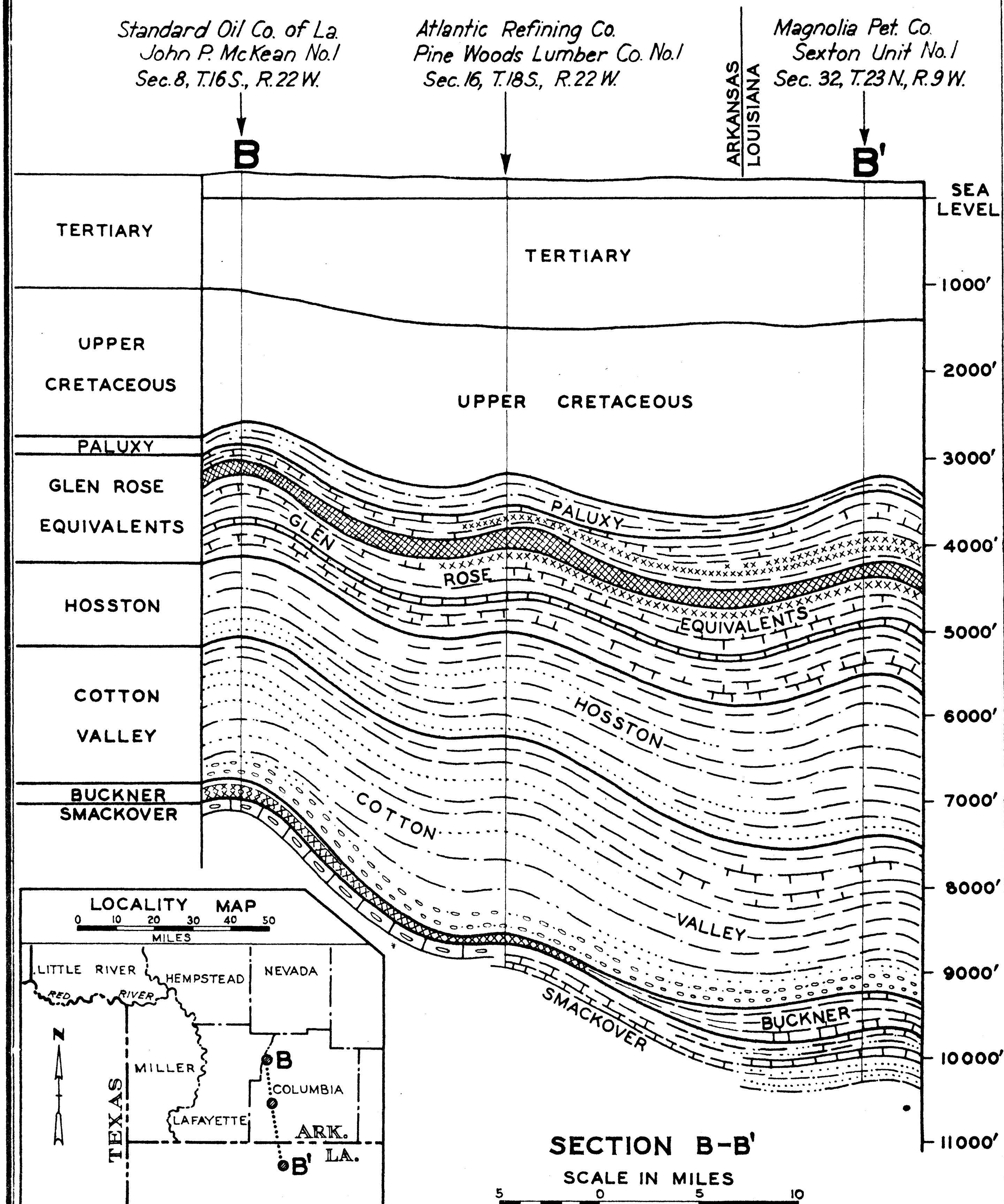
LOCATION OF STRUCTURE SECTIONS A-A' TO F-F'



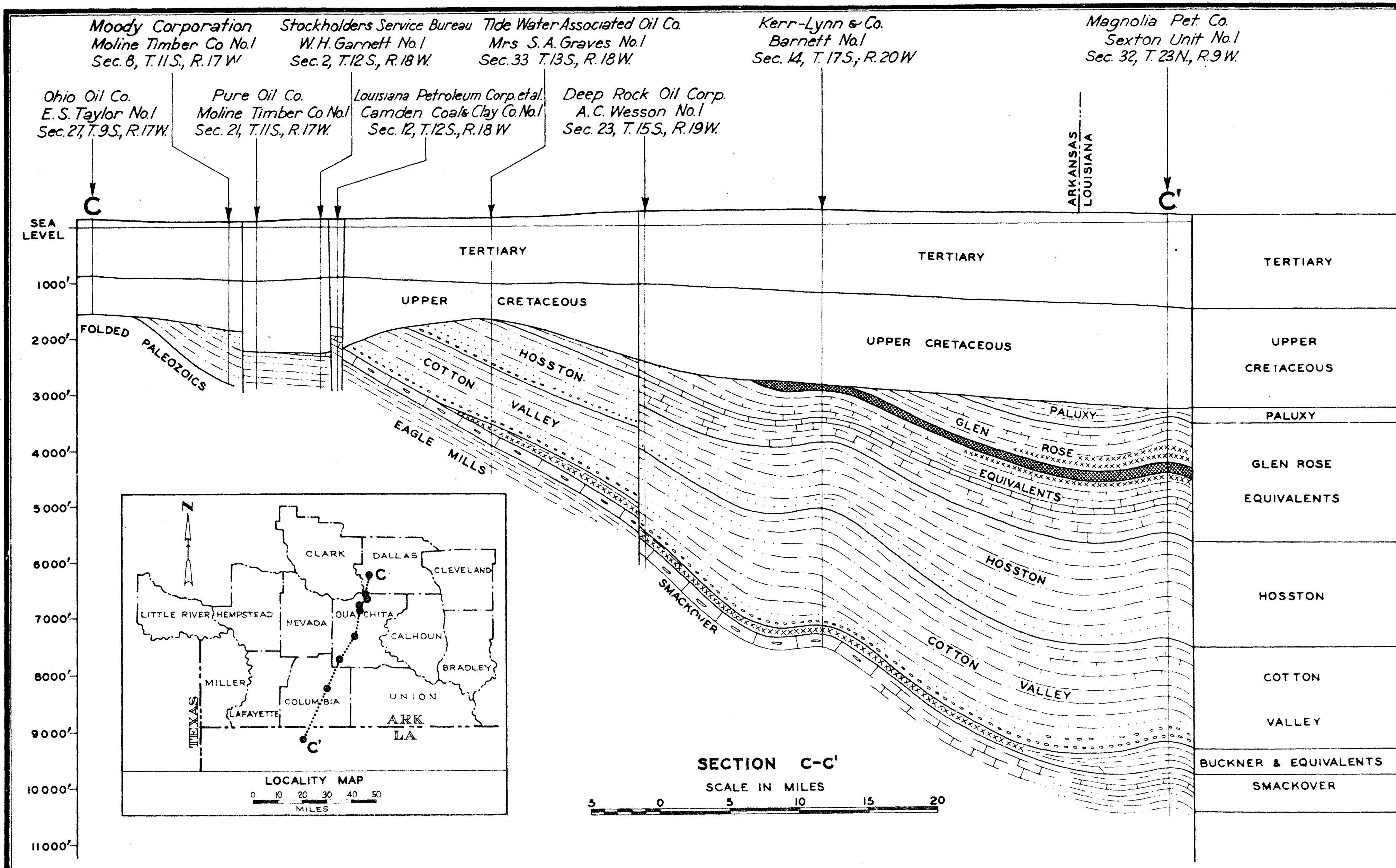
NUMBER	COMPANY	WELL	LOCATION			
1.	H D Easton, et al.	Lagrone No. 1	Sec. 5,	T. 12S.,	R 26 W.	Ark.
2.	Imperial Oil & Gas Products Co.	Eliza W. Foster No. 1	Sec. 35,	T. 12S.,	R. 26 W.	Ark.
3.	E. H. Moore, Inc.	Dale No. 2	Sec. 24,	T. 15S.,	R. 26 W.	Ark.
4.	Wadley, Erwin, et al.	G. W. Taylor No. 1	Sec. 15,	T. 19S.,	R. 26 W.	Ark.
5.	R. W. Norton	John E. Payne No. 1	Sec. 27,	T. 23N.,	R. 16 W.	La.
6.	Stanolind Oil & Gas Co.	Dillon Heirs No. 131	Sec. 14,	T. 21N.,	R. 15 W.	La.
7.	Standard Oil Co. of La.	John P. McKean No. 1	Sec. 8,	T. 16S.,	R. 22 W.	Ark.
8.	Atlantic Refining Co.	Pine Woods Lumber Co. No. 1	Sec. 16,	T. 18S.,	R. 22 W.	Ark.
9.	Magnolia Pet. Co.	Sexton Unit No. 1	Sec. 32,	T. 23N.,	R. 9 W.	La.
10.	Ohio Oil Co.	E. S. Taylor No. 1	Sec. 27,	T. 9S.,	R. 17 W.	Ark.
11.	Moody Corporation	Moline Timber Co. No. 1	Sec. 8,	T. 11S.,	R. 17 W.	Ark.
12.	Pure Oil Co.	Moline Timber Co. No. 1	Sec. 21,	T. 11S.,	R. 17 W.	Ark.
13.	Stockholders Service Bureau	W. H. Garnett No. 1	Sec. 2,	T. 12S.,	R. 18 W.	Ark.
14.	La. Petroleum Corp., et al	Camden Coal & Clay Co. No. 1	Sec. 12,	T. 12S.,	R. 18 W.	Ark.
15.	Tide Water Associated Oil Co.	Mrs. S. A. Graves No. 1	Sec. 33,	T. 13S.,	R. 18 W.	Ark.
16.	Deep Rock Oil Corp.	A. C. Wesson No. 1	Sec. 23,	T. 15S.,	R. 19 W.	Ark.
17.	Kerr-Lynn & Co.	Barnett No. 1	Sec. 14,	T. 17S.,	R. 20 W.	Ark.
18.	Phillips Petroleum Co.	Rogers-Askew No. 1	Sec. 4,	T. 17S.,	R. 21 W.	Ark.
19.	Lion Oil Refining Co.	J. G. Tissue No. 1	Sec. 15,	T. 18S.,	R. 19 W.	Ark.
20.	Cameron & Anderson	Henry No. 1	Sec. 15,	T. 11S.,	R. 16 W.	Ark.
21.	Amerada Petroleum Co.	Eagle Mills No. 1	Sec. 11,	T. 12S.,	R. 16 W.	Ark.
22.	C. E. Murdock (Eagle Mills)	Freeman-Smith Lumber Co. No. 1	Sec. 29,	T. 12S.,	R. 15 W.	Ark.
23.	C. E. Murdock (Lockhart)	Southern Kraft No. 1	Sec. 17,	T. 14S.,	R. 13 W.	Ark.
24.	Phillips Pet. Co.	J. T. Arnold No. 1	Sec. 27,	T. 15S.,	R. 15 W.	Ark.
25.	Fohs Oil Co.	Craig No. 1	Sec. 5,	T. 18S.,	R. 14 W.	Ark.
26.	Oliphant Oil Corp.	Union Saw Mill Co. No. 1	Sec. 22,	T. 19S.,	R. 14 W.	Ark.
27.	Phillips Pet. Co.	Marsden No. 1	Sec. 9,	T. 16S.,	R. 11 W.	Ark.
28.	Modisett Drilling Co.	Union Saw Mill Co. No. 2	Sec. 8,	T. 18S.,	R. 12 W.	Ark.
29.	Standard Oil Co. of La.	Frost Lbr. Ind. No. 1-B	Sec. 14,	T. 23N.,	R. 2 W.	La.
30.	Joe Modisette-Std. Oil Co. of La.	Frost Lbr. Co. No. 1	Sec. 14,	T. 21N.,	R. 1 E.	La.
31.	Hunter-Rowe, et al.	E. M. Clark No. 1	Sec. 10,	T. 20N.,	R. 7 E.	La.



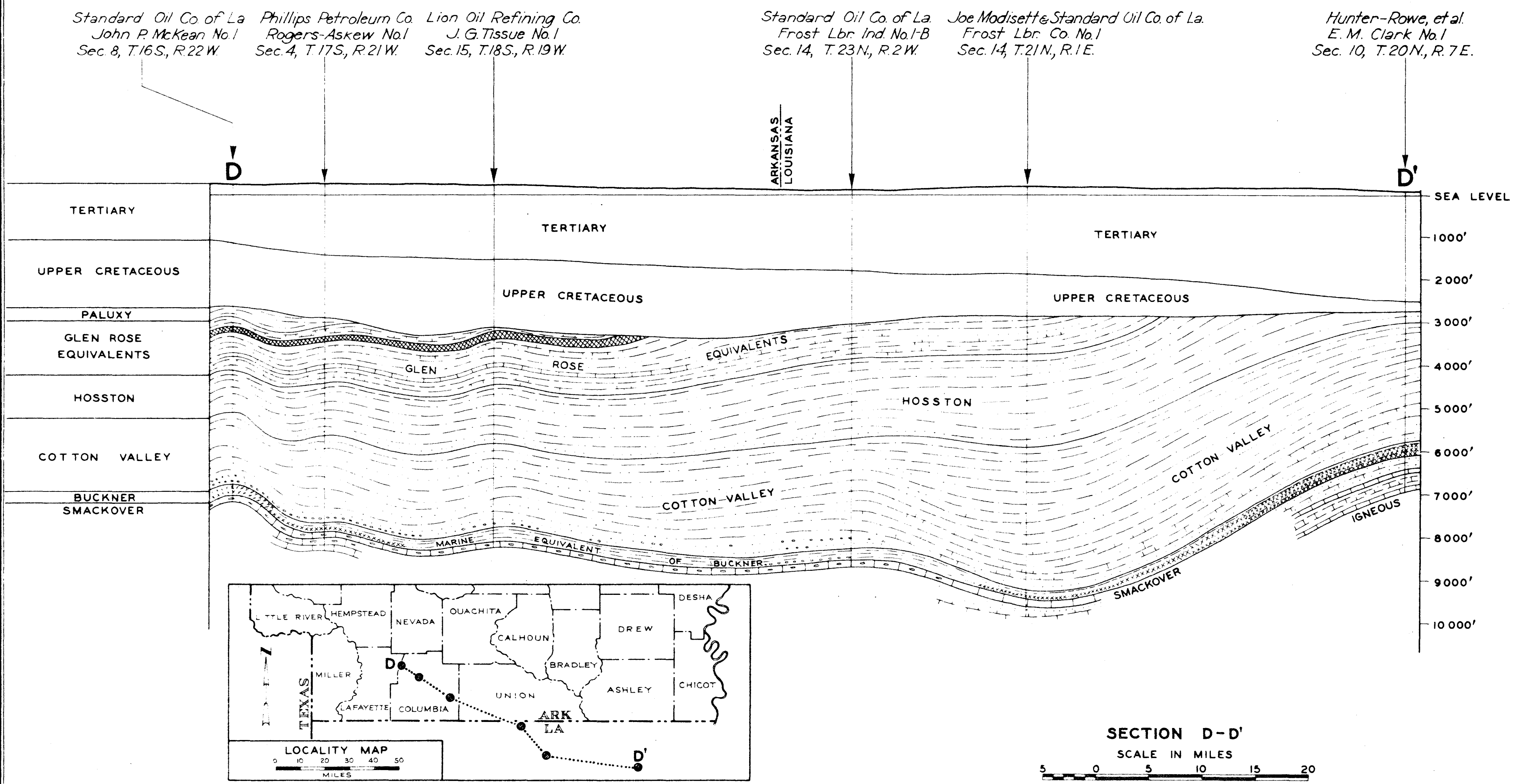
STRUCTURE SECTION
THROUGH SOUTHWEST ARKANSAS INTO NORTHWEST LOUISIANA



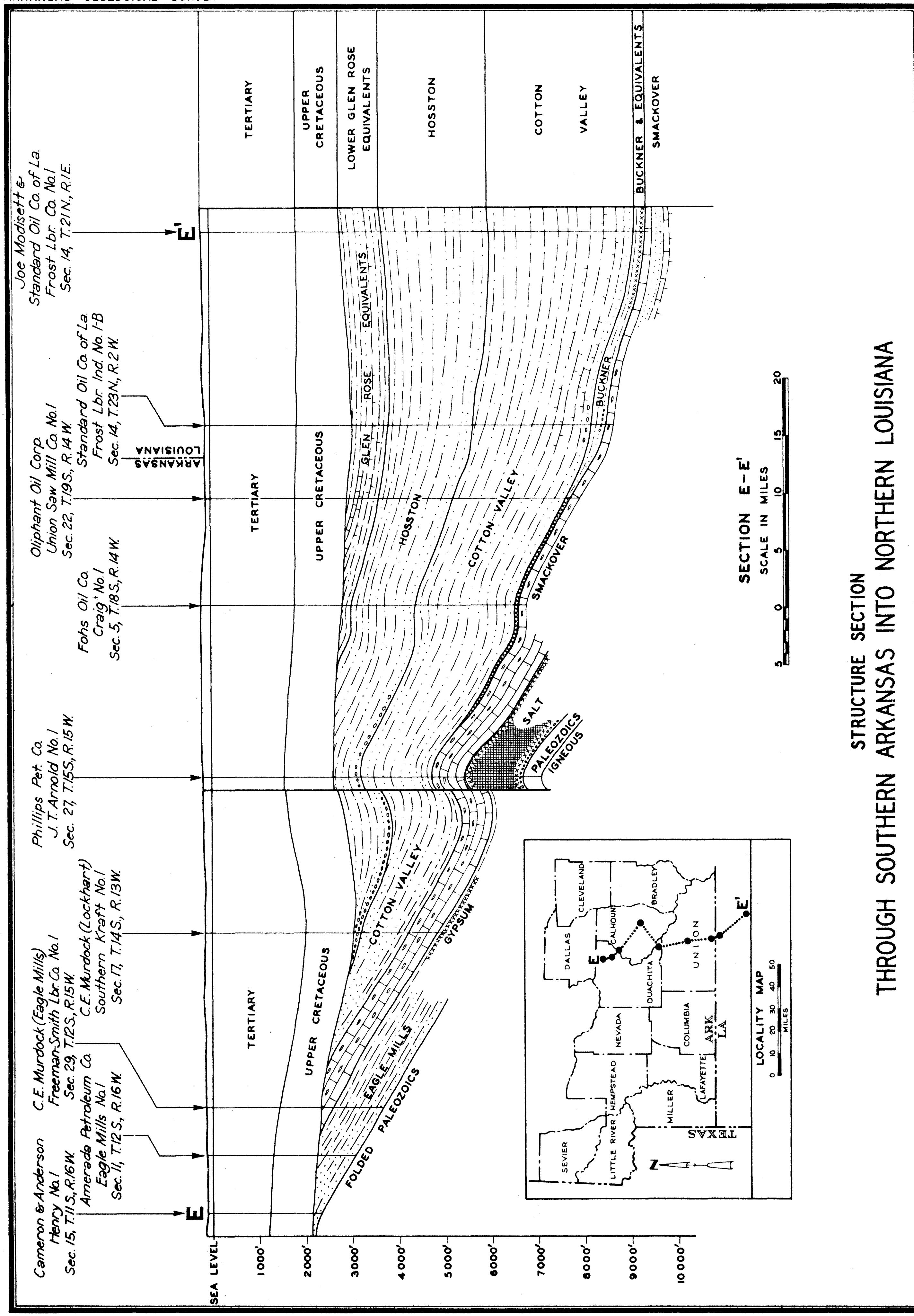
STRUCTURE SECTION
THROUGH COLUMBIA COUNTY, ARKANSAS INTO LOUISIANA



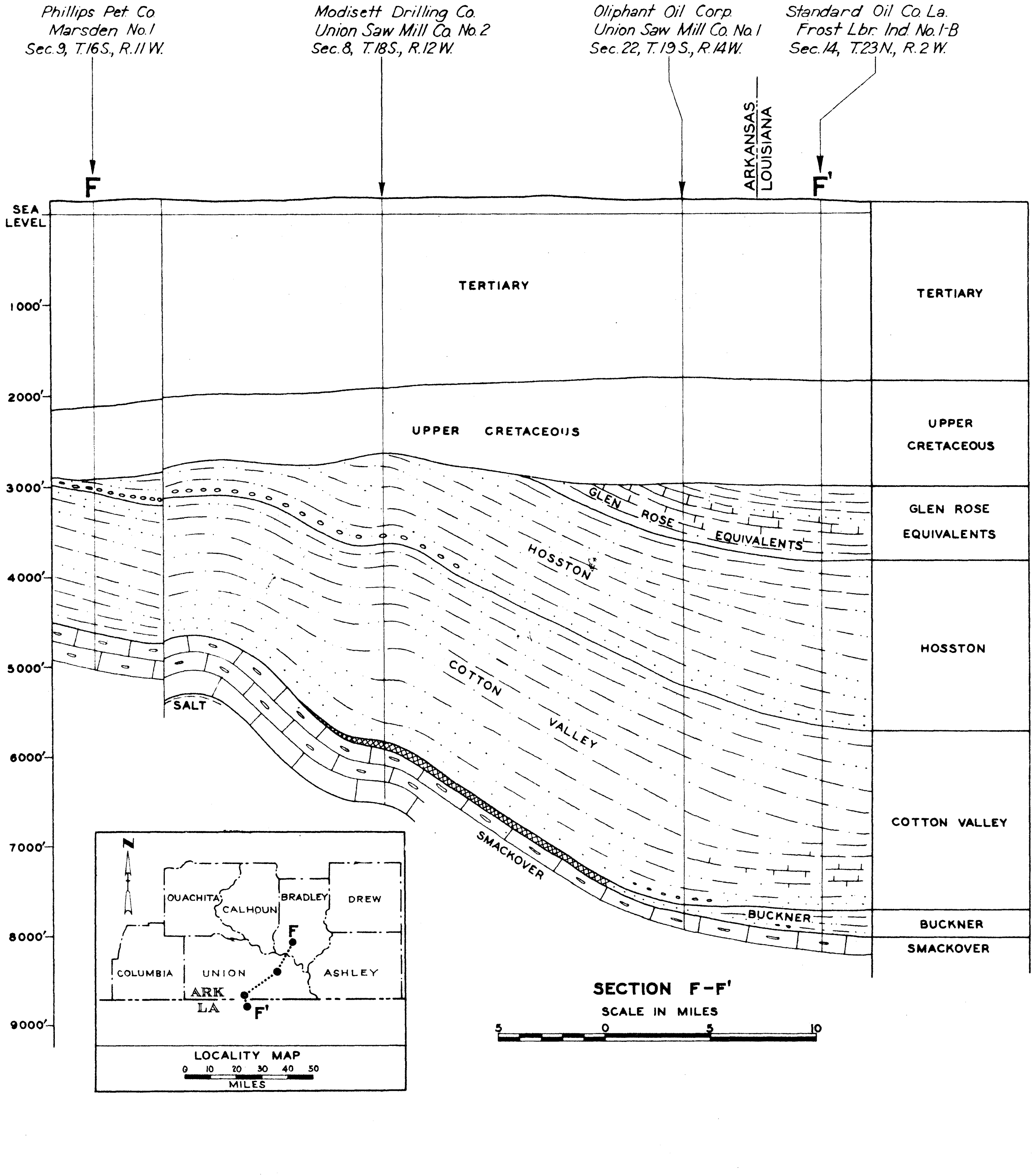
STRUCTURE SECTION
THROUGH SOUTH-CENTRAL ARKANSAS INTO LOUISIANA



STRUCTURE SECTION
THROUGH SOUTHERN ARKANSAS INTO NORTHEASTERN LOUISIANA



STRUCTURE SECTION
THROUGH SOUTHERN ARKANSAS INTO NORTHERN LOUISIANA



STRUCTURE SECTION
THROUGH SOUTHEASTERN ARKANSAS INTO LOUISIANA

Table 2. Time relations of Lower Cretaceous and Jurassic formations in southern Arkansas and northern Louisiana

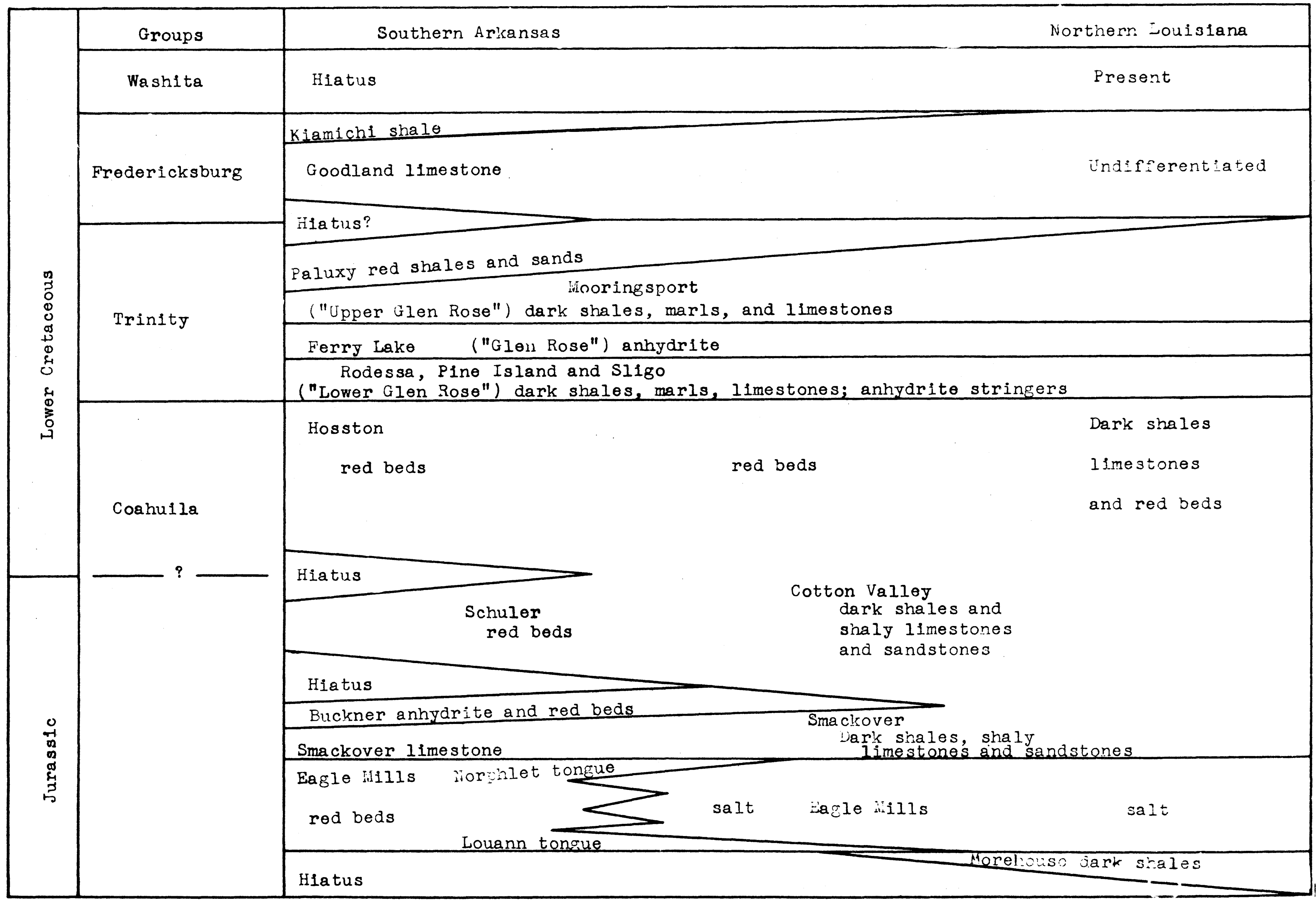


TABLE 3. CORRELATION OF LOWER CRETACEOUS AND JURASSIC DEPOSITS OF THE GULF COAST, TEXAS, AND NORTHERN MEXICO.

	European equivalents	Gulf Coast and Mexican groups	Sierra de Parras, southern Coahuila, Mexico (R. W. Imlay)	Menchaca Uplift, eastern Coahuila, Mexico (R. W. Imlay)	Southwestern Texas modified (after Adkins)	North-central Texas (after Adkins and Thompson in part)	Southern Arkansas and northern Louisiana: Modified after Hazzard & Blanpied	Southern Arkansas and northern Louisiana: Presented in this report
Lower Cretaceous	Upper Albian	Lower Washita	Cuesta del Cura limestone		Georgetown Kiamichi	Main Street Paw Paw Weno Denton Fort Worth Duck Creek Kiamichi fm.	Absent on surface Undifferentiated in subsurface Kiamichi fm.	Absent on surface Undifferentiated in subsurface Kiamichi fm.
Lower Cretaceous	Middle Albian	Fredericksburg	Aurora limestone	Aurora limestone	Finlay	Gates-ville fm. / Edwards, Comanche Peak Walnut	Gates-ville fm. / Goodland ls. Walnut	Gates-ville fm. / Goodland ls. Walnut
Lower Cretaceous	Lower Albian	Trinity	Aurora limestone	Aurora limestone Cuchillo fm.	Glen Rose limestone Cuchillo fm.	Paluxy fm. Glen Rose limestone	Paluxy fm. Upper Glen Rose Glen Rose anhydrite Lower Glen Rose: Rodessa	Paluxy "Glen Rose": Mooringsport Ferry Lake anhydrite Rodessa Pine Island
Lower Cretaceous	Aptian	Trinity / Coahuila	La Pena formation ?	Cuchillo fm. ? La Mula shale ?	Cuchillo fm.	Travis Peak fm.	Lower Glen Rose: Pine Island	Sligo
Lower Cretaceous, Neocomian	Barremian	Coahuila	Parritas fm. Cupido ls. Las Vigas	Padilla limestone	Las Vigas formation	PRESENT IN NORTHEASTERN TEXAS	"Travis Peak" formation	Hosston formation
Lower Cretaceous, Neocomian	Hauterivian	Coahuila	Las Vigas	Barril viejo sh.	Las Vigas formation ?	PRESENT IN NORTHEASTERN TEXAS	"Travis Peak" formation	Hosston formation
Lower Cretaceous, Neocomian	Valanginian	Coahuila	Taraises formation	San Marcos arkose	Torcer formation	PRESENT IN NORTHEASTERN TEXAS	"Travis Peak" formation	Hosston formation
Lower Cretaceous, Neocomian	Berriasian	Coahuila	Taraises formation ? Hiatus	Menchaca ls. Unnamed shale	? Hiatus	PRESENT IN NORTHEASTERN TEXAS	"Travis Peak" formation Hiatus	Hosston formation Hiatus
Upper Jurassic	Tithonian	Not named	Hiatus	Not exposed	Hiatus ?	PRESENT IN NORTHEASTERN TEXAS	Hiatus ? Cotton Valley formation	Hiatus ? Cotton Valley formation
Upper Jurassic	Portlandian	Not named	La Casita formation	Not exposed	Malone formation	PRESENT IN NORTHEASTERN TEXAS	Cotton Valley formation	Cotton Valley formation
Upper Jurassic	Kimmeridgian	Not named	La Casita formation	Not exposed	Malone formation ?	PRESENT IN NORTHEASTERN TEXAS	? Hiatus ? Buckner fm.	? Hiatus ? Buckner fm.
Upper Jurassic	Oxfordian	Not named	La Gloria formation	Not exposed	Hiatus	PRESENT IN NORTHEASTERN TEXAS	Smackover formation ? Eagle Mills formation ?	Smackover formation ? Eagle Mills formation ? Morehouse shale

The Buckner formation of southern Arkansas consists of from 240 to 275 feet of anhydrite, dolomite and red shale and disconformably underlies the Cotton Valley formation. In northwestern Louisiana, the Buckner equivalents consists of dark shales which conformably underlie the Cotton Valley formation. It is probably a lagoonal deposit of Upper Jurassic age.

The Cotton Valley formation includes two lithologic facies; namely, reddish sandstones and shales shoreward in Arkansas, and dark shales, limestones, and sandstones basinward in northern Louisiana. These facies grade into each other along the Arkansas-Louisiana boundary. Conglomerates occur throughout the lower few hundred feet of the formation in Arkansas and locally in northern Louisiana. The formation thickens southward from about 1,400 feet in Arkansas to nearly 3,200 feet in northern Louisiana. It is overlain disconformably by the Hosston formation throughout most of southern Arkansas, but is apparently conformably with the Hosston formation in most of northern Louisiana. The Cotton Valley formation was deposited in a shallow transgressing sea, probably during Upper Jurassic time. The main sources of sediments lay to the north and northeast.

The Hosston formation consists of two lithologic facies like those of the Cotton Valley formation, and the shoreward red bed facies extends farther south than the red beds of the Cotton Valley formation. In Arkansas, the lower hundred feet contains conglomerates. The thickness increases southward from about 50 feet in Pike and Howard counties, Arkansas, to over 2,000 feet in northern Louisiana. The Hosston formation belongs in the Coahuila group of early Lower Cretaceous age and is overlain by the Sligo formation. It was probably deposited in brackish water.

The Lower Glen Rose formation is herein divided from bottom to top into the Sligo, Pine Island, and Rodessa formations. The Sligo formation consists of dark shale which contain many lenses of limestone and sandstone. The Pine Island formation is much shalier than the Sligo formation and contains some red beds. The Rodessa formation consists of oölitic to coquinoid limestone, calcareous shale, and locally, two anhydrite beds. The Rodessa is mainly dark-colored but contains some red beds. These formations thicken southward from about 350 feet at the outcrop in Arkansas to over 1,200 feet in the subsurface in northern Louisiana. They were deposited in a shallow transgressing sea of lower Trinity; i. e., middle Lower Cretaceous age. The source of the sediments in Arkansas was from the north and northeast.

The Ferry Lake anhydrite consists mainly of white to gray, finely crystalline anhydrite, but includes minor amounts of shale, limestone, and dolomite. The thickness ranges from about 10 feet at the outcrop to over 500 feet subsurface in southwestern Arkansas. The Ferry Lake anhydrite was formed during a marked shoaling of the sea and is possibly a lagoonal deposit of Lower Cretaceous age.

The Mooringsport formation consists dominantly of marine shale and limestone which grade upward and northward into the Paluxy formation. The thickness ranges from about 70 feet at the outcrop in Arkansas to about 800 feet in the subsurface in northwestern Louisiana. It was deposited in shallow marine waters during Upper Trinity time.

The Paluxy formation in Arkansas consists of non-fossiliferous variegated shales and sands which are overlain by the Goodland (Comanche Peak) limestone. The thickness in Arkansas ranges from about 200 feet at the outcrop to about 1,200 feet subsurface. The Paluxy formation was deposited in a very shallow sea during Upper Trinity time.

The Goodland (Comanche Peak) limestone in Arkansas consists mainly of white, chalky limestone and gray, sandy limestone. The thickness at the outcrop near Cerro Gordo, Arkansas, is about 50 feet but in the subsurface increases to over 100 feet. In the subsurface it is probably underlain by the Walnut formation. The Goodland limestone was deposited in shallow waters fairly near shore and belongs in the Fredericksburg group of Lower Cretaceous age.

The Kiamichi formation in Arkansas consists of marls, marly clays, thin beds of limestones, and shell beds, and is apparently mostly limestone in the Rodessa field. The thickness at the outcrop near Cerro Gordo is about 20 feet and increases to about 100 feet in the subsurface. The Kiamichi formation was probably deposited in shallower water than the underlying Goodland limestone and is Upper Fredericksburg or early Washita in age.

JURASSIC SYSTEM

MOREHOUSE SHALE

Definition. The name, Morehouse, has been chosen by the Shreveport Geological Society to designate 1,190 feet of marine silty shales and thin siltstones penetrated at depths of from 9,285 to 10,475 feet in the Union Producing Company's Tensas Delta No. 1-A well located in Sec. 8, T. 22 N., R. 4 E., Morehouse Parish, Louisiana. The name is herein presented for the first time. The Morehouse formation underlies the Eagle Mills formation apparently conformably and gradationally. The base of this formation has not been determined. It is known from the type well but probably underlies a fairly large area.

Lithologic and stratigraphic features. The Morehouse formation consists mainly of gray, brownish gray, and black shales and siltstones but contains minor amounts of gray sandy shales, gray sandy limestones, and red shales. The shales are carbonaceous, siliceous, or finely micaceous, and are less commonly dolomitic or calcareous. Some beds contain carbonized or pyritized plant remains. The upper few feet of the formation contains streaks of anhydrite. The presence of this anhydrite suggests a gradational contact with the overlying red and white shales and anhydrite at the base of the Eagle Mills formation.

The type section of the Morehouse formation in the Union Producing Company's Tensas Delta No. 1-A well, from top to bottom, is as follows:

Section of the Morehouse shale in Union Producing Company's Tensas Delta No. 1-A well, Sec. 8, T. 22 N., R. 4 E. Morehouse Parish, Louisiana

	Depth (in feet)	Thickness (in feet)
Shale, dark gray to black, hard, non-calcareous, finely micaceous, fissile, carbonaceous, fossiliferous, contains thin parting of siltstone and streaks of anhydrite. Is overlain by hard red and gray shales of the Eagle Mills formation	9,285 - 9,316	31
Limestone, shaly, hard, black	9,316 - 9,330	14
Shale, black, hard, streaks of sandstone in lower two-thirds	9,330 - 9,362	32
Limestone, shaly, hard, black	9,362 - 9,375	13
Limestone, sandy, hard, black	9,375 - 9,395	20
Shale, calcareous, hard	9,395 - 9,408	13
Shale, black to gray, hard, fissile, non-calcareous, slightly silty, fossiliferous	9,408 - 9,526	118
Shale and limestone, black to gray, hard	9,526 - 9,535	9
Shale, sandy, gray, hard	9,535 - 9,553	18
Shale	9,553 - 9,563	10
Shale, sandy, gray to tannish gray, some reddish patches and streaks, hard, siliceous, finely micaceous	9,563 - 9,584	21
Shale, gray to black, hard	9,584 - 9,890	306

	Depth (in feet)	Thickness (in feet)
Shale and sandy shale, black, hard.	9,890 - 9,898	8
Shale, black, hard, micaceous, interlaminated with siliceous.	9,898 - 10,045	147
Shale, red and black.	10,045 - 10,053	8
Shale, black.	10,053 - 10,057	4
Shale, black, streaked with red	10,057 - 10,065	8
Shale, black and red, hard.	10,065 - 10,075	10
Shale, black to gray, hard.	10,075 - 10,095	20
Shale, sandy gray	10,095 - 10,105	10
Shale, black, hard, some plant remains.	10,105 - 10,218	113
Shale, sandy, gray, hard.	10,218 - 10,225	7
Limestone, sandy, gray, hard.	10,225 - 10,230	5
Shale, black, hard, finely micaceous, some carbonized plant remains, some siliceous streaks	10,230 - 10,315	85
Limestone, sandy, gray, hard.	10,315 - 10,323	8
Shale, gray, hard	10,323 - 10,333	10
Shale, sandy shale, and sandstone, gray, hard .	10,333 - 10,340	7
Shale, sandy, gray, hard.	10,340 - 10,364	24
Shale, gray to black, hard.	10,364 - 10,464	100
Sandstone, gray, hard	10,464 - 10,475	11
Total thickness in feet		1,190

Correlation. The Morehouse formation is probably of Jurassic age as indicated by the occurrence of a fossil sponge obtained at a depth of 9,304-9,305 feet in the type section. This sponge probably belongs in the family Staurodermidae which is known only from the Jurassic. Some pelecypods obtained from the type section are reported to be Mesozoic forms, but the writer has not had the opportunity to examine them.

Origin. A normal marine environment of deposition for the Morehouse formation is indicated by the presence of carbonaceous material and marine fossils. The predominance of siliceous and micaceous sediments over calcareous sediments possibly indicates rapid deposition near shore but might be due to certain climatic conditions on the landmasses, or to the character of the rocks from which the sediments were derived.

EAGLE MILLS FORMATION

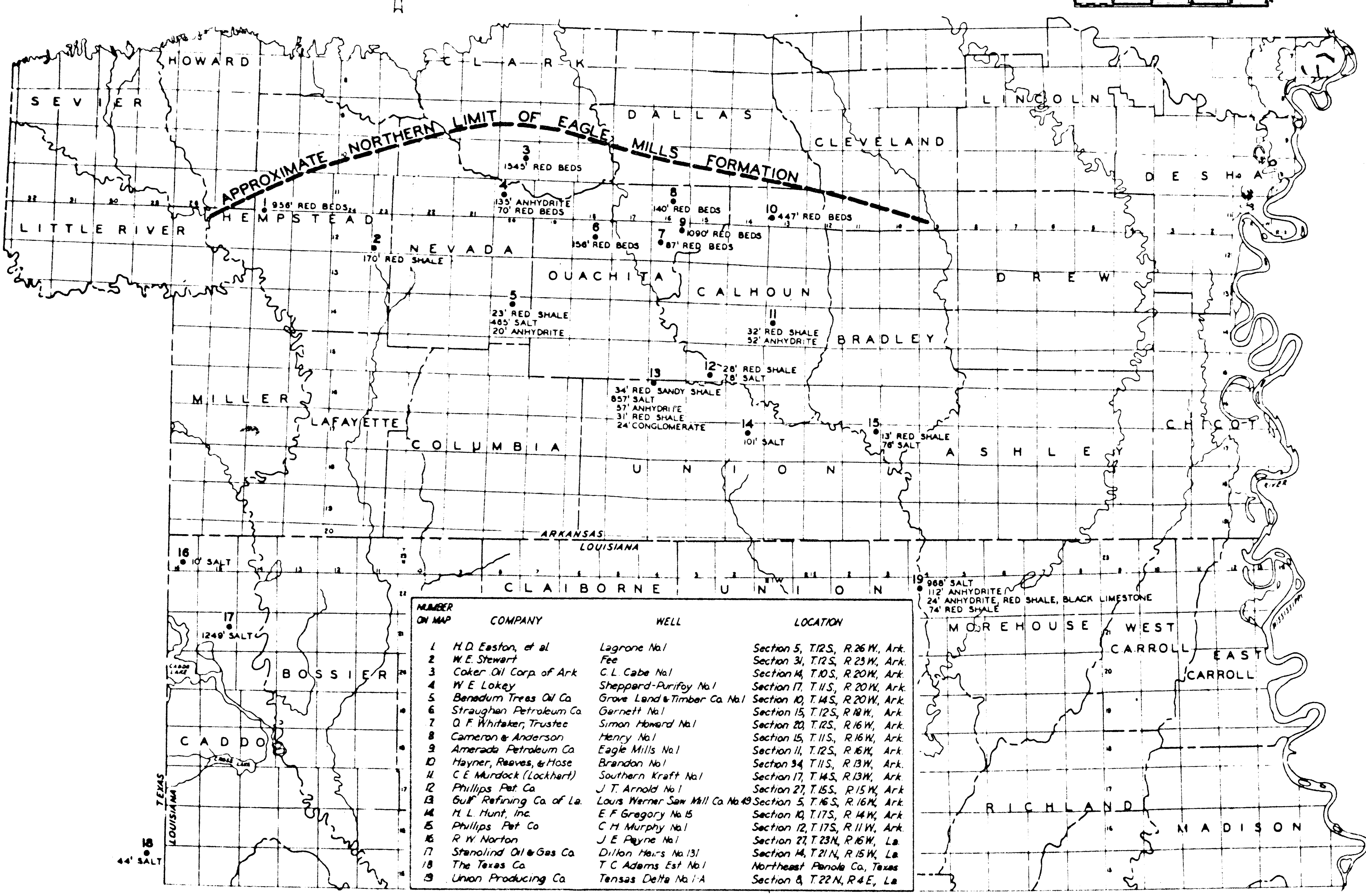
Definition. The Eagle Mills formation was named by the Shreveport Geological Society (16, p. 285) after the Amerada Petroleum Company's Eagle Mills No. 1 well in Sec. 11, T. 12 S., R. 16 W., just north of Eagle Mills in Ouachita County, Arkansas, where the formation consists of about 1,190 feet of hard red shale, sandy shale, and sandstone. In Arkansas it overlies with marked angular unconformity the Upper Paleozoic shale and slate and underlies with apparent conformity the Smackover limestone. Southward from the type locality the red beds pass rather abruptly into thick rock salt that contains minor amounts of anhydrite. The salt is bounded at top and bottom, in most sections in Arkansas, by red beds and associated anhydrite which constitute southward spreading tongues from the main mass of red beds. The upper red beds are herein defined as the Norphlet tongue and the lower red beds as the Louann tongue after localities in the Smackover field. These names have been proposed by the Shreveport Geological Society.

Distribution and thickness. The distribution and general lithology of the Eagle Mills formation in Arkansas is shown on Plate XI. The formation, which probably at one time extended considerably farther north, pinches out a little north of Ouachita and Nevada counties due to erosion previous to Upper Cretaceous deposition. According to Weeks[1]

[1] Personal communication

MAP OF EAGLE MILLS FORMATION SHOWING DISTRIBUTION, LITHOLOGY, AND PENETRATED THICKNESSES

DECEMBER 1939



NUMBER ON MAP	COMPANY	WELL	LOCATION
1	H.D. Easton, et al	Lagrone No.1	Section 5, T.12S., R.26W., Ark.
2	W.E. Stewart	Fee	Section 31, T.12S., R.23W., Ark.
3	Coker Oil Corp. of Ark	C.L. Cabe No.1	Section 14, T.10S., R.20W., Ark.
4	W.E. Lokey	Sheppard-Purifoy No.1	Section 17, T.11S., R.20W., Ark.
5	Benedum Trees Oil Co.	Grove Land & Timber Co. No.1	Section 10, T.14S., R.20W., Ark.
6	Straughan Petroleum Co.	Garnett No.1	Section 15, T.12S., R.19W., Ark.
7	O.F. Whitaker, Trustee	Simon Howard No.1	Section 20, T.12S., R.16W., Ark.
8	Cameron & Anderson	Henry No.1	Section 15, T.11S., R.16W., Ark.
9	Amerada Petroleum Co.	Eagle Mills No.1	Section 11, T.12S., R.16W., Ark.
10	Hayner, Reeves, & Hose	Brandon No.1	Section 34, T.11S., R.13W., Ark.
11	C.E. Murdock (Lockhart)	Southern Kraft No.1	Section 17, T.14S., R.13W., Ark.
12	Phillips Pet. Co.	J.T. Arnold No.1	Section 27, T.15S., R.15W., Ark.
13	Gulf Refining Co. of La.	Louis Werner Saw Mill Co. No.49	Section 5, T.16S., R.16W., Ark.
14	H.L. Hunt, Inc.	E.F. Gregory No.15	Section 10, T.17S., R.14W., Ark.
15	Phillips Pet. Co.	C.H. Murphy No.1	Section 12, T.17S., R.11W., Ark.
16	R.W. Norton	J.E. Payne No.1	Section 27, T.23N., R.16W., La.
17	Stanolind Oil & Gas Co.	Dillon Heirs No.131	Section 14, T.21N., R.15W., La.
18	The Texas Co.	T.C. Adams Est. No.1	Northeast Panola Co., Texas
19	Union Producing Co.	Tensas Delta No.1-A	Section 8, T.22N., R.4E., La.

the apparent absence of dark Devonian (?) novaculite fragments in the Eagle Mills formation indicates that the Ouachita Mountains were covered during the deposition of the Eagle Mills formation. In contrast the abundance of novaculite in the younger Cotton Valley and Hosston formations may indicate that they were confined south of the Ouachita area. Hazzard 2/ likewise considers that the Eagle Mills sea may have transgressed far northward of the present Ouachita Mountains. He thinks that this possibility is indicated by (1) the character and thickness of the Eagle Mills formation north of the Smackover field and (2) the fact that the present dip of the Eagle Mills formation projected northward would pass over the present Ouachita Mountains.

Typical Eagle Mills red beds are known principally from central Hempstead and northern Ouachita counties. The known distribution of red beds and salt facies suggests that a transitional zone between them extends northwest through southern Bradley and Calhoun counties, curves west through central Ouachita and Nevada counties, and then curves west-southwest through southern Hempstead County. The trend of this transitional zone is thus apparently parallel to the trend of Ouachita Mountain folding.

The greatest known thickness of the Eagle Mills red beds is 1,190 feet penetrated in the type section (51, p. 963) but this is probably not the total thickness. The salt facies and associated red beds and anhydrite lenses attain a thickness of 1,003 feet in the Gulf Refining Company of Louisiana, Louis Werner Saw Mill Company No. 49 well, located in the Smackover field in Sec. 5, T. 16 S., R. 16 W., Union County, Arkansas. In this well the salt comprises about 857 feet of the total thickness. A short distance to the east of the Norphlet dome the salt has a thickness of more than 1,325 feet (51, p. 963). A thickness of 1,249 feet of rock salt occurs in the Stanolind Oil and Gas Company's Dillon Heirs No. 131 well, located in Sec. 14, T. 21 N., R. 15 W., northwestern Louisiana. As these thicknesses were obtained on structural highs, they are probably much in excess of the original thicknesses.

Lithologic and stratigraphic features. The Eagle Mills formation comprises two facies, one consisting mainly of red beds, the other of rock salt. The red bed facies has been described by Weeks (51, p. 963) as follows:

> "The red shale forming the updip and basal portion of the formation is in general harder (and more lustrous) than the younger red shales (Hosston and Cotton Valley formations) of the area and contains only a small amount of greenish gray shale. There are a few streaks of bright red argillaceous sand (stone) and more or less nodular streaks of red argillaceous dolomite, which resemble the mudstones of the red Permian beds of western Oklahoma."

A typical section of the red bed facies is shown on page 10.

2/ Personal communication

Section of red bed facies of Eagle Mills formation in Amerada Petroleum Company's Eagle Mills No. 1 well, Sec. 11, T. 12 S., R. 16 W., Ouachita County, Arkansas

	Depth (in feet)	Thickness (in feet)
Shale, sandy, red, hard, underlies Upper Cretaceous beds.	2,410 - 2,650	240
Shale, argillaceous, red, hard	2,650 - 2,680	30
Shale, sandy, red, hard.	2,680 - 2,740	60
Shale, argillaceous, red, hard	2,740 - 2,765	25
Shale, sandy, red, hard.	2,765 - 2,790	25
Shale, argillaceous, red, hard	2,790 - 2,950	160
Shale, sandy, red, hard.	2,950 - 3,095	145
Shale, argillaceous, red, hard.	3,095 - 3,150	55
Shale, sandy, red, becomes more argillaceous downward	3,150 - 3,480	330
Shale, argillaceous, red, lower contact unknown.	3,480 - 3,500	20
Total thickness in feet.		1,090

The best known section of the salt facies in Arkansas is represented by the Gulf Refining Company of Louisiana, Louis Werner Saw Mill Company No. 49 well, located in Sec. 5, T. 16 S., R. 16 W., in Union County (18, p. 171-172). In this well the Eagle Mills formation is overlain conformably by Smackover limestone and underlain with pronounced angular unconformity by 338 feet of Paleozoic (?) "mudstones" which are hard, dense, silicified, reddish to purplish and have dips of 15 to 20 degrees. The "mudstones" are intruded by diabase. The complete section of the Eagle Mills formation, from top to bottom, is as follows:

Section of salt facies in Eagle Mills formation in Gulf Refining Company of Louisiana Louis Werner Saw Mill Company No. 49 well, Sec. 5, T. 6 S., R. 16 W., Union County, Arkansas

	Depth (in feet)	Thickness (in feet)
Shale, sandy, red.	6,597 - 6,631	34
Rock salt.	6,631 - 7,488	857
Anhydrite, grayish white	7,488 - 7,545	57
Shale, red	7,545 - 7,576	31
Conglomerate with red shale matrix. Pebbles of diabase, chert, silicified shale, and dense sandstone.	7,576 - 7,600	24
Total thickness in feet.		1,003

In the above section the salt is underlain by red shale which is similar to the red shale at the type locality of the Eagle Mills formation. In nearly all sections in Arkansas where the salt has been penetrated by drilling it is overlain by 10 to 35 feet of similar red shale. Thick beds of clear white anhydrite have been penetrated in several wells either directly below the upper few feet of red beds or below the salt. In the W. E. Lokey, Sheppard-Purifoy No. 1 well, located in Sec. 17, T. 11 S., R. 20 W., about 100 feet of anhydrite separates the Smackover limestone from the underlying red beds. Weeks (51, p. 964) considers it "logical to correlate these anhydrite beds." The salt is noteworthy for its purity (43, p. 603; 51, p. 964) as it contains only a few thin lenses of white anhydrite.

The best known section of the salt facies of the Eagle Mills formation in northern Louisiana is represented by the Union Producing Company's Tensas Delta No. 1-A well located in Sec. 8, T. 22 N., R. 4 E., Morehouse Parish, Louisiana.

Section of salt facies of Eagle Mills formation in Union Producing Company's Tensas Delta No. 1-A, Sec. 8, T. 22 N., R. 4 E., Morehouse Parish, Louisiana.

	Depth (in feet)	Thickness (in feet)
Salt, contains streaks of anhydrite.	8,114 - 9,080	966
Anhydrite, gray.	9,080 - 9,190	110
Anhydrite, white, hard	9,190 - 9,202	12
Anhydrite, white, hard, contains streaks of shale.	9,202 - 9,205	3
Anhydrite, white, hard, contains streaks of limestone and red shale.	9,205 - 9,218	13
Anhydrite, red and white, interbedded with limestone and red shale.	9,218 - 9,230	12
Anhydrite, contains streaks of red shale	9,230 - 9,240	10
Shale, red and maroon, contains streaks of gray limestone and gray shale, some carbonized plant remains.	9,240 - 9,265	25
Shale, red, hard	9,265 - 9,273	8
Shale, red, and white, hard, streaks of anhydrite, overlies gray shale of Morehouse formation . .	9,273 - 9,285	12
Total thickness in feet		1,171

The base of the Eagle Mills formation in Arkansas probably marks a pronounced angular unconformity which cuts strongly folded, black, slaty shales and quartzitic sandstones of probable Upper Paleozoic age. Such an unconformity is inferred from the section in the Gulf Refining Company of Louisiana, Louis Werner Saw Mill Company No. 49 well, noted above. The base of the Eagle Mills formation in northeastern Louisiana, known only from the Union Producing Company's Tensas Delta No. 1-A well, is apparently conformable and gradational with the underlying Morehouse shale which is of Mesozoic age and probably not much older than the Eagle Mills formation. The base of the salt was likewise penetrated in northwestern Louisiana in the Stanolind Oil and Gas Company's Dillon Heirs No. 131 well located in Sec. 14, T. 21 N., R. 15 W. In this well the salt is underlain at a depth of 11,405 feet by dark, dense igneous rock which has well developed flow structure. The contact of the salt with the igneous rock was not cored. A core specimen from a depth of 11,417 to 11,419 feet has a fresh, unweathered appearance 3/ which suggests either that it is intrusive into the salt or that the salt was deposited on a peneplained surface which had a very thin mantle of decomposed rock (4, p. 760). The latter possibility seems more probable to the writer.

According to the most reliable well records, the upper contact of the Eagle Mills formation with the Smackover limestone is abrupt but conformable. The driller's log of a well in Sec. 15, T. 12 S., R. 18 W., in north-central Ouachita County, records about 70 feet of interbedded gypsum and limestone lying above the red shales. This gypsum (probably anhydrite) indicates a transitional zone between the two formations. However, a driller's log is of doubtful value and, unless founded on well cores or cuttings, the record of gypsum may be due to misinterpretation. Weeks (51, p. 964) apparently assuming that the red beds are terrestrial and the limestones are marine and therefore that marked changes had occurred in the environment of deposition, suggests that the abrupt break from red beds to marine limestone may denote a hiatus. Weeks' assumption may not be true because (1) the Eagle Mills red beds were deposited at least mainly under water, as proven by the presence of argillaceous dolomite, and (2) the lower dense, banded, argillaceous limestone of the Smackover formation was probably deposited in fairly saline waters, according to evidence presented by Hazzard (18, p. 171). The waters in which the red sediments were deposited must have been unfavorable for the growth of organisms whose decay would have reduced the ferric oxides. Since both red beds and limestone were evidently deposited in very shallow saline waters, the change in deposition from one rock

3/ Hazzard, personal communication

type to the other might be ascribed to slight changes of the strand line. The change from red beds, or salt, to limestone deposition would occur if the basin were deepened, the waters freshened, and the strand line migrated landward. There might then be an abrupt change in lithologic type but no cessation of deposition. The widely distributed thin band of red beds occurring between the salt and the Smackover limestone in southern Arkansas might have been produced (1) by a minor regression of the sea, but (2) more probably was produced by a relatively sudden transgression over a fairly level landmass which had considerable red soil. The large quantity of soil temporarily available due to submergence would probably lead to fairly wide distribution. In conclusion, an unconformity between the Eagle Mills and Smackover formations seems unlikely in view of (1) concordant relationships of the two formations, (2) the absence of basal conglomerates or of any physical evidence of an unconformity, (3) and their similar saline shallow water environment of deposition.

Correlation. The Eagle Mills formation has been tentatively assigned by various writers to periods as removed as Permian (43, p. 605; 51, p. 963), Upper Jurassic (18, p. 174-175), and Lower Cretaceous (39, p. 290-291). Possibility of a Jurassic age has been suggested by Sellards (41, p. 42) and Grabau (15, p. 648). The writer considers its age as Jurassic. This age is indicated by the occurrence of a fossil sponge obtained from the highest gray shale unit of the Morehouse formation at a depth of 9,304 to 9,305 feet immediately below Eagle Mills red beds in the Union Producing Company's Tensas Delta No. 1-A well in Sec. 8, T. 22 N., R. 4 E., Morehouse Parish, Louisiana. The sponge is definitely a Mesozoic type and probably belongs in the family Staurodermidae which is known only from the Jurassic. Likewise the conformable relations of the Eagle Mills formation with the Smackover formation, which is of Upper or Middle Jurassic age, suggests that it is nearly the same age. An age assignment any older than Upper Triassic seems unlikely in view of the times of aridity elsewhere in North America during the early Mesozoic. In the Rocky Mountain region arid to semi-arid conditions prevailed from Upper Triassic to at least the end of Jurassic time (3, p. 48-63). In Mexico the climate appears to have been arid to semi-arid from the Rhaetic stage of the latest Triassic, or earliest Jurassic, (position of Rhaetic is variously interpreted) until middle Lower Cretaceous time (10, p. 43, 165; 21, p. 1146; 22, p. 629).

Additional reasons for considering the Eagle Mills formation of Jurassic age are furnished by comparisons with the Jurassic sections in southern Mexico and bordering Central American countries (10; 34; 18, p. 173-174; 37). In northern Pueblo, southern Veracruz, Tabasco, and northern Chiapas, the Jurassic section consists of two divisions. The upper division is marine and of Upper Jurassic age. The lower division consists mainly of terrestrial deposits with plant remains and is of Lower and Middle Jurassic age. The name, Todos Santos series, has been applied to the entire Jurassic section and the overlying Neocomian deposits for the region of the Isthmus of Tehuantepec and Guatemala. A fairly complete section of this series was penetrated by a well boring near Tonalapa in the region of Chinanameca to the west-northwest of Minatitlan, Veracruz. From top to bottom the well section, according to Huntley (20, p. 1165; 10, p. 97) is given below.

Section of Todos Santos series in well drilled near Tonalapa, Mexico

	Depth (in feet)	Thickness (in feet)
Limestones, alternating with whitish marls, black shales, and some chert. Contains ammonites of lower Neocomian and Upper Jurassic age (Burckhardt, 10, p. 97).	20 - 333	313
Red beds, with salt.	333 - 380	47
Salt	380 - 2,050	1,670
Limestones, brown shales, bluish sandy shales, red beds, red shale with rock salt	2,050 - 2,290	240
Shales, black.	2,290 - 2,360	70

Salt	2,360 - 2,418	58
Salt and black slate	2,418 - 2,453	35
Total thickness in feet.		2,433

In the above section the Upper Jurassic beds are separated from the main body of salt by 47 feet of red beds. The salt has not been intruded into the overlying Jurassic limestones but has been folded concordantly with them, according to Weaver (18, p. 174). These relationships are strikingly similar to those in the Gulf Refining Company of Louisiana, Louis Werner Saw Mill Company No. 49 well, and other wells, in southern Arkansas.

Farther south in Chiapas and Guatemala the Todos Santos beds, according to Sapper (37, p. 26-27), consist of sandstone, marl, shale, sandy shale, pudding stone, and conglomerate. Their colors are mainly yellow, red, or brown. In western Guatemala and eastern Chiapas they contain in places intercalations of limestone, marly limestone, gypsum, and probably rock salt. Similar rocks (Metapan beds) occur in southern Guatemala, in northwestern Salvador, and in western and middle Honduras. Near San Juancito in the department of Tegucigalpa, Honduras, they contain plant remains which Newberry considered Rhaetic (latest Triassic) but Böse (37, p. 27) considered more likely Liassic (Lower Jurassic). Sapper (37, p. 44-45) states: "Of special interest is the salt formation of southern Veracruz and Tabasco in the region of the Isthmus of Tehuantepec. Salt springs occur also in Chiapas and northern Guatemala in the Todos Santos strata. This salt formation corresponds to the lower part of the Todos Santos strata. It designates the southern boundary of the Mesozoic sea. . ." The presence of rock salt has been confirmed by Böckh, Lees, and Richardson (7, p. 164) who note that "the Todos Santos beds of Guatemala contain gypsum near San Mateo Ixtatan and both gypsum and salt near Quetzal."

The Jurassic of the state of Oaxaca, Mexico, according to the writings of Burckhardt (10, p. 24-43, 98-100), consists of Upper Jurassic marine beds and Lower Jurassic coaly beds, the latter resting directly on crystalline schists. However, Weaver (18, p. 174) notes that "unpublished and unconfirmed reports of some credibility give a salt, gypsum and red shale sequence below the plant beds and above a thin marine "Oxfordian" unit. The existence of salt beds is indicated by salt springs, which have been reported by Adkins 4/. The Jurassic sequence in Oaxaca appears, therefore, to be similar to that in the Isthmus of Tehuantepec and Guatemala.

These observations show that in southern Mexico the Upper Jurassic, in some areas, is underlain by red beds and in nearby areas by rock salt. The relation of the salt to the red beds is apparently like that of the Eagle Mills salt to the Eagle Mills red beds in southern Arkansas. The lower part of the red beds of northern Chiapas contains plant remains of middle and lower Jurassic age. Similar beds in Honduras contain plants which are possibly as old as latest Triassic.

In conclusion the writer considers that a Jurassic age for the Eagle Mills salt and red beds is indicated by:

(1) the presence of a fossil sponge showing Jurassic affinities in the Morehouse shale immediately below the base of the Eagle Mills formation in the Union Producing Company's Tensas Delta No. 1-A well in northeastern Louisiana;
(2) the presence of Middle or Upper Jurassic fossils in the overlying Smackover formation;
(3) the conformable relation of the Eagle Mills formation to the Smackover formation;
(4) a comparable section of salt, red beds, and Upper Jurassic marine beds in southern Mexico, and
(5) known aridity during late Triassic and Jurassic times in Mexico and the Rocky Mountain region of the United States.

4/ Personal communication

A Permian age for the Eagle Mills formation is precluded by fossil evidence although it is not impossible that Permian deposits may underlie the Mesozoic deposits somewhere in the Gulf Coastal region (49, p. 125).

The Eagle Mills salt of Arkansas is probably but a small part of an extensive body. Hazzard (18, p. 172) says, "It is current opinion that the salt encountered in the deep wells in the Rodessa field, Louisiana, and in Panola County, Texas, is the equivalent of the Eagle Mills salt of southern Arkansas; this salt horizon (formation) probably has contributed to the salt cores of the penetration salt domes of northern Louisiana and west-central Mississippi."

An extension of the salt formation across the East Texas basin is indicated by the section in the Stanolind Oil and Gas Company's Norris No. 1 well located in Limestone County, Texas. In this well the salt and associated red beds are overlain by 467 feet of limestone similar to the limestone facies of the Smackover formation. The section below this limestone is as follows:

Section of salt formation in Stanolind Oil and Gas Company's Norris No. 1 well, Limestone County, Texas.

	Depth (in feet)	Thickness (in feet)
Sand and shale	8,987 - 9,005	18
Rock salt	9,005 - 9,785	780
Anhydrite	9,785 - 9,845	60
Conglomerate and red sandstone	9,845 - 9,888	43
Sandstone, red	9,888 - 9,932	44
Conglomerate, red	9,932 - 9,951	19
Total thickness in feet		964

Whether the Eagle Mills salt is of the same age as the salt in the Gulf Coastal domes of Texas and Louisiana is not known. Brown (9, p. 1267-1270) thought he had proved that the salt was deposited in different basins of different ages and was not older than Lower Cretaceous. However, it is now definitely known that the salt in Arkansas and adjoining areas of Louisiana and Texas cannot be younger than Upper Jurassic. The same is probably true of the main salt masses farther south, although some of them may be of Cretaceous age. The latter possibility is suggested by the occurrence of bedded salt in the Lower Cretaceous sediments of the Rio Grande Embayment and of north central Mexico (41, p. 40, 42; 10, p. 148).

Origin. The origin of the rock salt of Arkansas, Mississippi, Louisiana, and Texas has been discussed by many writers (39, p. 288-291). Van der Gracht (49, p. 130) and Brown (9, p. 1227-1228) considered that the salt was formed in distinct basins. On the contrary Hazzard (18, p. 174) conjectured that "the salt basin of the Isthmus of Tehuantepec and the salt basin of South Arkansas (and North Louisiana) are of one and the same age, connecting through the area now the site of the Gulf of Mexico; that the northern known tip of an Upper Jurassic salt basin terminates in southern Arkansas, and a southwesterly indentation of the same basin, marks the site of the salt basin of the Isthmus of Tehuantepec."

A similar speculation was made by Barton (5, p. 1289-1290). Something possibly suggestive of such an immense salt basin is the occurrence of submarine dome-like shapes on the outer margin of the coastal shelf of the Gulf of Mexico (42). As an alternate possibility, the salt basin of the Isthmus of Tehuantepec may have been distinct from that of the Gulf Coast, each basin representing a nearly enclosed or perhaps relic sea of considerable size. Structural evidence for separated relic seas is very meagre.

The Eagle Mills formation bears a transgressive relationship to the underlying Paleozoic (?) sediments where their contact was penetrated in the Gulf Refining Company of

Louisiana, Werner Saw Mill Company No. 49 well as shown by (1) the truncated surface of the steeply dipping Paleozoic (?) sediments and (2) the character of the basal beds of the Eagle Mills formation. The lower 24 feet of the Eagle Mills formation contains pebbles of silicified shale, chert, dense sandstone, and diabase. Part of these pebbles were probably derived from the underlying Paleozoic silicified shale and pre-Eagle Mills diabase. These structural and stratigraphic features, plus the upward change to red beds, anhydrite, and rock salt, seem to indicate a transgression due to gradual subsidence of the area of deposition.

The Eagle Mills red beds were formed mainly, or perhaps entirely, under water as indicated by streaks of argillaceous dolomite and associated anhydrite. The water must have been highly saline, or perhaps brackish, in order to prevent the growth of organic matter that would have reduced the ferric oxide to the ferrous condition (24, p. 885-888). Likewise, the climate of the surrounding land areas must have been sufficiently dry (although not extremely so) to prevent the growth of much organic matter (48, p. 317-318). Petroleum geologists who have worked in the extremely arid region of eastern Arabia report that most of the erosion is by wind and that the recent deposits are gray salty clays and marls5/ The rolling of the particles by the wind is held responsible for the removal of any films of red iron oxide that might have originally coated the particles.

Evidently the Eagle Mills red beds were deposited nearer the land and in shallower or less saline waters than the salt. Their present distribution in Arkansas is possibly related to an inferred flexure which seems to parallel the entire trend of the present Ouachita Mountains and the subsurface southeastward projected trend of these mountains (44, p. 129-130; 51, p. 963). The salt deposits apparently do not occur on the site of the inferred flexure but are thickly developed a short distance to the south. This rather abrupt change in facies possibly reflects a difference in the depth of the sea floor due to structural control. However, the thickness of salt near the northeastern margin of its present extent may not be the same as at the time of deposition. On most of the domes where the salt has been penetrated, its greater thickness is due possibly to flowage. Hazzard 6/ thinks that the change of facies from red beds to salt is more dependent on several factors than on the presence of a structural flexure which would have produced an abrupt shallowing of the sea. These factors are: (1) differences in salinity within the sea; (2) size of the basin, or (3) source of sediments. He thinks that the flexure was a reality, but that the evidence for its existance is based mainly on the lithology and thicknesses of post-Buckner formations.

Possible sources of the material of the red beds would include the Rocky Mountain region, the Pennsylvanian-Permian red beds of Oklahoma and Texas, the Appalachian highlands, and perhaps the southern part of the Canadian shield. As it is generally agreed that considerable amounts of red residual soils form "only on upland areas with warm and moist climate" (48, p. 315), the Rocky Mountain region of late Triassic and Jurassic times does not seem to be a possible source (3, p. 44-55). The Pennsylvanian and Permian red beds of Oklahoma and Texas would have been a likely source for much of the red beds of the Eagle Mills formation, especially as the distance of transportation was not great. Another likely source would have been the Appalachian region which was undoubtedly a highland region during part of the Jurassic as a result of faulting and regional uplift at the end of the Triassic period. Since some of the sediments overlying the Eagle Mills formation were derived from the east, as indicated by marked coarsening in that direction, it seems most probable that part of the Eagle Mills red beds was likewise derived from the east, probably from the region of the present Southern Appalachian Mountains. It follows that if the time of deposition of the Eagle Mills formation coincides with the uplift of eastern United States in the Jurassic, then a depression and widening of the ancestral Gulf of Mexico occurred during the same time as the uplift.

5/ Hazzard, personal communication
6/ Personal communication

SMACKOVER FORMATION

Definition. The Smackover formation was named after the Smackover field (6, p. 1068, 1072) where it consists of 700 feet of dense to oölitic limestone which lies with apparent conformity above the Eagle Mills red beds and salt and below the Buckner anhydrite and red beds (51, p. 964-965). A local disconformity occurs between the Cotton Valley and Smackover formations (52, p. 28). In southern Arkansas it is divisible into two members of which the upper consists of oölitic to chalky limestone and the lower of dense limestone with dark argillaceous bands. These limestone facies grade southward in northern Louisiana into an interbedded limestone, shale, and sandstone facies which is likewise included in the Smackover formation. The term, Smackover limestone, will be used in this report only in reference to the limestone facies.

Distribution and thickness. The distribution of the Smackover limestone in Arkansas is indicated on Plate XVII. In northern Louisiana the equivalent beds consist of shale, shaly limestone, and sandstone. In the central part of the East Texas basin the Smackover limestone, as such, does not exist according to some petroleum geologists who base their views on geophysical data. However, equivalent strata, which are probably shales, undoubtedly underlie most of the basin. On the west side of the East Texas basin about 467 feet of dolomitic limestone, probably Smackover, was penetrated by the Stanolind Oil and Gas Company's Norris No. 1 well located in Limestone County, Texas. This limestone is lithologically similar to the Smackover limestone of Arkansas and occupies a similar stratigraphic position with respect to the Eagle Mills salt and the Buckner anhydrite.

In Arkansas, the Smackover formation is 880 feet thick (51, p. 965) and probably ranges in thickness between 450 to 900 feet (18, p. 158). In the Rodessa field of northwestern Louisiana, the Smackover formation is about 1,230 feet thick. Total thicknesses of the Smackover formation, in areas where it has not undergone appreciable erosion after deposition, have been determined at only a few places (see Table 4). Near the northern margin of its present extent, it thins markedly due to erosion during post-Buckner and post-Lower Cretaceous times.

Table 4. Thicknesses of Smackover limestone

Name of well	Field	County	Location Sec.	Location Twp.	Location Rge.	Thickness Upper member	Thickness Lower member	Total
Benedum Trees Oil Co. Grove Land & Timber Co. No. 1	Troy	Nevada	10	14S	20W	280	222	502
Phillips Petroleum Co. C. H. Murphy No. 1		Bradley	12	17S	11W	354	269	623
Phillips Petroleum Co. Rogers-Askew No. 1		Columbia	4	17S	21W	381	84a/	
C. E. Murdock (Lockhart) Southern Kraft No. 1		Calhoun	17	14S	13W	426	158	584
Phillips Petroleum Co. J. T. Arnold No. 1	Snow Hill	Ouachita	27	15S	15W	415	270	685
Gulf Refining Co. of La. Louis Werner Saw Mill Co. No. 49	Smackover	Union	5	16S	16W	477	200	677
Phillips Petrleum Co. Godfrey No. 1		Ashley	18	17S	9W	370	61a/	
Modisett Drilling Co. Union Saw Mill Co. No. 2		Union	8	18S	12W	357	96a/	
Phillips Petroleum Co. Marsden No. 1		Bradley	9	16S	11W	369a/		
Phillips Petroleum Co. Marcus Justiss Nos. 1 and 3	Schuler	Union	18	18S	17W	500	223a/	773a/

a/ Incomplete thickness

Lithologic and stratigraphic features. The Smackover limestone in Arkansas is comprised of two members which are transitional into each other and show marked lateral variation in lithology. Probably neither member represents exactly the same time interval throughout its extent but each member probably represents a depositional facies which overlaps in time with the other.

The upper member ranges from 280 to 500 feet in thickness and thickens toward the south. It consists mainly of white to brown oölitic to chalky, porous limestone in which the oölites are most common near the top. This is the zone of greatest porosity. Some thin layers of highly porous limestone contain an abundance of colony corals, brachiopods, pelecypods, and gastropods which are preserved mainly as molds. The porosity of the oölitic limestones is probably due to lack of cementation. The porosity of the fossiliferous limestones is due mainly to solution of the organic remains. Some of the external molds of fossils are encrusted with pyrite. Stylolitic structure is well developed in some cores examined by the writer. The type section of the upper member in the Smackover field is about 400 feet thick, and according to Weeks (51, p. 965) "the top 100 feet is composed of oölitic, very porous, buff limestone. This porous oölitic zone is known as the Reynolds oölite, from the Phillips Petroleum Company's J. D. Reynolds No. 1 in Sec. 27, T. 15 S., R. 15 W., the discovery well in the Snow Hill area and the first well to produce from this zone. The remainder of the upper part (member) of this limestone is more or less chalky white limestone with varying amounts of disseminated dolomite rhombs. Streaks of hard crypto-crystalline white limestone are plentiful near the base of this zone. In a few places another streak of porous, oölitic limestone has been found immediately above the (lower member) dense limestone."

The section of the upper member in the Magnolia Pool of Columbia County has been summarized by Trager (47, p. 14) as follows:

Section of upper member of Smackover formation in Magnolia Pool, Columbia County, Arkansas

	Thickness (in feet)
Shaly dolomite or dolomitic shale, gray, dense	5 - 12
Limestone, brown, dense, oölitic, non-porous	10 - 30
Limestone, white to brown, soft, oölitic and pisolitic, good porosity and permeability	175 ±
	200 ±

The section of the upper member in the Schuler Pool of the west-central part of Union County has been summarized by Weeks (53, p. 24-27) as follows:

Section of upper member of Smackover formation in Schuler Pool, Union County, Arkansas

	Thickness (in feet)
Limestone, dense, forming a thin cap	?
Limestone, oölitic; porous, some dense lenses	70 - 90
Limestone, interbedded dense, oölitic, dolomitic, and sandy	315
Limestone, dense to sandy	95
	500 ±

The section of the upper member in the Snow Hill Pool of Ouachita County, according to Weeks (52, p. 2803-) is as follows:

Section of upper member of Smackover formation in Snow Hill Pool, Ouachita County, Arkansas

	Thickness (in feet)
Limestone, porous, oölitic, contains some cellular and granular streaks.	100
Limestone, chalky to finely crystalline, some beds slightly porous	300
	400 ±

The above sections show that the upper member of the Smackover limestone varies markedly in lithology both laterally and vertically. Southward in Arkansas from the Smackover field "the chalky limestone is replaced by dense, crypto-crystalline, brown limestone, showing faint oölitic structure at the top, grading to non-oölitic at the base" (51, p. 965). In northwestern Louisiana the upper member is replaced by dark limestones and shales and in northeastern Louisiana by limestones, sandstones, and dark shales (see Plates IV, V, VI, VII, VIII, IX, and X). According to Weeks, these changes, from north to south, are about as follows: (1) chalky limestone, (2) dolomite and chalk, (3) oölitic limestone cemented with dolomite, (4) oölitic limestone, (5) oölitic limestone cemented with calcite, (6) limestone and shaly beds with some oölites and sandstone.

Corresponding with its variable lithology, the upper member of the Smackover limestone likewise varies considerably in porosity, particularly in the Reynolds oölite zone near the top. In the Schuler Pool the porosity of the Reynolds oölite averages 14 per cent (53, p. 25), and in the Snow Hill Pool 25 per cent (52, p. 30). The porosity is related mainly to the degree of cementation of the oölites and is probably a primary feature rather than due to secondary solution. This is indicated by its being much reduced (1) toward the north (35, p. 115) in areas where the Smackover limestone underwent erosion after Buckner time and (2) in the vicinity of faults[6/]. In both cases the action of ground water tended to cement the oölites with calcite.

The lower member of the Smackover limestone ranges from 200 to 450 feet in thickness and thickens southward. Probable equivalents in the Rodessa field of northwestern Louisiana are about 740 feet in thickness. It consists of "gray to brown, dense, crypto-crystalline (limestone), banded in many places with carbonaceous argillaceous partings. In the vicinity of Smackover, it may grade to lighter gray, slightly chalky to granular limestone toward the base. Basinward, in the Schuler area in Union County, and in the Rodessa area in the northwest corner of Louisiana, this basal 'dense lime' becomes darker and more argillaceous" (51, p. 965). Equivalents in northeastern Louisiana consist mainly of dark calcareous shales, shaly limestones, and sandstones. Compared with the upper member, the lower member is harder, denser, darker, contains argillaceous material, and lacks oölitic, chalky or dolomitic material.

The upper contact of the Smackover limestone with the Buckner formation is apparently conformable, fairly definite within a narrow transitional zone, and in most places does not indicate a time break (51, p. 966). However, for the Buckner Pool, Link (25, p. 97) notes that "the upper 20 feet of porous and permeable limestone have a decided reworked appearance, sometimes approaching a lime breccia in character. This reworked appearance of the upper part of the Smackover limestone at Buckner, leads one to suspect the possibility of an unconformity between the Smackover and the Buckner shale-anhydrite zone." Link (26, p. 100-101) also says in regard to the Village Pool that "there is some evidence for an unconformity between the Reynolds oölitic lime and the Buckner formation." Other evidence for a post-Smackover disconformity consists of slightly reworked Smackover oölitic limestone in the basal beds of the Buckner formation as noted in the following occurrences:

6/ Weeks, personal communication

(1) Benedum Trees Oil Company's Grove Land and Timber Company No. 1, Sec. 10, T. 14 S., R. 20 W., Nevada County, Arkansas. Bottom two feet of core from depth of 5.136 to 5,142 feet, at base of Buckner formation, consists of light buff-gray, fine textured dolomite with rounded cavities which are filled with anhydrite and some reworked oölite remains.

(2) Joe Modisett Drilling Company's Union Saw Mill Company No. 1, Sec. 8. T. 18 S., R. 12 W., Union County, Arkansas. Core from depth of 6,053 to 6,059 feet, at base of Buckner formation, consists of white. coarse grained, cherty, conglomeratic, calcareous sandstone. The pebbles consist of pyrite and buff-gray oölites.

(3) The Atlantic Refining Company's Harrington No. 1, Sec. 14, T. 17 S., R. 20 W., Columbia County, Arkansas. Core from Buckner formation at depth of 7,698 to 7,705 feet consists of light buff, calcareous, finely crystalline anhydrite which contains grains of reworked Smackover limestone.

In many sections in Arkansas the Smackover limestone grades into the Buckner formation through a few feet of dolomitic limestones or shales which might logically be placed at either formation, but are herein placed in the Smackover limestone. The conformable relationship of the Buckner and Smackover formations is shown by these gradational beds, by the occurrence of some dolomitic beds at varous intervals throughout the upper member of the Smackover limestone, and by the occurrence of anhydrite in the upper part of the Smackover limestone in Columbia County, Arkansas, and Union Parish, Louisiana. In northern Louisiana the marine equivalents of the Buckner formation make a fairly definite but conformable contact with the equivalents of the Smackover limestone. In the Texas Company's T. C. Adams Estate No. 1 well, located in the Bethany gas field of Panola County, Texas, the Cotton Valley formation grades into the Smackover limestone equivalents. On the whole, the evidence indicates that the Buckner formation, Smackover limestone, and Eagle Mills salt and red beds are a continuous sedimentary sequence (18, p. 171). In areas in which the Buckner formation is missing, the Smackover limestone is overlain disconformably by the Cotton Valley or younger formations.

Correlation. Fossils from the Smackover formation show that its age is Middle or Upper Jurassic. During the past two years various oil companies have sent the writer fossiliferous cores from the Smackover formation and adjoining formations. Significant pelecypod genera from the Smackover formation include *Coelastarte*, *Coelopis*, and *Quenstedtia*. Significant gastropod genera include *Nerinea*, *Xystrella* (?), and *Cryptotyxis*(?). Of these genera *Coelopis* and *Quenstedtia* have not been recorded in beds younger than Jurassic. *Coelastarte* is fairly common in the Jurassic and uncommon in the Cretaceous. The genera *Nerinea* and *Quenstedtia* indicate an age not older than Middle Jurassic. The association of *Xystrella* and *Cryptotyxis*, if these be correctly identified, indicates lower Upper Jurassic. It is probably significant that none of the species from the Smackover formation is identical with described upper Upper Jurassic species from Mexico and Texas but that several are very similar to species from the Middle Jurassic and lower Upper Jurassic of Europe.

Other fossil evidence consists of a few ammonite fragments obtained from sandy shale equivalents of the Smackover formation at a depth of 10,545 to 10,550 feet in the Texas Company's T. C. Adams Estate No. 1 well, located in the Bethany gas field of northeastern Panola County, Texas. The fossiliferous bed is about 515 feet above bedded salt and about 4,800 feet below the base of the Sligo formation. Several of the ammonite fragments were suggestive of an Upper Jurassic age. Photographs of the ammonite were sent to Dr. L. F. Spath of the British Museum of Natural History who reported concerning the largest specimen that it "may indeed to a perisphinctoid or Berriasellid of Upper Jurassic or Lower Cretaceous age, or it may not, for there are earlier Jurassic and even Liassic genera (e. g., *Dactylioceras*) that could look like your crushed specimen."

Another bit of evidence suggesting a Jurassic age for the Smackover formation consists of a crinoid stem from a depth of 6,848 to 6,856 feet, in the Fohs Oil Company's Craig No. 1 well located in Sec. 5, T. 18 S., R. 14 W., Union County, Arkansas. The shape of this stem greatly resembles stems of Pentacrinus, but identification cannot be made as no surface markings are preserved.

A collection of pelecypods were obtained from the Smackover formation at depths of 4,951 to 5,072 feet in the Phillips Petroleum Company's J. T. Arnold No. 1 well, located in Sec. 27, T. 15 S., R. 15 W., Ouachita County, Arkansas. These were examined by W. S. Adkins and subsequently by C. C. Albritton, and Gayle Scott (18, p. 166-168) who reported independently that the pelecypods are not like those from the Upper Jurassic Malone formation of west Texas but resemble pelecypods of the Cuchillo formation which is of lower Trinity age.

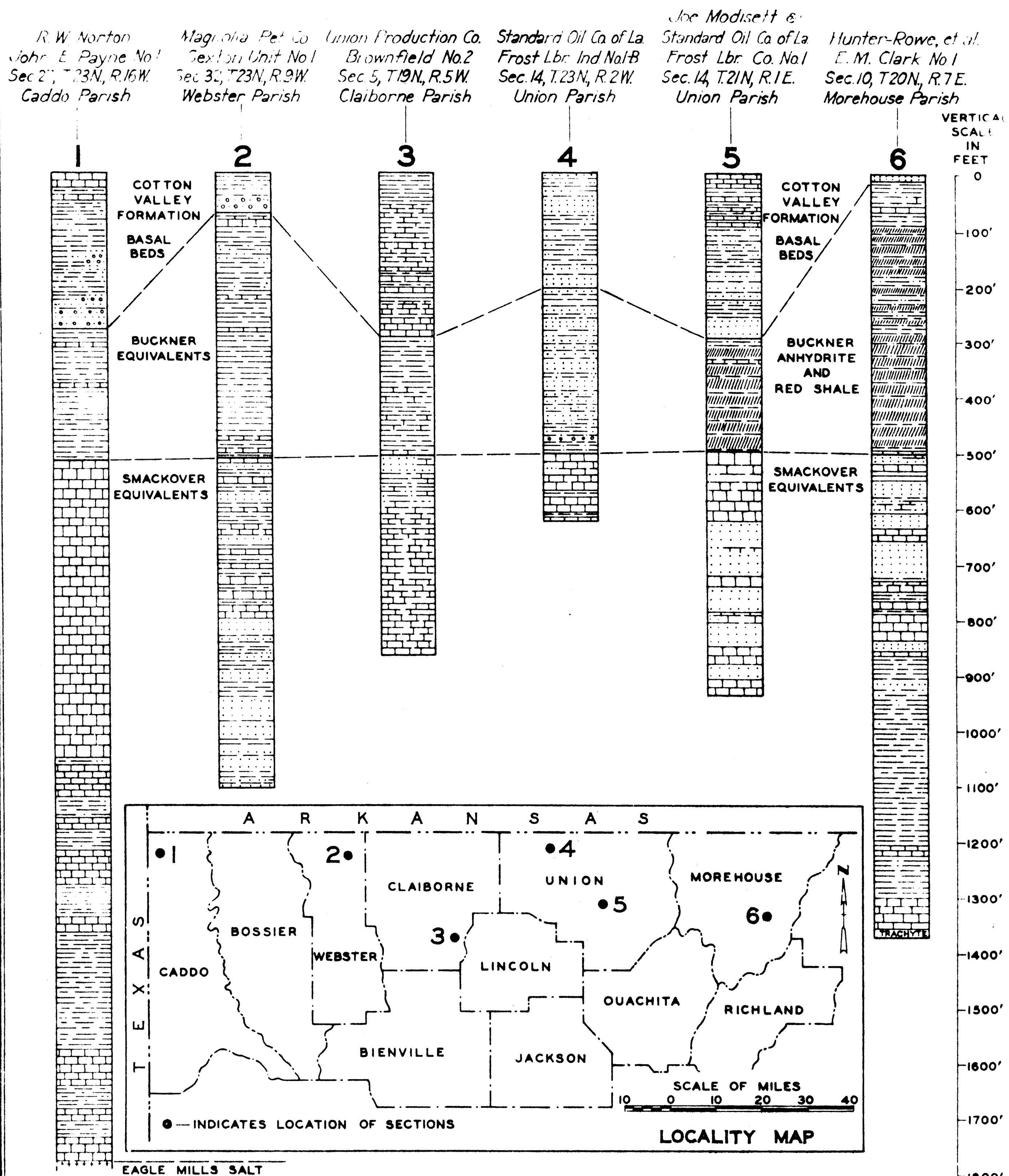
The corals and brachiopods of the Smackover formation have not yet been studied in detail. Some corals obtained from the Atlantic Refining Company's Levi Garrett No. C-1 well, located in Sec. 13, T. 17 S., R. 20 W., were sent to T. Wayland Vaughan who reported 7/ as follows: "The specimens all belong to the genus Thamnasteria Le Sauvage, of which the genus Centrastrea d'Orbigny is a synonym. The species appears to be new. Previously, two species of the genus have been described from America, both by Dr. J. W. Wells. One is named Centrastrea vaughani from the basal Glenrose in Comal and Hays counties, Texas. The other species is Thamnasteria hoffmeisteri from the Buda limestone at Round Rock, Williamson County, Texas. The species from the Smackover limestone is different from each of these. The horizon of the Smackover limestone is, therefore, definitely Mesozoic, but the single species of coral supplies insufficient evidence to decide whether the horizon is Lower Cretaceous or Upper Jurassic."

Origin. Deposition of the Smackover limestone upon the red beds and salt of the Eagle Mills formation indicates deepening of the sea and decrease in its salinity. The lower member of the Smackover limestone may be chiefly of chemical origin as indicated by its extremely fine texture. Girty (18, p. 168, 171) notes that the few fossils found in the lower member are related to forms which normally inhabit fresh or brackish waters but whose occurrence suggests supersaline conditions. He does not give any convincing evidence for the latter statement. In fact the presence of many brown to black argillaceous bands suggests that the salinity of the waters was not much above normal. Hazzard (18, p. 172) interprets these dark argillaceous bands, or laminae, as the "feather-edge deposits of the fore-reef type inter-fingering with reef-type deposits. . . which are represented by the Smackover limestone itself." However, the only part of the Smackover limestone indicative of reef deposits is the upper member. Therefore, if Hazzard be correct, the lower member must be in part a time-equivalent of the upper member. This possible relationship will be discussed more fully later.

The upper member of the Smackover limestone is of shallow water origin as shown by the presence of oölites, chalky limestone, and colony corals. The corals are associated with brachiopods, pelecypods, and gastropods in oölitic to coarsely granular limestone beds that are usually less than one foot in thickness. These coral beds are interbedded with oölitic or chalky limestone and constitute a smaller part of the member than do the other types of rock. The beds are of variable importance from place to place, but occur over a considerable part of southern Arkansas. They greatly resemble the coral sheets of the Jurassic of England which Arkell (2, p. 557-562) classifies as fringing reefs. Their presence clearly implies that the shore slopes gently for a considerable distance from the land. The oölitic limestone probably formed in very shallow agitated waters between, or above, coralline masses of the reef. The chalky white limestone probably represents chemical deposition of oozes in the deeper bodies of water between coralline masses.

The fore reef deposits are fairly well known as a result of deep drilling in northern Louisiana. Their lithologic features and probable stratigraphic relationships are indicated on Plate XII. In northwestern Louisiana they consist of dense, fine-grained brown limestone that is somewhat oölitic toward the top. This limestone is underlain by

7/ Personal communication



COLUMNAR SECTIONS
BUCKNER FORMATION & SMACKOVER FORMATION EQUIVALENTS
IN
NORTHERN LOUISIANA

brown to black shales and shaly limestones which are correlated with the lower member of the Smackover limestone. In north-central and northeastern Louisiana, sections of the Smackover limestone equivalents contain considerable sandstone which becomes increasingly more common toward the east. The sections indicate that the typical Smackover limestone of reef facies is thinly developed in eastern Louisiana. Termination of the main body of the reef in southeastern Arkansas correlates with the presence of sandstones and shales in northern Louisiana. Very likely the deposition of fringing reefs of Smackover time was interrupted at intervals by tidal channels or by channels opposite the mouths of rivers.

Back reef deposits have not been definitely identified. This has been explained as due to the erosion of the original northern part of the Smackover limestone. However, fringing reefs which rise only a few feet above the sea floor and which grow close to the shore need not have an appreciable thickness of back reef deposits. It is possible that the overlying Buckner formation in part represents back reef deposits; but, in part, it must represent regressive deposits as it overlies the southern margin of the reef limestone and is well developed on the eastern side of the Monroe uplift of northeastern Louisiana where the reef limestone is lacking. Back reef deposits originally present were probably similar lithologically to the Buckner formation.

The writer visualizes the Smackover limestone as having been formed in a transgressive sea. The lower member was certainly deposited in deeper and less saline waters than the underlying Eagle Mills red beds and salt. The upper member was deposited under nearly normal marine conditions as shown by the presence of reef organisms. Overlap of the upper member is shown by the absence of the lower dense limestone member near the northern margin of the formation (51, p. 982). However, locally the highest beds of the formation may have formed at the beginning of a regression represented by the Buckner formation. Hazzard 8/ visualizes that the environment of the deposition of the Permian Capitan reef limestone of the Delaware Basin (24, p. 847, 863) of west Texas was probably on a small scale like that of the Jurassic Smackover limestone.

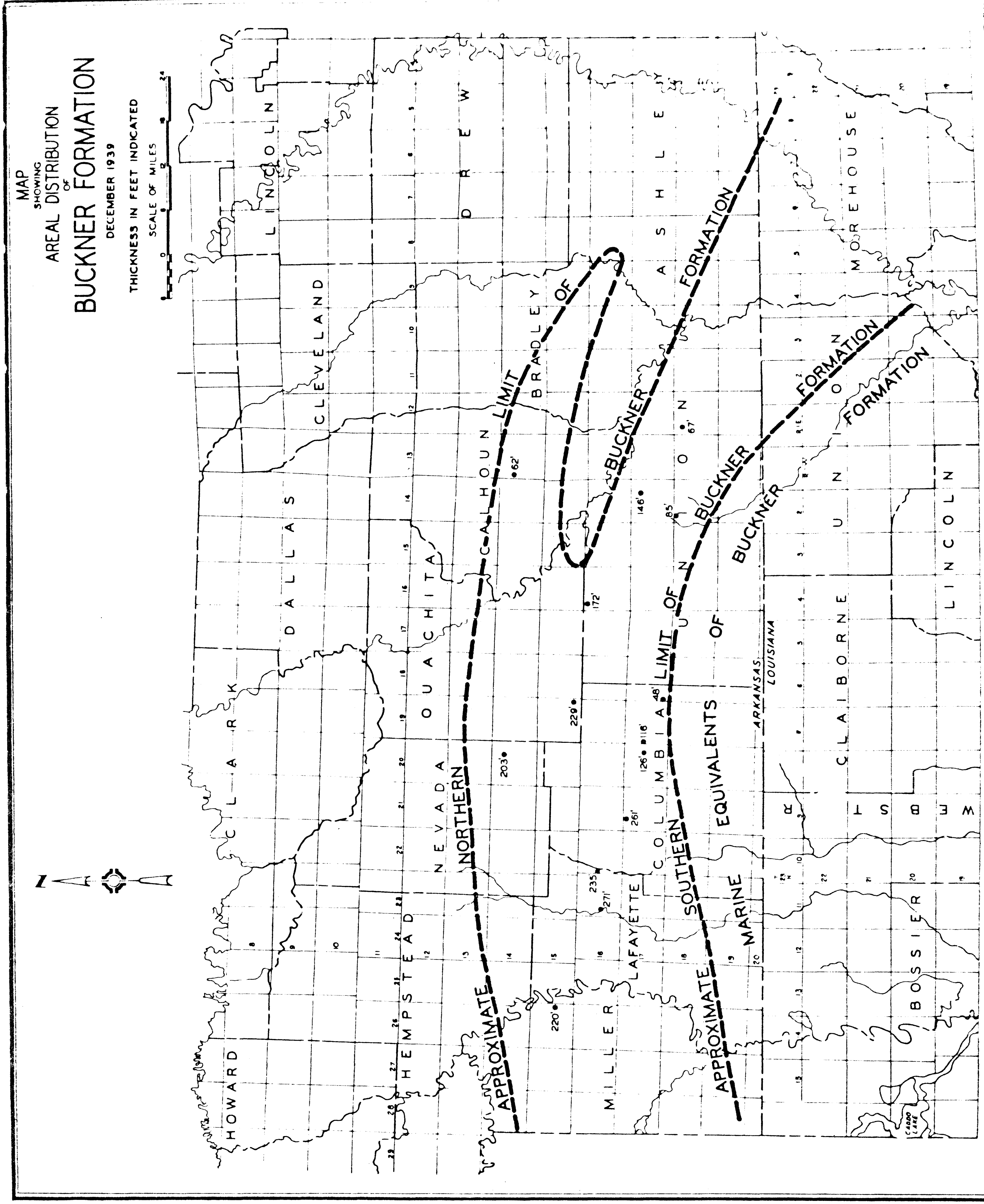
The sea of Smackover time was probably fed by several rivers. One of these lay to the east, apparently draining the region that is now the southern Appalachian Mountains. Evidence for this river is based on (1) the considerable amounts of shale and sandstone deposited in northern Louisiana, south of the Smackover limestone reef and (2) the increasing thickness of the sandstone toward the east. Possibly another river fed the sea from the north or northwest. This is indicated by the occurrence of the Smackover limestone on the west side of the East Texas basin, as revealed by drilling, and its probable absence in the central part of the basin, as indicated by geophysical investigations. It is suggested that the Smackover limestone passes basinward into shales that were deposited at depths greater than that at which reef organisms could grow. The material may have been derived from several sources.

BUCKNER FORMATION

Definition. The Buckner formation was named after the Buckner field of Columbia County (16, p. 285; 51, p. 966) where it consists of about 240 feet of anhydrite, dolomite, and red shale. It overlies the Smackover limestone with apparent conformity in most places and underlies the Cotton Valley formation disconformably. The formation should be restricted to the anhydrite and red bed facies and should not include equivalent dark shales in northern Louisiana.

Distribution and thickness. The distribution and thickness of the Buckner formation is shown on Plate XIII. Its present northern limit is due to pre-Cotton Valley erosion. Its southern limit, as an anhydrite red shale facies, approximately coincides with the southern limit of the Smackover limestone, although marine equivalents are undoubtedly present seaward. It extends southeastward into Louisiana and westward into Texas. Beds identified as the Buckner formation occur in Limestone County, Texas, on the west side of

8/ Personal communication


MAP
SHOWING
AREAL DISTRIBUTION
OF
BUCKNER FORMATION
DECEMBER 1939
THICKNESS IN FEET INDICATED
SCALE OF MILES
0
24
LINCOLN
DREW
CLEVELAND
BRADLEY
ASHLEY
DALLAS
CALHOUN
OUACHITA
UNION
MOREHOUSE
CLARK
NEVADA
COLUMBIA
CLAIBORNE
LINCOLN
HOWARD
HEMPSTEAD
MILLER
LAFAYETTE
WEBSTER
BOSSIER
CADDO LAKE
ARKANSAS
LOUISIANA
APPROXIMATE NORTHERN LIMIT OF BUCKNER FORMATION
APPROXIMATE SOUTHERN LIMIT OF BUCKNER FORMATION
MARINE EQUIVALENTS OF BUCKNER FORMATION
BUCKNER FORMATION
62'
67'
146'
85'
172'
229'
48'
203'
126'
118'
261'
235'
271'
220'

Section of Buckner formation in Shell Petroleum Corporation and Ohio Oil Company's Warren No. 1 well, Sec. 13, T. 16 S., R. 24 W., Lafayette County, Arkansas

	Depth (in feet)	Thickness (in feet)
Shale, red	6,915 - 6,960	45
Shale, dolomitic or calcareous	6,960 - 6,995	35
Shale, red, and anhydrite streaks	6,995 - 7,095	100
Anhydrite	7,095 - 7,100	5
Shale, red	7,100 - 7,105	5
Anhydrite	7,105 - 7,125	20
Shale, red, calcareous or dolomitic	7,125 - 7,143	18
Anhydrite	7,143 - 7,155	12
Shale, sandy, dolomitic	7,155 - 7,165	5
Total thickness in feet		245

The section in the Troy field may be represented by the Benedum Trees Oil Company Grove Land and Timber Co. No. 1 well, located in Sec. 10, T. 14 S., R. 20 W., Nevada County, given below.

Section of Buckner formation in Benedum Trees Oil Company's Grove Land and Timber Company No. 1 well, Sec. 10, T. 14 S., R. 20 W., Nevada County, Ark.

	Depth (in feet)	Thickness (in feet)
Shale, red	4,920 - 4,995	75
Shale, red, and anhydrite	4,995 - 5,030	35
Anhydrite	5,030 - 5,125	95
Shale, red	5,125 - 5,135	10
Total thickness in feet		215

The following section occurs in the Deep Rock Oil Corporation A. C. Wesson No. 1 well, located in Sec. 23, T. 15 S., R. 19 W., Ouachita County:

Section of Buckner formation in Deep Rock Oil Corporation's A. C. Wesson No. 1 well, Sec. 23, T. 15 S., R. 19 W., Ouachita County, Arkansas.

	Depth (in feet)	Thickness (in feet)
Shale, red	5,702 - 5,727	25
Shale, sandy, red	5,727 - 5,734	7
Shale, red	5,734 - 5,740	6
Shale, sandy, red	5,740 - 5,747	7
Shale, calcareous, red, contains anhydrite streaks	5,747 - 5,864	117
Anhydrite	5,864 - 5,917	53
Shale and dolomite	5,917 - 5,932	15
Total thickness in feet		270

The following section occurs in the Phillips Petroleum Company's Rogers-Askew No. 1 well, located in Sec. 4, T. 17 S., R. 21 W., Columbia County, Arkansas.

Section of Buckner formation in Phillips Petroleum Company's Rogers-Askew No. 1 well, Sec. 4, T. 17 S., R. 21 W., Columbia County, Arkansas

	Depth (in feet)	Thickness (In feet)
Shalē, red.	7,783 - 7,798	15
Shale, red, and anhydrite	7,798 - 7,935	137
Anhydrite, mottled with red shale	7,935 - 7,965	30
Anhydrite, ...	7,965 - 8,043	78
Total thickness in feet		260

Correlation. The Buckner formation is considered part of the same sedimentary sequence as the Smackover limestone because of its conformable relationship with the Smackover limestone. It is, therefore, probably about the same age as the Smackover limestone and presumably Upper Jurassic. Outside of southern Arkansas and northeastern Louisiana, the Buckner formation occurs in two deep wells in Limestone County, Texas. Micro-fossils have been reported from the Buckner formation but have not been studied. One crustacean belonging to the genus, Estheria,was reported by Reeside and Stanton (18, p. 165) from the Buckner formation in the Hunter-Rowe, et al., E. M. Clark No. 1 well, located in Sec. 10, T. 20 N., R. 7 E., Morehouse Parish, Louisiana. The species is of no value for age determination.

Origin. The Buckner formation is clearly a regressive deposit as shown by the transition from dolomitic beds at its base, to anhydrite in its middle, and to red beds at its top. The lowest dolomite beds overlying the Smackover limestone were probably formed in nearly normal marine water. The anhydrite and associated dolomite formed in highly saline waters. The highest red beds were probably formed in fresh or brackish waters as indicated by the presence of the normally fresh-water crustacean, Estheria. The regressive character of the Buckner formation is due to infilling from the land rather than to withdrawal of the sea, as the formation thickens southward, thereby showing that the ocean bottom continued to subside. Stratigraphic and paleogeographic relationship show that the waters in which the Buckner formation was deposited were connected southward with normal marine waters. Deposition in a marginal lagoon, rather than in a marine salina, or relic sea, is indicated by the large extent of the Buckner formation and the long but rather narrow transitional zone separating it from equivalent, normal marine dark shales toward the south. The barrier separating the lagoon from the open sea might have been built (1) by waves, (2) by reef-forming organisms, (3) by reef growths on a submarine swell, or (4) it might have been a submarine swell.

A barrier built mainly by wave action seems unlikely in this case considering (1) that the Buckner formation in nearly all places rests conformably on the Smackover limestones from which the barrier materials would probably have been derived; (2) the rather considerable width of the Buckner formation, indicating that the barrier did not move much, if any, inland; and (3) the progressive thickening of the formation toward the south, indicating progressive upward growth of the barrier at about the same rate as subsidence of the sea bottom.

These objections do not hold for a reef built by organisms, as such a reef might have great linear extent and be built up at the same rate as subsidence of the sea floor. Evidence of the presence of organic reefs have been found only in the upper part of the Smackover limestone where coralline beds constituted widespread fringing reefs over an area nearly coextensive with that of the Buckner formation. It is logical to correlate at least part of these coralline beds with the anhydrite-dolomite beds of the Buckner formation. According to this interpretation (18, p. 173) the Buckner formation is the lagoonal, back reef equivalent of the upper part of the Smackover limestone. The Buckner formation evidently was deposited in quiet waters behind the coralline reefs and graded landward into red beds. As most of the Smackover limestone is definitely transgressive on older beds, only the highest part of the limestone where overlain by the Buckner gypsum and dolomite could be interpreted as a regressive deposit formed during a time of relatively slow subsidence. Very likely the surfaces of the reefs woud be partially destroyed by waves before burial beneath the anhydrite and red shale of the southward spreading Buckner formation.

An argument against the back reef origin of the Buckner formation is the occurrence of a typical anhydrite section above noncoralline Smackover equivalents of sandstone, limestone, and shale in the Hunter-Rowe et al., E. M. Clark No. 1 well, located in Sec. 10, T. 20 N., R. 7 E., in northeastern Louisiana. The possibility that coralline reefs may have flourished farther west on the site of the Monroe uplift is refuted by the lack of such in the Smackover limestone equivalents of the Union Producing Company's Tensas Delta No. 1-A well, located in Sec. 8, T. 22 N., R. 4 E., Morehouse Parish, Louisiana.

A barrier formed by a submarine swell is favored by the approximate coincidence of the southern limits of the Smackover and Buckner formations. This coincidence probably reflects a change in slope of the sea floor due to underlying structural control. The growth and distribution of coralline reefs may have been controlled by submarine structure swells and by mud-free waters along parts of the coastal shelf. The deposition and distribution of the Buckner anhydrite, red beds, and argillaceous dolomite may likewise have been controlled by a submarine swell, but not by the influx of muds. Consequently, if the barrier was primarily structural, the Buckner formation might be expected to have a wider distribution than the Smackover limestone.

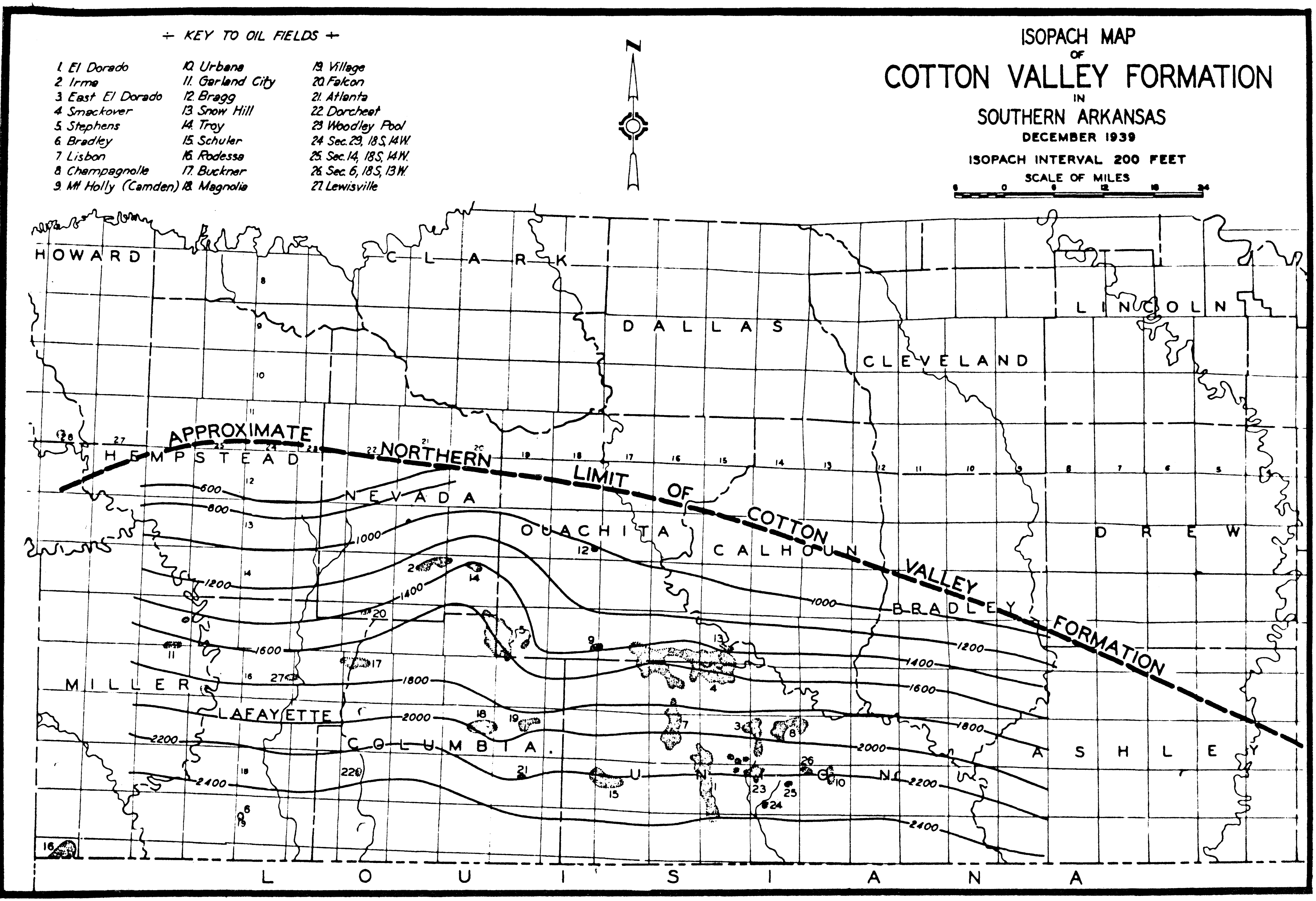
COTTON VALLEY FORMATION

Definition. The Cotton Valley formation is the name given by the Shreveport Geological Society to a group of marine, fossiliferous, dark shales, limestones, and sandstones lying immediately below the red beds of the Hosston formation in the Cotton Valley field in northern Louisiana (16, p. 285; 51, p. 966; 13, p, 1665). Northward in southern Arkansas, the Cotton Valley formation changes into red beds known as the Schuler facies because of its occurrence in the Schuler field in Union County. The Schuler facies is separated from the adjoining Hosston and Buckner formations by disconformities which are marked by thick basal conglomerates in Little River, Hempstead, Nevada, and Ouachita counties and by thinner conglomerates farther south. The typical dark shale facies of the Cotton Valley formation in Louisiana appears to be conformable with the adjoining formations.

Distribution and thickness. The distribution of the Cotton Valley formation in Arkansas in indicated on Plate XIV. The Schuler red bed facies is known in southern Arkansas and the extreme northeastern part of Louisiana. It is doubtfully reported in Mississippi on the west side of the Jackson dome. The Cotton Valley dark shale facies is known in southern Arkansas and in northwestern Louisiana as far south as southern Bienville Parish. Beds identified as the Cotton Valley formation have been penetrated in two deep wells in Limestone County, Texas. It seems likely that the East Texas basin is underlain by black shales of the Cotton Valley formation.

The thickness of the Cotton Valley formation increases considerably toward the south as may be noted on the siopach map (Pl. XIV). The Schuler red bed facies ranges from about 1,400 to 2,400 feet in thickness and attains a maximum thickness of 2,479 feet in the Oliphant Oil Corporation's Union Saw Mill Company No. 1 well, located in Sec. 22, T. 19 S., R. 14 W., Union County, Arkansas. Thinning toward the north is probably mainly depositional but some is due to pre-Hosston erosion. The Cotton Valley dark shale facies of northwestern Louisiana ranges from about 1,850 to 3,175 feet in thickness and thickens southward.

Stratigraphic and lithologic features. The Schuler facies consist of interbedded variegated shales and sandstones, and locally, basal conglomerate. The sandstones range from fine to coarse grained, are mainly red or white, are more abundant in the lower part of the formation than in the upper, become more abundant northward, and predominate over the shales near the northern limit of the formation. Most of the shales are red and gray,


ISOPACH MAP
OF
COTTON VALLEY FORMATION
IN
SOUTHERN ARKANSAS
DECEMBER 1939
ISOPACH INTERVAL 200 FEET
SCALE OF MILES
N
÷ KEY TO OIL FIELDS ÷
1. El Dorado
2. Irma
3. East El Dorado
4. Smackover
5. Stephens
6. Bradley
7. Lisbon
8. Champagnolle
9. Mt Holly (Camden)
10. Urbana
11. Garland City
12. Bragg
13. Snow Hill
14. Troy
15. Schuler
16. Rodessa
17. Buckner
18. Magnolia
19. Village
20. Falcon
21. Atlanta
22. Dorcheat
23. Woodley Pool
24. Sec. 29, 18S, 14W.
25. Sec. 14, 18S, 14W.
26. Sec. 6, 18S, 13W.
27. Lewisville
APPROXIMATE NORTHERN LIMIT OF COTTON VALLEY FORMATION
HOWARD
CLARK
DALLAS
CLEVELAND
LINCOLN
HEMPSTEAD
NEVADA
OUACHITA
CALHOUN
BRADLEY
DREW
MILLER
LAFAYETTE
COLUMBIA
UNION
ASHLEY
LOUISIANA
600
800
1000
1200
1400
1600
1800
2000
2200
2400

but some are brownish or greenish gray. Some gray shales in the upper part of the formation contain numerous pellets of brown to brownish-black siderite 9/ which are distinctive of the formation. The shales are interbedded with subordinate amounts of dolomite and argillaceous dolomite 10/ which the petroleum geologists generally recognize as "mudstones". In well cuttings the dolomite is distinguished from associated shale by its higher luster and lack of shaly texture. Pebbles of chert and quartzite occur locally throughout the lower few hundred feet of the formation.

The Schuler red bed facies in the Schuler field of Union County, Arkansas, described by Weeks (51, p. 967) may be summarized from top to bottom as shown below:

	Thickness (in feet)
Interbedded fine, white sandstone and variegated shales.	
Interbedded fine, white sandstone and variegated shales.	120
Light gray shale with intercalated red shale and lenticular sandstones. Locally 10 to 15 feet of glauconitic shale at top	570
Red and gray shale with much interbedded fine to coarse white sandstone which becomes more plentiful than shale updip. Some streaks of red sandstone in lower third.	970
Red shale with streaks of coarse red sandstone and white sandstone .	280
Red sandstone, fine to coarse, with streaks of red shale and coarse white sandstone. Updip contains pebbles of chert and quartzite. .	210
Gray shale with streaks of fine white sandstone.	20
White sandstone and gray shaly sandstone, some pebbles near base . .	100
Total.	2,270

It is doubtful that the divisions of the Schuler facies noted by Weeks in the Schuler field can be traced far from that field. Red beds are noted for their high variability, and the Schuler facies seems to be no exception. The typical dark marine facies of the Cotton Valley formation of northern Louisiana consists mainly of gray to black shales and thin-bedded limestones but includes many lenses of calcareous sandstone and shaly sandstone. No major divisions of the formation are recognizable from the few complete sections now available.

The contact of the Cotton Valley formation with the underlying formations is marked by a sharp change in lithology, which in southern Arkansas indicates a disconformity. The Schuler facies rests directly on the eroded surface of the Smackover limestone in the Schuler and Snow Hill fields (51, p. 967; 38, p. 16) due to removal of the Buckner formation by pre-Cotton Valley erosion. A disconformity at the base of the Schuler facies (47, p. 15; 25, p. 97; 26, p. 101) is indicated by drilling data from the Magnolia, Buckner and Village fields. Conglomerates have been noted at the base of the Cotton Valley 11/ formation in the Schuler field (51, p. 967), in the Tide Water Associated Oil Company's Mrs. S. A. Graves No. 1 well located in Sec. 33, T. 13 S., R. 18 W., in the W. S. King W. E. Stewart No. 1 well located in Sec. 6, T. 13 S., R. 22 W., in the Village field, and in other localities in Arkansas. Deep wells in the Rodessa and Shongaloo fields of northern Louisiana penetrated pebbly sandstones throughout a thickness of about 350 feet in sediments which probably represent the basal part of the Cotton Valley formation (18, p. 170). The contact of the Cotton Valley formation with the overlying Hosston formation is

9/ Optical determination made by Ernest Dobrovolny, a graduate student of the University of Michigan, who found that the Index of Refraction of the ordinary ray was higher than 1.8 and therefore within the range of siderite, but not of ankerite.

10/ Weeks, personal communication

11/ The unconformable contact of the Cotton Valley formation with the Smackover limestone in the Schuler field is excellently shown by a core section taken from a depth of 7,675½ to 7,678½ feet in the Atlantic Refining Company's B. M. Dumas No. 1 well, located in Sec. 21, T. 18 S., R. 17 W., Union County, Arkansas. This core is now exhibited in the Geology Museum at the University of Michigan as Specimen No. 11,000. It was presented by H. H. Trager of the Atlantic Refining Co.

fairly easily recognized in southern Arkansas and adjoining parts of Louisiana. Conglomerates occurring at the base of the Hosston formation in Little River, Hempstead, Nevada and Ouachita counties in Arkansas are highly suggestive of a disconformity. In northwestern Louisiana no evidence of a hiatus at the Hosston-Cotton Valley contact has been observed by the geologists who have made detailed studies of cuttings, cores, and electrical logs. In Bienville Parish, Louisiana, the formations grade into each other (18, p. 170).

Correlation. The age of the Cotton Valley formation, on the basis of stratigraphic position, must be either late Upper Jurassic or early Lower Cretaceous. Hazzard (18, p. 170) speculated that its age is lower Neocomian; i.e., early Lower Cretaceous. This age assignment is favored by the fact that the disconformity at the base of the Cotton Valley formation is more extensive than the disconformity at the base of the Hosston formation.

The few fossils that have been obtained from the Cotton Valley formation suggest Jurassic age. One species of *Pseudomonotis* from the lower part of the Cotton Valley formation is nearly identical with an undescribed species from the Kimmeridgian stage of the Upper Jurassic of Mexico. This species was obtained from the Magnolia Petroleum Company's Pardee C-1 well, located in Sec. 17, T. 23 N., R. 11 W., Louisiana, at depths ranging from 9,470 to 9,790 feet. It was also found in the Magnolia Petroleum Company's Sexton Union No. 1 well, located in Sec. 32, T. 23 N., R. 9 W., Louisiana, at the depth of 9,418 feet.

Other evidence in favor of Jurassic age of the Cotton Valley formation consists of two species referable to *Tancredia.* The genus ranges from Triassic to Cretaceous, but is rather rare except in the Jurassic. One of the species from the Cotton Valley formation belongs to the group of *T. planata* Morris & Lycett (12, p. 574) which has been recorded only from the Middle and Upper Jurassic.

Some fossiliferous cores from the lower part of the Cotton Valley formation of the Hunter-Rowe, et.al., E. M. Clark No. 1 well, located in Sec. 10, T. 20 N., R. 7 E., Louisiana, were sent by M. N. Broughton to the U. S. Geological Survey for examination (18, p. 164-165). Reeside and Stanton examined the cores and reported several fresh water and brackish water mollusks which do not form a definite basis for an age determination but which "seem to be not older than Cretaceous." They noted a species of *Estheria* common to both the Buckner and Cotton Valley formations and concluded that "there does not appear to be any valid reason for supposing the Buckner formation to be greatly older than the Cotton Valley formation." M. N. Broughton has expressed the opinion to the writer that some of the microfossils of the Cotton Valley formation suggest a Jurassic rather than a Cretaceous age. These microfossils are now being studied and may furnish the deciding evidence. The writer is inclined to favor Jurassic age for the Cotton Valley formation.

Origin. The Cotton Valley formation is transgressive on the Buckner, Smackover, and Eagle Mills formations as is shown by overlapping of its basal sands and gravels. The thickness indicates the amount of subsidence of the sea bottom. A rather marked thinning near its present northern limit indicates that it never extended much farther north. A shallow water origin for the Schuler facies is indicated by variegated beds, many wood fragments, and fresh or brackish water fossils. A fairly shallow water origin for the dark shale facies is indicated by the occurrence of oysters at many horizons. The coastal shelf must have been very gently sloping as sands were transported a long distance from shore. The darker color of the Schuler red beds than that of the overlying Hosston red beds might be due to (1) deposition in deeper, more normally saline waters, (2) less aridity on the bordering land masses or (3) climatic differences in the areas where the sediments originated. The amount of sandstone increases to the north and northeast. This indicates that most of the sediments in Arkansas and Louisiana were derived from lands lying to the north and northeast. The isopach map of the Cotton Valley formation (Pl. XIV) reveals that an area along the boundary of Nevada and Ouachita counties received more material than areas to the east and west. The greater thickness signifies greater subsidence and possibly indicates the position of a river mouth.

LOWER CRETACEOUS SYSTEM

HOSSTON FORMATION

Definition. The Hosston formation is named after the town of Hosston located about seven miles north of the top of the Pine Island anticline. The type well is designated as the Dixie Oil Company Robertshaw No. 92 (Dillion No. 92) in Sec. 13, T. 21 N., R. 15 W. The type section is about 2,000 feet thick and consists mainly of gray and red shale and sandstone of which gray sandstone predominates toward the base.

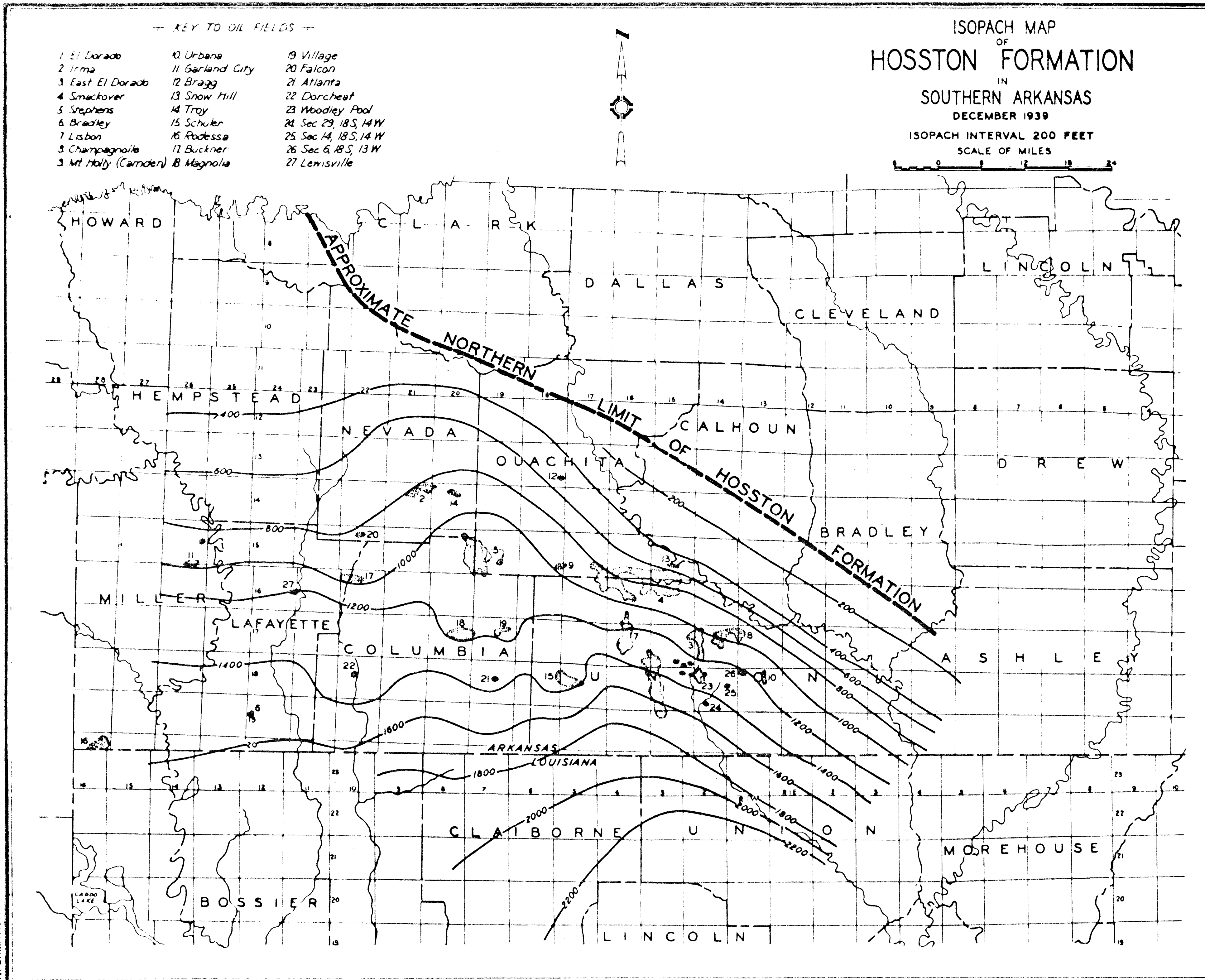
The name, Hosston, has been chosen by the Shreveport Geological Society to designate the Lower Cretaceous red and gray shales, dolomites, and sandstones lying above the Cotton Valley formation and below the Sligo formation. The name, herein presented for the first time, replaces the name, Travis Peak, as applied to beds older than the real Travis Peak formation of Texas. The stratigraphic equivalents of the Travis Peak formation of Texas are present in the Pine Island field of northwestern Louisiana in the lower part of the Pine Island formation which lies about 250 feet above the Hosston formation. This correlation is based on the occurrence of the ammonites, Dufrenoya and Procheloniceras, (18, p. 161-163) which mark the Travis Peak formation of Texas and the upper Aptian stage of the European section. The occurrence of these fossils in the Pine Island formation refutes the argument of those geologists who consider the Hosston formation as the downdip equivalent of the Travis Peak formation. Although the time limits of the Travis Peak formation need not be the same throughout its extent, the inclusion in it of rocks representing a large part, or all, of the Neocomian subperiod seems illogical.

The top of the Hosston formation in the Pine Island field of northwestern Louisiana is apparently near, or at, the base of the Dufrenoya texana zone, but due to the transgressive character of the formation its top probably becomes slightly older southward and younger northward. The base of the Hosston formation is placed above the highest black shale unit of the Cotton Valley formation. It is marked by a basal conglomerate in Arkansas and in northern Louisiana at least as far south as the Cotton Valley field. The formation grades offshore, south of the Shreveport area, into fossiliferous dark shales and limestones which contain minor amounts of interbedded red shald and sandstone. It will probably be desirable in the future to apply separate names to the various lithologic facies of the Hosston formation and to its offshore, fossiliferous equivalents.

Distribution and thickness. The distribution of the Hosston formation in Arkansas is shown on Plate XV. Dark offshore equivalents are known in Louisiana as far south as the Converse oil field in Sabine Parish. Equivalent beds are reported from two deep wells in Limestone County, Texas. Its distribution is somewhat less extensive than the underlying Cotton Valley formation, apparently due to uplift and erosion at the end of Lower Cretaceous time.

The thickness of the Hosston formation ranges from about 800 feet in Arkansas to over 2,000 feet in northern Louisiana and eastern Texas. In Arkansas a maximum thickness of 1,606 feet was penetrated in Sec. 22, T. 19 S., R. 14 W., by the Oliphant Oil Corporation's Union Saw Mill Company No. 1 well. In northern Louisiana, the formation ranges from about 300 feet to 2,300 feet and is thinnest on the Monroe Uplift. In Texas a thickness of about 2,100 feet has been reported in the Texas Company's T. C. Adams Estate No. 1 well in the Bethany gas field of Panola County. The Hosston formation pinches out northward due to depositional thinning and is probably not represented by outcrops in Arkansas.

Stratigraphic and lithologic features. The Hosston formation of Arkansas consists mainly of red shale with interbedded lenses of white sandstone. Some of the shale is greenish-gray or gray and some of the sandstone is reddish. Sandstone is uncommon in the upper third of the formation, abundant in the middle third, and predominates in the lower 100 feet. It is fine-grained in the upper two-third and medium- to coarse-grained in the lower third. The lower 100 feet contains novaculite and quartzitic pebbles that become more abundant northward. Nodules of white dolomite are present. Some


ISOPACH MAP
OF
HOSSTON FORMATION
IN
SOUTHERN ARKANSAS
DECEMBER 1939
ISOPACH INTERVAL 200 FEET
SCALE OF MILES
— KEY TO OIL FIELDS —
1 El Dorado
2 Irma
3 East El Dorado
4 Smackover
5 Stephens
6 Bradley
7 Lisbon
8 Champagnolle
9 Mt Holly (Camden)
10 Urbana
11 Garland City
12 Bragg
13 Snow Hill
14 Troy
15 Schuler
16 Rodessa
17 Buckner
18 Magnolia
19 Village
20 Falcon
21 Atlanta
22 Dorcheat
23 Woodley Pool
24 Sec 29, 18 S, 14 W
25 Sec 14, 18 S, 14 W
26 Sec 6, 18 S, 13 W
27 Lewisville
APPROXIMATE NORTHERN LIMIT OF HOSSTON FORMATION
HOWARD
CLARK
DALLAS
CLEVELAND
LINCOLN
HEMPSTEAD
NEVADA
OUACHITA
CALHOUN
DREW
BRADLEY
MILLER
LAFAYETTE
COLUMBIA
UNION
ASHLEY
ARKANSAS
LOUISIANA
CLAIBORNE
MOREHOUSE
BOSSIER
LINCOLN
CADDO LAKE

beds are calcareous. The formation is highly variable vertically and laterally. In Arkansas, Weeks (51, p. 969) has distinguished some major divisions which, from top to bottom, may be summarized as follows:

	Thickness (in feet)
Red shale, occasional lenses of white siltstone and fine sandstone. Grades upward and southward into the Sligo formation.	540 - 640
Red shale, many lenses of white siltstone and fine white sandstone, some nodules of white dolomite.	390
Red shale, interbedded medium to coarse-grained white sandstone, some nodules of white dolomite. Basal 100 feet mainly sandstone containing scattered pebbles of quartz and novaculite. Makes distinct contact with Cotton Valley formation	350

In the border region of northern Louisiana the Hosston formation is somewhat darker than in Arkansas and interfingers southward with black shale and shaly limestone. In the Pine Island field of Caddo Parish the formation consists of red, purple, and greenish shale, and sandstone. In the Bellevue field of Bossier Parish the formation consists of mottled red, green, and purple sandstone, and shale (13, p. 1666-1667). In the Sugar Creek field of Claiborne Parish the formation consists mainly of red, brown, and greenish gray shales and fine-grained, gray and red sandstones, but contains some black shale, shaly limestone in its upper part (16, p. 287) and a few streaks of lignite (11, p. 1510). Fossiliferous beds in the upper part of the formation have been noted from the Elm Grove, Sligo, Caspiana, and Sugar Creek fields.

Widespread conglomerates at the base of the Hosston formation indicate a disconformity between the Hosston and Cotton Valley formations throughout most of their extent in Arkansas. In northwestern Louisiana the Hosston-Cotton Valley contact is sharply defined (16, p. 287-288). Weeks[12] thinks that a disconformity may exist as far south as the Cotton Valley field. Relations between the Hosston formation and the overlying Sligo formation indicate that sedimentation was continuous. According to Grage and Warren their "contact is sufficiently distinct for marking a time boundary between two periods of contrasted conditions of sedimentation. However, from a regional standpoint, this time boundary does not appear to be a persistent one throughout any wide area. It appears that the contrasted sedimentary environments which define the character of the lower Glen Rose-Travis Peak (Sligo-Hosston) contact in a local area have migrated toward the edges of the sedimentary basin and upward in the stratigraphic column."

The Hosston formation may be distinguished from the Cotton Valley formation by its dominantly brighter colors; smaller amounts of calcareous material, carbonaceous material, and plant fragments; absence of brownish-black pellets of siderite; and lack of variegated, maroon and gray shales.

Correlation. The fossils obtained from the Hosston formation include species of Astarte, Lucina, Exogyra, Panope, and Cardium. None of these indicates an age older than Lower Cretaceous. Panope is questionably represented in the Jurassic period but is fairly common thereafter. One species of Cardium was obtained from the upper part of the Hosston formation at a depth of 6,260 to 6,280 feet in the Prairie River Syndicate Hutchinson No. 1 well, located in Sec. 15, T. 15 N., R. 12 W., Caddo Parish, Louisiana. This Cardium is unusual because it bears radial ribs on both its anterior and posterior margins like the unique Cardium germani Pictet & Campiche from the Valanginian of Switzerland.

The age of the Hosston formation is known within limits by its position a couple hundred feet below the Pine Island formation whose basal beds contain several species of

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[12] Personal communication

the ammonite Dufrenoya (18, p. 158-163). This genus is indicative of the lower Trinity[13] of the Gulf region and Mexico, and of the upper Aptian of Europe. Therefore, the Hosston formation, which underlies the Sligo formation transitionally, must be of Lower Cretaceous age, but older than Trinity. It belongs in the Coahuila group (23, p. 124) which includes Lower Cretaceous formations older than the Dufrenoya texana zone. Whether it represents all or only part of the Coahuila group is not known.

The Hosston formation is correlated in part with the lithologically similar Las Vigas formation of northern Mexico and southwestern Texas. Other correlations should not be made until the age of the Cotton Valley formation has been determined definitely. By comparisons with the Mexican section, it may be expected that the Hosston formation grades southward into marls and limestones in central Louisiana.

Origin. Several writers have considered that the red bed facies of the Hosston formation of Arkansas is predominantly nonmarine (13, p. 1665; 16, p. 287-288) and interfingers southward with marine wedges. The presence of dolomite nodules throughout most of the red beds shows that the red beds were deposited in water rather than on land. The scarcity of fossils, other than wood fragments, in the red beds probably indicates that the waters were not normally marine. Grage and Warren (16, p. 287) considered that "the dark shale and shaly limestone facies of the Hosston formation in northwestern Louisiana represents a shallow-water marine deltaic deposit. . ." The shallow water origin is proved by the occurrence of oysters. The deposits are deltaic in the broad sense recently used by Russell and Russell (36, p. 154-155). Thickening of the formation toward the south shows that the seaward part of the basin sank more rapidly than its margins. The main sources of the sediments in Arkansas and Louisiana lay to the north and northeast as indicated by reddening and coarsening of the sediments in those directions.

SLIGO FORMATION

Definition. Sligo is the name proposed by the Shreveport Geological Society for some gray to brown shale containing local lenses of sandstone and limestone which represent the lowest beds of the Lower Glen Rose formation. The base of the Sligo formation is defined by the uppermost red beds of the Hosston formation and its top by the highest of three limestone units which are called the Three Finger limestone. In northern Louisiana it contains locally one or two porous oölitic limestone lentils known as the Pettet limestone. The type locality is designated as the Sligo field of northwestern Louisiana. It is understood that the Nomenclature Committee of the Shreveport Geological Society will describe the type section and show graphically the boundaries of the formation in a forthcoming paper.

Distribution and thickness. The distribution of the Sligo formation in Arkansas is indicated on Plates II and V by the lowest part of the Glen Rose equivalents. The formation, as defined, has been recognized in the subsurface of east Texas and northern Louisiana. The thickness ranges from about 300 feet in Louisiana and Texas to less than 100 feet in Arkansas. It thins toward the north and is almost certainly not represented by outcrops in Arkansas.

Stratigraphic and lithologic features. The Sligo formation of Arkansas consists mainly of gray to brown shale with lenses of dense gray limestone and sandstone. In Louisiana the formation locally contains dark, oölitic, argillaceous, or sandy limestone lentils (Pettet limestone) which do not occur at the same stratigraphic positions in the various fields. The limestone lentils are typically developed in the Sligo, Lisbon,

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13/ The Trinity group of Texas was divided by Hill (19) into the Paluxy, Glen Rose, and Travis Peak formations. As formations older than the Travis Peak exist in western Texas, Adkins (1, p. 273, 284-286) amended the Trinity group to include all Lower Cretaceous rocks older than Fredericksburg. During the course of studies in Mexico the writer found the Trinity, as defined by Adkins, much too comprehensive for usefulness and has consequently proposed (23, p. 124-125) to restrict its lower limit to the base of the Dufrenoya texana zone.

Bistineau, Bear Creek, and Driscoll fields and are thinly developed in the Pine Island field.

The section in Stanolind Oil and Gas Company's Dillon Heirs No. 131 well, located in Sec. 14, T. 21 N., R. 15 W., Caddo Parish, Louisiana, is given below:

Section of Sligo formation in Stanolind Oil and Gas Company's Dillon Heirs No.131 well, Sec. 14, T. 21 N., R. 15 W., Caddo Parish, Louisiana

	Depth (in feet)	Thickness (in feet)
Limestone, sandy, porous	3,612 - 3,630	18
Limestone	3,630 - 3,634	4
Shale, calcareous	3,634 - 3,643	9
Shale	3,643 - 3,650	7
Limestone	3,650 - 3,655	5
Shale, calcareous	3,655 - 3,673	18
Limestone	3,673 - 3,676	3
Shale, calcareous	3,676 - 3,697	21
Limestone	3,697 - 3,702	5
Shale	3,702 - 3,705	3
Limestone	3,705 - 3,708	3
Shale	3,708 - 3,717	9
Limestone	3,717 - 3,720	3
Shale, calcareous in part	3,720 - 3,746	26
Limestone	3,746 - 3,750	4
Shale	3,750 - 3,756	6
Limestone	3,756 - 3,760	4
Shale, calcareous	3,760 - 3,776	16
Limestone	3,776 - 3,782	6
Shale	3,782 - 3,787	5
Limestone	3,787 - 3,800	13
Shale, calcareous	3,800 - 3,817	17
Limestone	3,817 - 3,825	8
Shale, calcareous	3,825 - 3,836	11
Limestone	3,836 - 3,844	8
Shale	3,844 - 3,852	8
Limestone	3,852 - 3,857	5
Shale, calcareous	3,857 - 3,864	7
Limestone	3,864 - 3,870	6
Shale, calcareous	3,870 - 3,878	8
Limestone	3,878 - 3,883	5
Shale	3,883 - 3,887	4
Limestone	3,887 - 3,890	3
Shale, overlies red shale of Hosston formation	3,890 - 3,895	5
Total thickness in feet		283

The section in the Standard Oil Company of Louisiana W. P. Phillips et al. No. 1 well, located in Sec. 15, T. 17 S., R. 19 W., Columbia County, Arkansas, is given below.

Section of Sligo formation in Standard Oil Company of Louisiana W. P. Phillips et al No. 1 well, Sec. 15, T. 17 S., R. 19 W., Columbia County, Arkansas

	Depth (in feet)	Thickness (in feet)
Limestone, porous	3,890 - 3,896	6
Shale, sandy	3,896 - 3,900	4
Limestone, porous	3,900 - 3,905	5
Shale, sandy	3,905 - 3,912	7
Limestone	3,912 - 3,916	4
Shale, in part calcareous	3,916 - 3,955	39
Shale, sandy	3,955 - 3,972	17
Limestone	3,972 - 3,977	5
Shale, calcareous at base	3,977 - 4,010	37
Limestone	4,010 - 4,015	5
Shale, sandy in part	4,015 - 4,040	25
Limestone, porous, overlies Hosston formation	4,040 - 4,048	8
Total thickness in feet		158

Correlation. The Sligo formation is probably of lowest Trinity age as it underlies the Pine Island formation whose lower beds contain lower Trinity fossils. It is tentatively correlated with the Sycamore member of the Travis Peak formation of Texas.

Origin. The Sligo formation represents deposition in shallow, normal marine waters as shown by the presence of oölites and sandstones, and by its dark color. The relation of its dark shales to the underlying red beds of the Hosston formation is clearly transgressive.

PINE ISLAND FORMATION

Definition. The Pine Island formation was first defined by Crider (13, 1666) for the beds here called the Hosston formation. However, the name, Pine Island, was originally proposed by the Shreveport Geological Society for the dark marine shales and limestone above the uppermost red beds of the Hosston formation (then called Travis Peak) and below the James limestone lentil. The Shreveport Geological Society has subsequently decided to restrict the name, Pine Island, to the dark shales with some interbedded limestone and sandstone lying above the "Three finger limestone" lentil and below the James limestone member. The restricted Pine Island formation contains some red beds and is much shalier than the underlying Sligo formation. The type locality is designated as the Pine Island field of northwestern Louisiana. The type section and the boundaries of the formation will be described by the Nomenclature Committee of the Shreveport Geological Society in a forthcoming paper.

Distribution and thickness. The distribution of the Pine Island formation in Arkansas is indicated on Plates II and V by part of the Glen Rose equivalents lying immediately below the James limestone lentil. The formation is widespread in northern Louisiana and eastern Texas. The thickness ranges from 500 feet in Louisiana to about 50 feet at the outcrops in Arkansas. In the oil fields of Arkansas the thickness ranges from about 150 to 280 feet.

Stratigraphic and lithologic features. The Pine Island formation consists mainly of gray to brown shale, is interbedded with dense gray limestone and fine sandstone, and contains some red shale. It becomes coarser, redder, and thinner toward the north and northeast. The Pine Island formation probably grades northward into the gray and yellow sandstone, shale, and gravels that form the basal 50 to 200 feet of the Trinity outcrops.

The section in the Stanolind Oil and Gas Company's Dillon Heirs No. 131 well, located in Sec. 14, T. 21 N., R. 15 W., Caddo Parish, Louisiana, is given below.

Section of Pine Island formation in Stanolind Oil and Gas Company's Dillon Heirs No. 131 well, Sec. 4, T. 21 N., R. 15 W., Caddo Parish, Louisiana

	Depth (in feet)	Thickness (in feet)
Shale	3,127 - 3,155	28
Shale, sandy	3,155 - 3,166	11
Limestone	3,166 - 3,174	8
Shale	3,174 - 3,187	13
Shale, calcareous	3,187 - 3,210	23
Limestone	3,210 - 3,214	4
Shale	3,214 - 3,230	16
Shale, sandy	3,230 - 3,236	6
Limestone	3,236 - 3,247	11
Shale	3,247 - 3,267	20
Shale, sandy	3,267 - 3,280	13
Shale, calcareous in upper part	3,280 - 3,300	20
Limestone	3,300 - 3,308	8
Shale, calcareous	3,308 - 3,316	8
Limestone	3,316 - 3,320	4
Shale, calcareous	3,320 - 3,325	5
Shale	3,325 - 3,336	11
Shale, sandy	3,336 - 3,342	6
Shale	3,342 - 3,355	13
Shale, calcareous	3,355 - 3,437	82
Shale	3,437 - 3,568	131
Shale, sandy	3,568 - 3,577	9
Shale	3,577 - 3,597	20
Shale, calcareous	3,597 - 3,612	15
Total thickness in feet		485

Correlation. The age of the Pine Island formation of northern Louisiana has been definitely determined as lowest Trinity because of the presence of species of the ammonites Dufrenoya and Procheloniceras (18, p. 158-163). These genera characterize the Travis Peak formation (strict sense) of Texas, the upper member of La Pena formation of northern Mexico, and the upper Aptian of Europe. In Louisiana these genera have been found only in the lower part of the Pine Island formation. Ammonites which Scott (18, p. 161-162) considered Hypacanthoplites and Rhytidhoplites were obtained from the upper part of the same formation. Hypacanthoplites is known from upper Aptian and lower Albian deposits of areas other than North American. Scott considers the range of Rhytidhoplites as middle Albian. The Pine Island formation is definitely of Trinity age and probably represents only lower Trinity. Its probable Texas and Mexican equivalents are shown on Table 3.

Origin. The Pine Island formation is of shallow water origin. The dark color of most of its sediments indicates a normal marine environment of deposition. The occurrence of some reddish beds at the northern extremity of the formation suggests an arid or semi-arid climate on the bordering land masses.

RODESSA FORMATION

Definition. The Rodessa formation was named by the Shreveport Geological Society (18, p. 156-157) and includes oölitic to coquinoid limestone, calcareous shale, and two anhydrite beds. Its base is defined by the lowermost beds of the James limestone member and its top by the bottom of the Ferry Lake anhydrite. It contains a number of members.

lentils, and tongues. The type locality is designated as the Rodessa field on the boundary of Louisiana and Arkansas. The type section and boundaries of the formation will be defined in a forthcoming paper by the Nomenclature Committee of the Shreveport Geological Society. The formation corresponds to the upper part of the Lower Glen Rose formation.

Distribution and thickness. The distribution of the Rodessa formation is indicated on Plates II and V by the part of the Glen Rose equivalents lying between the base of the James limestone and the massive anhydrite. The formation is widespread in northwestern Louisiana and eastern Texas. The thickness ranges from about 500 feet in Louisiana to less than 300 feet at the outcrops in Arkansas.

Stratigraphic and lithologic features. A generalized section of the Rodessa formation of southwestern Arkansas and northwestern Louisiana, according to Weeks (51, p. 961, 969-971), is as follows:

	Feet
Interbedded gray shale and light gray, dense to porous oölitic limestone.	70 - 90
White anhydrite tongue (Basal stringer); barely extends into Arkansas. Persists at least as far south as southern Bienville Parish, Louisiana, and northeastern Panola County, Texas.	10 - 30
Hill sandy lentil of interbedded shale, marl, limestone and lenses of reddish brown to gray, fine-grained sandstone and sandy shale. Reddish beds persistent through a thickness of 100 feet or more in northwestern Louisiana	160
Pink and white anhydrite tongue; extends about 12 miles into Arkansas	5 - 10
Gloyd limestone lentil of gray limestone and marl, locally oölitic, dense to slightly porous. Sandy beds near middle. Upper part grades to shale northeastward. Lower part glauconitic and mottled red, green, and black. Red beds increase in thickness eastward and northward.	100 +
James limestone member of oölitic, coquinoid, to sandy gray limestone and fine sandstone; changes eastward to calcareous sandstone in Union Parish, Louisiana; changes westward to black marl and shale in northwestern Louisiana; changes northward to dense limestone and red and gray shale in Arkansas	70 - 100
	415 - 490

Locally in northwestern Louisiana the James limestone has been divided into two lentils. At the top the Dees lentil consists of sandy limestone and coquina from 10 to 20 feet thick. Below this is the Young lentil of oölitic to coquinoid limestone which grades downward into dark shale streaked with sandstone, and is about 80 feet thick.

The Rodessa formation becomes coarser, redder, and thinner toward the north and northeast. The James limestone member grades northward into Dierks sandy limestone and green shale (51, p. 970). The remainder of the Rodessa formation grades northward into the Holly Creek member of the outcrops which consists of 150 to 300 feet of red and yellowish shale, and lenses of sandstone and gravel.

Correlation. The age of the Rodessa formation is determined approximately as lower Trinity by its position directly above the Pine Island formation. The Rodessa formation may be correlated with the lower part of the Glen Rose formation of Texas (Table 3) as the Dierks-James limestone member contains typical Glen Rose fossils.

Origin. The presence of oölites, coquinas, sandstones, and oysters indicates that the Rodessa formation is of shallow water origin. The brecciated character of the coquina-like limestone was probably produced by wave action (16, p. 291). The abundance of invertebrate fossils and the dark color of many of the sediments indicate normal marine environment during most of the time. The occurrence of several widespread anhydrite stringers and reddish beds suggests temporary shoaling of the sea and an arid or semi-arid climate on the surrounding land masses. The interlensing of the various types of deposits suggests an oscillating sea, or climatic changes. The occurrence of anhydrite and associated dense, light gray limestone indicates that chemical deposition occurred during the latter part of Rodessa time. The source of the sediments in Arkansas was apparently the north and in Louisiana was evidently the east. Marked thinning of the sediments in Pike, Howard, and Sevier counties, Arkansas, suggests that the sea did not extend much farther north.

FERRY LAKE ANHYDRITE

Definition. The Ferry Lake anhydrite consists of about 250 feet of white to gray, finely crystalline anhydrite which contains minor amounts of interbedded gray to black shale, dense limestone, and dolomite. It lies conformably between the Rodessa and Mooringsport formations. The name, Ferry Lake anhydrite, replaces Glen Rose massive anhydrite. The type section and boundaries of the formation will be described in a forthcoming paper by the Shreveport Geological Society.

Distribution and thickness. In Arkansas the Ferry Lake anhydrite is limited on the north by outcrops of gypsum in Sevier, Howard, and Pike counties, and on the northeast along a line from the outcrop to R. 16 W. at the Arkansas-Louisiana boundary (Plate II). It occurs at least as far south as southern Bienville Parish, Louisiana, and northeastern Panola County, Texas. According to Hazzard[14/] the section in a deep well in the Zwolle field of Sabine Parish shows that the Ferry Lake anhydrite lenses rapidly toward the south and may never have been present ten to 20 miles south of the field. The anhydrite appears to be nearly coextensive with the East Texas basin, judging from the occurrences recorded by Adkins (1, p. 301-304). The Ferry Lake anhydrite, as well as all Lower Cretaceous formations younger than the Hosston, are not present on the Monroe-Richland uplifts but are fully developed near the Mississippi River in Madison Parish, Louisiana. This occurrence suggests that central Mississippi is underlain by a thick section of Lower Cretaceous rocks.

The anhydrite ranges in thickness from about ten feet at the outcrop to over 500 feet subsurface in the southwestern corner of Arkansas and adjoining parts of Louisiana and Texas. The thickness in the oil fields of Arkansas ranges between 150 and 250 feet.

Lithologic features. The Ferry Lake anhydrite is finely crystalline, thin- to thick-bedded, locally brecciated, and white to dark gray. It generally contains some thin, dense to earthy or oölitic, limestone, some gray to black calcareous shale, and some thin-bedded dolomite. The anhydrite probably makes up 80 to 90 per cent of the total thickness. Fossils occur rarely in the limestone and shale. Several detailed sections have been given by Spooner (44, p. 50-57).

The base of the Ferry Lake anhydrite, according to observations made by Hazzard[15/] is not always sharp but grades upward within a six-inch core from (1) shale or shaly limestone containing irregular masses of anhydrite to (2) anhydrite breccia in shale or limestone, and to (3) nearly pure anhydrite. He notes that the anhydrite breccia fragments are irregular in outline, have their longer axes inclined at all directions to the bedding, and are embedded in a matrix which may be anhydrite, limestone, or calcareous shale. He thinks that the breccias were formed by wave action in very shallow water soon after solidification of the anhydrite composing them.

Hazzard also notes that anhydrite cores from northern Louisiana have a peculiar "chicken wire lattice structure" in which individual anhydrite masses are separated by

14/ Personal communication
15/ Personal communication

thin films of calcareous mud. He suggests that this structure was formed by discrete, nearly gelatinous anhydrite masses settling through muddy waters from which mud was settling at the same time. The writer suggests that the structure was formed by wave action in shallow, muddy waters before solidification of the anhydrite.

Correlation. Judging by its stratigraphic position the Ferry Lake anhydrite is of middle Trinity age. Its probable equivalents in southwestern Texas and northern Mexico are indicated on Table 3.

Origin. The character of the Ferry Lake anhydrite and its relation to the overlying normal marine beds indicates a marked shoaling of the sea and aridity on the bordering land masses during its formation. It is possibly a lagoonal deposit although no barrier has been discovered. However, in northern Mexico equivalent gypsum and dolomite deposits grade basinward into thick rudistid limestone which formed reefs that gave rise to the lagoonal conditions.

MOORINGSPORT FORMATION

Definition. The Mooringsport formation includes the dominantly marine shale and limestone lying above the Ferry Lake anhydrite and below the red shales and sands of the Paluxy formation, and corresponds to the Upper Glen Rose formation. Its lower boundary is fairly abrupt; its upper boundary is transitional. Its type section and boundaries will be described in a forthcoming paper.

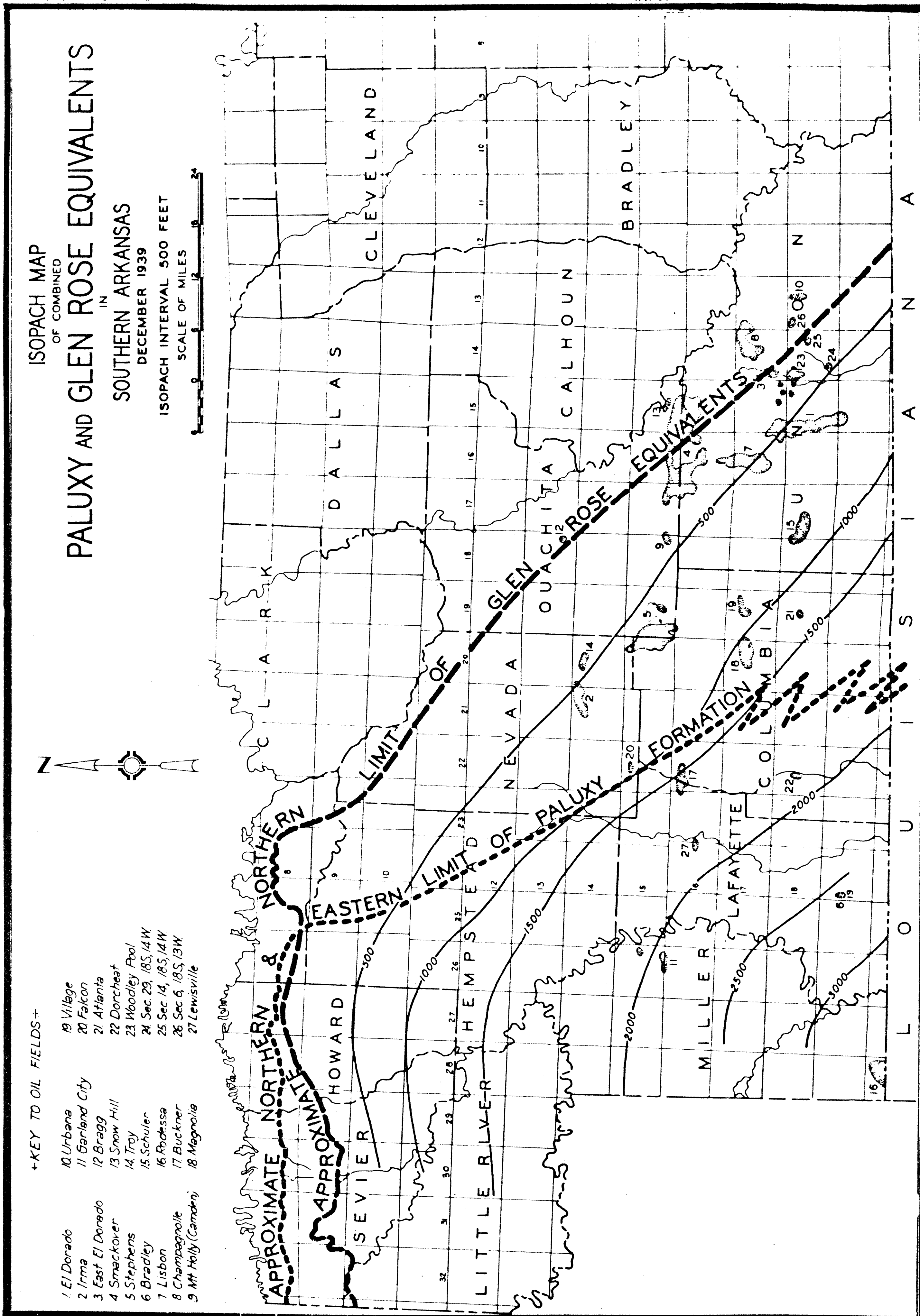
Distribution and thickness. The Mooringsport formation in Arkansas is limited on the north by the outcrops of the DeQueen limestone in Sevier, Howard, and Pike counties and on the northeast along a line extending from the southwestern part of T. 8 S., R. 25 W., to the southwestern part of T. 19 S., R. 17 W., at the Arkansas-Louisiana boundary (Plate II). It is widespread in northwestern Louisiana and northeastern Texas. The Mooringsport formation is absent from the Monroe-Richland uplifts of northeastern Louisiana but is present near the Mississippi River in Madison Parish, Louisiana. It ranges in thickness from about 60 to 75 feet at the outcrop to about 730 feet in the extreme southwestern corner of Arkansas and to about 800 feet in northwestern Louisiana.

Stratigraphic and lithologic features. The Mooringsport formation of Arkansas, according to Weeks (51, p. 971-972) "is composed of gray to dull brown shale and marls with streaks of dense fossiliferous limestone and here and there streaks of fine sand. Two thin anhydrite stringers are present at 260 and 160 feet, respectively, above the top of the massive anhydrite. These stringers pinch out northeastward within 15 or 20 miles from the southwest corner of the state. Practically the entire formation grades to red shales of the Paluxy formation northward, so that on the outcrop only 30 to 50 feet remain as the DeQueen limestone." Some lignite occurs in the shales and sandstones of the upper part of the formation. Maroon shale occurs throughout the formation but is most common in the upper part (44, p. 48).

In northwestern Louisiana the Mooringsport formation consists of interbedded gray to black, calcareous shales and gray to white thin-bedded limestones which grade at the top into red sandy shales and fine-grained sandstones. Some of the limestones are oölitic. Two anhydrite lenses, ranging from 5 to 15 feet in thickness, generally occur in the lower part of the formation but locally are absent. Three anhydrite lenses which are not everywhere developed occur in the Lisbon field (16, p. 292).

The Mooringsport formation grades into the Paluxy, both vertically and laterally. Their boundary must, therefore, be chosen arbitrarily and is generally chosen where the first fossils appear (44, p. 48). Because of this graditional relationship, their thicknesses are combined on the isopach map (Pl. XVI).

Correlation. The Mooringsport formation of the subsurface and its equivalent De Queen limestone at the outcrop contain fossils (50, p. 1082-1085) which, according to Stanton (33, p. 85), are definitely related to the fauna of the Glen Rose limestone of


ISOPACH MAP
OF COMBINED
PALUXY AND GLEN ROSE EQUIVALENTS
IN
SOUTHERN ARKANSAS
DECEMBER 1939
ISOPACH INTERVAL 500 FEET
SCALE OF MILES
0 6 12 18 24
+KEY TO OIL FIELDS+
1 El Dorado
2 Irma
3 East El Dorado
4 Smackover
5 Stephens
6 Bradley
7 Lisbon
8 Champagnolle
9 Mt Holly (Camden)
10 Urbana
11 Garland City
12 Bragg
13 Snow Hill
14 Troy
15 Schuler
16 Rodessa
17 Buckner
18 Magnolia
19 Village
20 Falcon
21 Atlanta
22 Dorcheat
23 Woodley Pool
24 Sec 29, 18S, 14W
25 Sec 14, 18S, 14W
26 Sec 6, 18S, 13W
27 Lewisville
APPROXIMATE NORTHERN LIMIT OF GLEN ROSE EQUIVALENTS
APPROXIMATE NORTHERN & EASTERN LIMIT OF PALUXY FORMATION
CLEVELAND
BRADLEY
DALLAS
CALHOUN
CLARK
OUACHITA
NEVADA
UNION
COLUMBIA
HOWARD
HEMPSTEAD
SEVIER
LITTLE RIVER
MILLER
LAFAYETTE
LOUISIANA
500
1000
1500
2000
2500
3000

Texas. As most of the fossils of the DeQueen limestone are also common to the Dierks limestone of the Rodessa formation, their age must be about the same. The most characteristic fossil found in the subsurface is the large foraminifera, Orbitolina texana (Roemer).

Origin. The Mooringsport formation of Arkansas is mainly a submarginal neretic facies. It grades northward into coarse marginal sediments and southward into calcareous offshore sediments. The presence of ripple marks, sun cracks, worm trails, corals, anhydrite, and celestite indicates that the Mooringsport formation was deposited in very shallow waters (33, p. 83; 1, p. 300).

PALUXY FORMATION

Definition. The Paluxy formation of Arkansas consists of nearly nonfossiliferous variegated shales and sands which grade laterally and downward into the Mooringsport formation. It is overlain abruptly by the Goodland limestone (Comanche Peak formation).

Distribution and thickness. The distribution of the Paluxy formation in Arkansas is shown on Plates II and XVI. It is limited on the north by the outcrop in Sevier, Howard, and Pike counties and on the east by a line drawn from the outcrop to R. 20 W., at the Arkansas-Louisiana boundary. Near the southern boundary of Arkansas the Paluxy formation becomes finer and more calcareous. The Paluxy formation consists mainly of red shales and sands in northwestern Louisiana in Caddo and Bossier parishes, and grades southward into gray limestones and shales, thin sands and some red beds which are commonly classified as part of the Mooringsport formation.

The maximum reported thickness of the Paluxy formation in Arkansas is about 1,200 feet (51, p. 972). It thins northward to the outcrop where it ranges from 160 to 270 feet in thickness (44, p. 31).

Stratigraphic and lithologic features. The Paluxy formation of Arkansas consists of red, brown, and gray shales, gray to white sand, and gray limestone. Some beds are lignitic. The sands on the outcrops are generally cross-bedded. Detailed well sections have been given by Spooner (44, p. 51-55). Weeks (51, p. 972) has divided the formation from top to bottom as follows:

	Feet
Variegated shales and streaks of fine white sand.	400
Red to dull brownish gray fossiliferous shale with streaks of dense gray fossiliferous limestone and fine white sand	460
Red shale with streaks of fine white sand	350
	1,210

Correlation. An upper Trinity age for the Paluxy formation is indicated by its lateral gradation into typical Mooringsport limestone and shale in northern Louisiana and Texas (1, p. 320).

Origin. The Paluxy formation of Texas has been interpreted as a shoreward sandy facies of the upper part of the Glen Rose formation (19, p. 170). Scott (40, p. 50-52) regards it as a littoral deposit of a withdrawing sea and thinks that the relief of the abandoned area was so low that the sand was not removed by erosion. In Arkansas the relation of the Paluxy sands and clays to the underlying Mooringsport shales and limestone is clearly regressive. However, its maximum thickness of 1,200 feet shows considerable subsidence of the sea bottom and suggests that the water level was not lowered much. The accumulation of fairly thick regressive deposits might be explained if the sea bottom was sinking so slowly during Paluxy time that sediments accumulated to a base level of deposition for a great distance from shore, thereby permitting by-passing of sands an equal distance. Another explanation might be that a climatic change enabled the rivers to bring larger amounts of sand and clay to the sea than in earlier Trinity time.

GOODLAND (COMANCHE PEAK) LIMESTONE

Definition. The Goodland limestone of Texas, Oklahoma, and Arkansas is considered by Adkins (1, p. 334) as synonymous with the Comanche Peak limestone of Texas and according to Thompson (46, p. 1536-1537) the name should be abandoned. Mendenhall (28, p. 1537) favors retaining the name, Goodland limestone, "for the northern thin limestone of the Fredericksburg where the Edwards is either very thin or not recognizable as such." In Arkansas the Goodland limestone is abruptly separated from the underlying Paluxy formation.

Distribution, thickness and character. The eastern limit of the Goodland limestone is indicated on Plate II. The Goodland limestone outcrops north and east of Cerro Gordo, Arkansas, where, according to Adkins (1, p. 335), "It consists of 50 feet or less of thick-bedded, gray, sandy limestone, containing some beds of hard, yellow-gray, calcareous sandstone. At some horizons, the Goodland beds are notably lenticular; lentils of limestone six feet long and one foot thick, of varying degrees of sandiness, stand at small angles with the normal bedding. The upper eight feet of the formation, where exposed, is less sandy limestone. The top is a ledge a foot thick, or hard, white limestone, which weathers into cavernous slabs."

Available information concerning the subsurface stratigraphy of southwestern Arkansas is not sufficient to permit separating the Goodland limestone from the overlying Kiamichi formation, or the underlying Walnut formation. These formations, according to drilling records (44, p. 62; 51, p. 972), attain a maximum thickness of about 300 feet and consist of dense to chalky white limestone and some gray shale. Most of this section probably belongs to the Goodland limestone. The abrupt contact at the base of the Goodland limestone indicates a minor disconformity.

The section in the Hill and Estabrook, Sherman No. 1 well, located in Sec. 29, T. 19 S., R. 28 W., Miller County, Arkansas, probably represents both Fredericksburg and Washita and is given below.

Section in Hill and Estabrook, Sherman No. 1 well, Sec. 29, T. 19 S., R. 28 W., Miller County, Arkansas

	Depth (in feet)	Thickness (in feet)
Limestone, dense.	3,630 - 3,655	25
Shale	3,655 - 3,675	20
Shale, calcareous	3,675 - 3,685	10
Shale	3,685 - 3,690	5
Limestone, dense.	3,690 - 3,695	5
Shale	3,695 - 3,705	10
Limestone, dense.	3,705 - 3,715	10
Shale	3,715 - 3,755	40
Limestone, dense.	3,755 - 3,765	10
Shale	3,765 - 3,770	5
Limestone, porous	3,770 - 3,830	60
Shale	3,830 - 3,835	5
Limestone, porous	3,835 - 3,867	32
Shale	3,867 - 3,880	13
Limestone, porous to dense.	3,880 - 3,835	55
Shale, calcareous	3,835 - 3,840	5
Limestone, porous	3,840 - 3,872	32
Shale, calcareous	3,872 - 3,887	15
Shale	3,887 - 4,003	16
Limestone, dense.	4,003 - 4,018	15

	Depth (in feet)	Thickness (in feet)
Shale	4,018 - 4,022	4
Limestone	4,022 - 4,025	3
Total thickness in feet		395

Correlation. The Goodland limestone near Cerro Gordo, Arkansas, is the easternmost outcrop of the Fredericksburg group (1, p. 324). In Texas it contains *Oxytropidoceras acuticarinatum* (Shumard) which characterizes the lower and middle Fredericksburg. Thompson (46, p. 1532) thinks that the Comanche Peak (Goodland) limestone grades downward and northward into the Walnut formation and upward and southward into the Edwards limestone. His conclusions apparently are not shared in their entirety by some other geologists who have studied the Lower Cretaceous rocks of Texas.

Origin. The paleogeographic relations of the Goodland (Comanche Peak) limestone to adjoining formations have been discussed by Thompson (46, p. 1531-1535) who says: "At the beginning of Fredericksburg time the country was. . .tilted toward the northwest and the sea. . .began its northwestward advance. . .over the low flat topography of the Paluxy sand. Wave-marked banks of shells were piled along the beach, later to be covered with yellow clay marl of the upper part of the Walnut as the sea gradually crept landward. This time it swept beyond the limits to which the Trinity sea had formerly advanced. . . (and its sediments overlapped) "onto the Trinity rocks and finally onto the Paleozoic floor of Oklahoma." Judging from descriptions by Thompson (46) and Adkins (1, p. 328), the Walnut formation is a beach and marginal facies; the Comanche Peak (Goodland) limestone is a shallow water sub-marginal facies; and the Edwards limestone is mainly an offshore reef facies. According to Thompson's interpretation, these facies were forming contemporaneously during Fredericksburg time, and as the sea deepened their sites of deposition migrated northward.

KIAMICHI FORMATION

Definition. The Kiamichi formation consists of marly clays alternating with hard, thin beds of limestone and shell aggregates. It overlies the Goodland limestone in northeastern Texas, southeastern and south-central Oklahoma, and southwestern Arkansas (1, p. 349; 54, p. 1091).

Distribution, thickness and character. Exposures near Cerro Gordo, Arkansas, have been described by Adkins (1, p. 349) as follows: "One-half mile north of Cerro Gordo, the Kiamichi consists of a few feet of one-foot beds of closely packed gryphaeas, set in a scant matrix of dense, hard, gray-green marl, and alternating with poorly exposed, softer, gray and green marls, containing *Gryphaea navia.* One-half mile northeast of Cerro Gordo, 20 feet of Kiamichi consists of blue-gray and green-gray marls alternating with discontinuous beds and lenses of gray fossiliferous limestone."

The Kiamichi formation has not been differentiated from the Goodland limestone in the subsurface of southwestern Arkansas. It is possibly represented by the 100 feet of shales and marls at depths of 3,655 to 3,755 in the Hill and Estabrook, Sherman No. 1 well, located in Sec. 29, T. 19 S., R. 28 W., Miller County, Arkansas.

Correlation. The Kiamichi formation is characterized by *Oxytropidoceras belknapi* (Marcou) and *Gryphaea navia* (Hall) (1, p. 359). It is included by some authors in the Fredericksburg group (1, p. 323, 328, 339, 344; 46, p. 1536) and by others in the basal Washita group (45, p. 405).

Origin. The Kiamichi formation is of shallow water origin and was probably deposited in shallower water than the underlying Goodland limestone. Some geologists think that the sea withdrew briefly from north, central, and southwest Texas at the end of Kiamichi deposition (46, p. 1535).

S T R A T I G R A P H Y (B Y C O U N T I E S)

SEVIER, HOWARD AND PIKE COUNTIES

Lower Cretaceous outcrops, representing the Trinity group, extend from the western border of Sevier County eastward about 45 miles to eastern Pike County and range in width from about 15 miles near the Oklahoma border to less than five miles in Pike County. The Lower Cretaceous strata are nearly horizontal but dip southward 75 to 100 feet per mile. They are of particular interest to the oil prospector, as they form the only outcrops of Trinity rocks in Arkansas and constitute the thin, shoreward edges of the thick subsurface formations of southern Arkansas. Therefore, an understanding of the lithologic and stratigraphic features of the Lower Cretaceous rocks is essential in interpreting the subsurface geology. As the Trinity outcrops have been adequately described by previous writers (32, p. 274-276; 33, p. 79-86; 50, p. 1070-1089; 44, p. 28-63), a tabulation of their main characteristics will suffice to show their relations to equivalent offshore strata toward the south (Table 5).

LITTLE RIVER COUNTY

Lower Cretaceous rocks are represented in Little River County by the Coahuila, Trinity, and Fredericksburg groups. The Fredericksburg group outcrops along Little River near Cerro Gordo (44, p. 32), where it is represented by about 25 feet of Kiamichi clay and 50 feet of Goodland limestone. These formations thicken underground toward the southwest, and about 130 feet of limestones and shales from the Grote, et.al., Arden No. 1 well in Sec. 2, T. 13 S., R. 31 W., have been assigned to them (44, p. 62). The groups older than the Fredericksburg are represented by thick deposits that do not crop out in the county. The Trinity group is represented by the Paluxy, Mooringsport, Ferry Lake, Rodessa, Pine Island, and Sligo formations. The Coahuila group is represented by the Hosston formation. The main characteristics of the formations of Coahuila and Trinity ages are summarized in Table 6.

HEMPSTEAD COUNTY

The Lower Cretaceous and Jurassic systems, as revealed by drilling, have a thickness of at least 3,500 feet in the southern part of Hempstead County. They are characterized by marginal and nearshore deposits such as red beds, sandstones, gravels, lignite, anhydrite, and oölitic limestones. The coarser sediments vastly predominate in the Paluxy, Hosston, Cotton Valley, and Eagle Mills formations. The finer sediments, especially limestone, anhydrite, and dark shales, are most common in the Glen Rose equivalents (i.e., Mooringsport, Ferry Lake, Rodessa, Pine Island, and Sligo formations and in the Smackover formation. Northward and northeastward, the Lower Cretaceous deposits become generally thinner, coarser, and more highly variegated. The thinning is in part depositional and in part due to pre-Upper Cretaceous erosion. The Paluxy is present only in the southern and western parts of the county as indicated on Plate II. The Glen Rose equivalents are probably present in all parts of the county, but are very thin in some sections toward the northeast. The Eagle Mills formation has not been completely penetrated by drilling. A summary of Lower Cretaceous and Jurassic stratigraphy of Hempstead County is given in Table 7.

NEVADA COUNTY

The Lower Cretaceous and older Mesozoic rocks of Nevada County range in thickness from a few hundred feet in the northern part of the county to more than 3,700 feet in the southern part. They consist mainly of nearshore sands, shales, conglomerates, and anhydrites. The limestone of the Glen Rose equivalents and Smackover formation are more

Table 5. Trinity rocks in Sevier, Howard and Pike counties, Arkansas

Surface formations	Thickness at outcrop (feet)	Lithologic features	Relations to subsurface formation	Subsurface equivalent
Upper sand and clay member	160-200	Fine, gray sand and interbedded clays. Weathers red and yellow.	Thickens to southward and lower beds interfinger with limestone and shale which are not separated from the upper Glen Rose. About 600 feet thick in southern Sevier and Howard counties.	Paluxy
DeQueen limestone member	30-75	Green clay; gray, thin limestones; some gypsum and celestite; fossiliferous, lignitic.	Thickens southward and becomes more calcareous; shales dominantly gray to brown, some red; anhydrite stringers. About 100 feet thick in southern Sevier County.	Mooringsport
White gypsum member	3-14	Sugary gypsum, some clay	Thickens southward and passes into anhydrite containing partings of gray shale and dense limestone. About 200 feet thick in southern Howard County.	Ferry Lake anhydrite
Holly Creek clay and sand member	150-300	Red and yellow clays, thin beds of sand, lenses of gravel	Thickens southward and passes into limestone containing anhydrite stringers; 200 to 300 feet thick in southern Howard and Sevier counties.	Rodessa
Dierks limestone lentil	0-40	Hard, gray limestone; some thin layers of green shale; sandy shales and limestones; many fossil oysters.	Thickens slightly southward and becomes more calcareous	
Lower sand and clay member	100 ±	Mainly fine, gray to yellow, generally cross-bedded, asphalt bearing sand; some thin clay beds.	Thickens southward and passes into dark shales and limestones. Some red shale. About 350-400 feet thick in southern Howard County.	Pine Island
Pike gravel member	20-100	Angular to rounded pebbles, mainly novaculite. Brown to gray sand and clay lenses in upper part.	Basal beds become progressively older toward south	

Table 6. Coahuila and Trinity rocks in Little River County

Formation	Thickness (in feet)	Lithologic features	Regional relationships
Paluxy	630-1,060	Variegated shales, red predominating; thin beds of limestone and fine white sandstone. Limestone beds most common near middle of formation. Highly variable.	Thickens toward south and southeast. Northward basal beds are progressively older.
Mooringsport	120-370	Limestone, marl, shale, sandy limestone, pyrite, streaks of fine sandstone. Limestones, mainly gray. Shales gray, brown, rarely red.	Thickens toward south. Upper part changes northward into red shales which are recognized as lower part of Paluxy formation.
Ferry Lake anhydrite	50-190	Anhydrite, contains some thin limestone and shale beds. Not recorded in all wells.	Thickness highly variable locally. Becomes thicker toward south.
Rodessa Pine Island Sligo	520-850	Variegated shales, mainly red. Thin beds of limestone, sandy limestone, and sandstone. Local conglomerate. Gypsum rare. Becomes darker and more calcareous toward base.	Thickens southward, darkens and becomes more highly calcareous. Brightens and becomes coarser northward.
Hosston	400-630+	Sandstone and shale, some sandy limestone. Locally lignitic, or conglomeratic. Sands gray, brown, white. Shales mainly red. Siltstone white. Limestones gray and white. Basal conglomerate.	Thickens toward south.

Table 7. Summary of Lower Cretaceous and Jurassic stratigraphy of Hempstead County

Formations		Thickness (in feet)	Lithologic features	Regional relationships
Paluxy		0-500	Red, gray and black shales. Thin beds of sandstone and limestone.	Thickens southward. Terminates northeastward along a line drawn from T. 9 S., R. 25 W., toward southeast corner of county.
Glen Rose equivalents	Mooringsport	18-240	Dense limestone, sandy limestone, some sandstones, shale, and anhydrite.	Thickens southward. Thickness in northeastern part of county highly variable due to pre-Upper Cretaceous erosion. Absent in extreme northeastern part of county.
	Ferry Lake anhydrite	20-195 +	Anhydrite, shale, dense limestone, pyrite. Some red beds toward northeast.	About 200 feet thick in southwestern part of county. Thins northward to a few feet.
	Rodessa	600-1,000 +	Upper part consists of oölitic to dense limestone; brown, black, white, and red shales; streaks of anhydrite; some lignite and green sands.	Southward becomes darker, more oölitic and lignitic. Northward becomes redder, thinner, and coarser.
	Pine Island Sligo		Lower part consists of shales and sandstones. Some thin beds of white sandstone and limestone. Shales are brown, gray, green and red.	Thickens southward, darkens and becomes more calcareous. Becomes thinner, redder and coarser northward.
Hosston		300-750	Red and gray shales. Thin beds of sandstone and limestone. Conglomerate lenses fairly common in lower part.	Deposits become thicker and finer southward. Conglomerates most common toward base.
Cotton Valley (Schuler facies)		0-1,300	Red shale; conglomerates	Occur only in southern part of county and thicken southward.
Smackover		115	Limestone, white, finely crystalline to granular.	
Eagle Mills		170	Red shale. Color is deeper and more lustrous than red of Hosston formation.	

distinctly marine than the other rock types, but were probably formed fairly near the shore. The Paluxy formation is possibly present as a thin layer in the extreme southwest corner of the county. The Glen Rose equivalent formations are well represented in the southern part of the county but thin northeastward and are absent in the extreme northeastern part of the county. The Hosston formation ranges in thickness from about 100 feet in the northeastern part of the county to over 1,000 feet in the southern part. The thinning of these formations is due in part to original depositional thinning and in part to pre-Upper Cretaceous erosion. The Cotton Valley and underlying concordant Mesozoic formations underlie the southern part of the county. A summary of the stratigraphy is given in Table 8.

OUACHITA COUNTY

The Lower Cretaceous and underlying Mesozoic formations are at least 4,000 feet thick in the southwestern part of the county. They consist mainly of variegated shales and sandstones which were deposited on, or near, the margin of a landmass. The Rodessa, Pine Island, and Sligo formations occur only in the southwestern part of the county. The Hosston formation occurs throughout most of the county. All these formations thin markedly northward. The Cotton Valley, Buckner, and Smackover formations occur only in the southern three-fourths of the county. The Eagle Mills formation probably underlies the entire county. A summary of the stratigraphy is given in Table 9.

CALHOUN, BRADLEY, AND ASHLEY COUNTIES

Jurassic and Lower Cretaceous formations are at least 3,800 feet thick in the southern parts of these counties. They consist mainly of reddish sandstone and shale, except for the Smackover limestone and part of the Cotton Valley formation. The darker color of the Cotton Valley formation than that of the Hosston and Eagle Mills formations is probably due to deposition in more nearly normal marine waters farther from shore. The Hosston formation, Cotton Valley formation, and Smackover limestone underlie the southwestern parts of the counties. The Buckner formation occurs only in the extreme southwestern part of Calhoun County. The Eagle Mills formation underlies all three counties. In sections in which the Smackover limestone is missing, the Eagle Mills formation may be distinguished from the younger red beds by the presence of anhydrite, by its generally greater hardness, and by its higher luster. All these formations thin northward due to less deposition and to pre-Upper Cretaceous erosion. The stratigraphic features of the formations and their regional relationships are noted in Table 10.

CLARK, DALLAS, CLEVELAND, DREW, AND CHICOT COUNTIES

Mesozoic red beds have been penetrated by drills in the southwestern parts of these counties but not in the northeastern parts. The red beds of Dallas, Drew, and Chicot counties consist of hard sandstone, shale, sandy limestone, and locally anhydrite. The thickness ranges from 130 to 275 feet. The red beds undoubtedly belong to the marginal facies of the Eagle Mills formation. In the southwestern part of Clark County, the red beds range from 500 to 1,275 feet in thickness, contain a number of conglomerate lenses, and probably represent both the Eagle Mills and the Hosston formations. The Eagle Mills formation is underlain by hard brown sandstones and shales of Paleozoic age.

MILLER COUNTY

The Jurassic and Lower Cretaceous formations of Miller County are more than 6,000 feet thick and probably approach 9,000 feet. The Fredericksburg group is represented by several hundred feet of white limestone, chalk, and some gray shale and occurs only in the southwestern part of the county. The Paluxy formation consists of reddish shales and sandstones which thin and become redder toward the north. The Mooringsport, Rodessa,

Table 8. Summary of Lower Cretaceous and Jurassic stratigraphy of Nevada County

Formations		Thickness (in feet)	Lithologic features	Regional relationships
Paluxy		?		May be present in extreme southeast corner but not indicated by well records.
Glen Rose equivalents	Mooringsport Ferry Lake anhydrite	65-185	Hard to soft limestone; stringers of gypsum and shale; anhydrite most abundant near base.	Present only in southeastern corner of county.
Glen Rose equivalents	Rodessa Pine Island Sligo	20-1,100	Shales, limestone, sandy shales and sandy limestones. Black and gray, in places red or white. Upper beds with some pyrite and gypsum.	Absent in extreme northeastern margin of county. Thickens markedly and becomes darker in southern part of county
Hosston		100-1,000	Variegated shales; sandstones, sandy shales, some limestone; intraformational and basal conglomerates. Red and gray colors dominant.	Thins to about 100 feet in northeastern part of county.
Cotton Valley (Schuler facies)		0-1,600	Sandstone, shale, sandy shale, conglomerates, chert, streaks of limestone; colors mainly gray, some red.	Probably underlies most of southern part of the county. Thickens southward.
Buckner		185-270	Red, green shale; much anhydrite in lower part.	Known only in southern part of county.
Smackover		245-570	Limestone, upper part porous, lower part dense.	Probably underlies most of southern part of county.
Eagle Mills		500	Mainly salt, some gypsum at base, about 25 feet of red (?) shale at top.	Known only in southern part of county.

Table 9. Summary of Lower Cretaceous and Jurassic stratigraphy of Ouachita County

Formations	Thickness (in feet)	Lithologic features	Regional relationships
Rodessa Pine Island Sligo	0-650 +	Variegated sandstone and shale; much hard gray limestone.	Occurs only in southwestern part of county. Thickens and becomes darker toward south.
Hosston	0-1,100 +	Red and gray shales, sandy shale, sandstone, some hard limestone; basal conglomerate.	Thins northward and terminates in northeastern third of county.
Cotton Valley (Schuler facies)	0-1,500	Red and gray shale and sandy shales, shaly and sandy limestones. Streaks of gray and white sandstone. Intraformational and basal conglomerates.	Absent in northern third of county. Thickens, becomes darker and more calcareous southward.
Buckner	0-230 ±	Red shale and sandy shale; dolomite; much anhydrite. Calcareous shale at base.	Known only in southern part of the county
Smackover limestone	125-695	Oölitic and chalky limestone in upper part underlain by denser limestone.	Underlies southern part of county. Thickens southward.
Eagle Mills	1,190 ±	Red and gray shales, sandy shale; some sandstone, limestone and chalk; salt locally.	Probably underlies entire county. Salt known only in southeastern corner of county.

Table 10. Summary of Lower Cretaceous and Jurassic stratigraphy of Calhoun, Bradley, and Ashley counties

Formations	Thickness (in feet)	Lithologic features	Regional relationships
Hosston	0-900+	Red and gray sandstone and shale. Streaks of limestone. Local basal conglomerates.	Present only in southern parts of counties. Thins markedly northward.
Cotton Valley (Schuler facies)	0-2,400+	Sandstone, shale, limestone, some red beds, some lignite, and local basal conglomerate.	Occurs in southern parts of Calhoun and Bradley counties and in most of Ashley County. Thickens markedly in extreme southwestern parts of counties. Becomes coarser and redder toward the north.
Buckner (?)	0-75±	Red, white, and green shale. Some sandy to rather pure limestone.	Known only in extreme southwestern part of Calhoun County.
Smackover limestone	0-700	Hard, gray and black limestone; upper part porous.	Underlies southwestern parts of counties.
Eagle Mills	0-500 +	Red and green shale and sandstone; some sandy limestone, and pink to white anhydrite. Beds very hard. Some white sandstone.	Apparently underlies all three counties. Contains salt in southern part of Bradley County. Directly underlies Cotton Valley formation in northern part of Ashley County.

Pine Island, and Sligo formations consist mainly of shales and limestones but contain some anhydrite stringers. They become coarser and redder toward the north. The Ferry Lake anhydrite, as well as the anhydrite stringers, thins toward the north. The Hosston and Cotton Valley formations are known only in deep wells in the northeastern part of the county. Both formations consist of shale, sandstone, and some limestone; but the Hosston formation contains somewhat coarser deposits and is not as thick as the Cotton Valley formation. Only a few feet of the Smackover limestone has been penetrated in drilling. Undoubtedly, the still older Eagle Mills formation underlies the entire county. A summary of the stratigraphy is given in Table 11.

LAFAYETTE COUNTY

The Jurassic and Lower Cretaceous formations of Lafayette County are about 6,000 feet thick from the top of the Paluxy formation to the top of the Smackover limestone. The Paluxy formation ranges in thickness from about 1,100 feet in the southern part of the county to a few feet in the northern part. The Glen Rose equivalent formations range in thickness from about 2,000 feet in the southern part of the county to 1,400 feet in the northern part and become shalier and redder northward. Formations older than the Hosston have been penetrated deeply only in the northern part of the county, but the records show that the Hosston and Cotton Valley formations thicken considerably toward the southwest. The Hosston formation consists of 800 to 1,600 feet of red and gray shale and sandstone and of some hard limestone. The Cotton Valley formation consists of 1,300 to 2,400 feet of interbedded shale, sandstone, and some limestone. Its upper part is mainly gray, and its lower part, red. The Buckner formation consists of about 150 feet of variegated shale, some anhydrite, and thin dolomite. The oölitic limestone marking the top of the Smackover limestone has been penetrated slightly in several wells. A summary of the outstanding stratigraphic features are shown in Table 12.

COLUMBIA COUNTY

The known Jurassic and Lower Cretaceous formations of Columbia County include the Paluxy formation at the top and the Smackover limestone at the bottom. The formations are at least 6,000 feet thick in the southwestern part of the county but thin to slightly less than 4,000 feet in its northeastern part. This thinning is due largely to pre-Upper Cretaceous erosion of the younger Cretaceous formations. The total thickness is probably considerably greater than stated above since only the upper part of the Smackover limestone has been penetrated, and it is undoubtedly underlain by considerable thickness of the Eagle Mills formation. Marginal red bed deposits includethe Paluxy, Mooringsport (in part), Hosston, Cotton Valley (in part), and Buckner formations. These interfinger southward with submarginal marine deposits which include the lower part of the Mooringsport, the Rodessa, Pine Island, Sligo, Cotton Valley (in part), and the Smackover formations. A summary of the stratigraphy is given in Table 13.

UNION COUNTY

Jurassic and Lower Cretaceous formations, older than the Ferry Lake anhydrite, are at least 6,500 feet thick in the southwestern part of Union County and about 5,000 feet thick in the northeastern part. This thinning is due mainly to pre-Upper Cretaceous erosion of the Lower Cretaceous formations and in part to original depositional thinning toward the north. The Mooringsport formation and the Ferry Lake anhydrite probably exist in the extreme southwest corner of the county, but their presence has not been definitely established by drilling. The Rodessa formation consists of red beds, limestone and anhydrite stringers. The Pine Island and Sligo formations consist of dark shale, sandy shale, and limestone. They terminate on the northeast along a line drawn from the northeastern part of T. 16 S., R. 16 W., to the southwest part of T. 19 S., R. 12 W. The Hosston and Cotton Valley formations of Union County are thick, red bed facies of which the Hosston formation is the coarser and redder. The contact between the two formations is locally marked by a basal conglomerate, but may be difficult to determine

Table 11. Summary of Lower Cretaceous and Jurassic stratigraphy of Miller County

Formations		Thickness (in feet)	Lithologic features	Regional relationships
Kiamichi shale Goodland limestone		0-240	Limestone, chalk, some gray shale.	Occur only in southwestern part of county.
Paluxy		600-1,200	Shale, sandstone, marl, some limestone. Characteristically red. Some beds are brown or gray. Middle part most calcareous.	Thins and becomes redder toward north.
Glen Rose equivalents	Mooringsport	375-600	Shale, shaly to sandy limestone, some thin beds of limestone. Becomes more calcareous toward base. Stringers of anhydrite in lower 250 feet. Colors gray, brown, uncommonly red.	Anhydrite stringers thin toward north. Upper part grades northward into red beds.
	Ferry Lake anhydrite	45-385	Anhydrite; contains streaks of shale and limestone.	Anhydrite thins toward north.
	Rodessa	550-650	Dense to oölitic limestone, marl, shale, anhydrite stringers	Becomes shalier toward north.
	Pine Island Sligo	225	Dark limestone and shale.	Grades northward into red beds.
Hosston		600-1,500±	Shale, sandstone, and some limestone; conglomerate at base.	Known only in northeastern part of county.
Cotton Valley		1,000-2,400	Sandstone, shale, and limestone.	Thickens southward.
Buckner		225	Red shale, limestone, and dolomite at top, grading into anhydrite in lower part.	Known only in southeastern part of county.
Smackover		45+	Porous limestone.	

Table 12. Summary of Lower Cretaceous and Jurassic stratigraphy of Lafayette County

Formation		Thickness (in feet)	Lithologic features	Regional relationships
Paluxy		50-1,100	Red and gray shale, some hard gray limestone	Thins to feather-edge in northeastern part of county. Becomes more calcareous and darker toward south.
Glen Rose equivalents	Mooringsport	350-740	Hard, gray, limestone; black to red shale; some sandstone. Stringers of anhydrite near base.	Thins and becomes shalier toward north.
	Ferry Lake anhydrite	130-235	Anhydrite, some shale and limestone.	Thins northward.
	Rodessa Pine Island Sligo	850-1,000	Upper part consists of dense to oölitic limestone, shale, sandy shale, some sandstone, and several anhydrite stringers. Colors gray, brown, and red. Lower 250 feet consists of dark limestone and shale.	Thins somewhat northward; anhydrite stringers disappear, and red beds become more common.
Hosston		800-1,600	Red and gray shale and sandstone, some hard limestone.	Known only in northern part of county but undoubtedly underlies entire county.
Cotton Valley		1,300-2,400+	Interbedded shale, sandstone, and some limestone. Red colors common in lower part; gray in upper part.	Thickens southwestward. Known only in northern part of county.
Buckner		150-275	Red and gray shale, and much anhydrite; streaks of dolomite toward base.	
Smackover limestone		58	Oölitic, porous, gray limestone.	

Table 13. Summary of Lower Cretaceous and Jurassic stratigraphy of Columbia County

Formations		Thickness (in feet)	Lithologic features	Regional relationships
Paluxy		0-300 +	Red and gray shale, some hard white sand, a few streaks of Limestone.	Present only in southwestern part of county. Grades southward into darker shale and limestone.
Glen Rose equivalents	Mooringsport	0-550 +	Gray, brown and red shale; limestones, streaks of sandstone. Darker toward base. A 28-foot stringer of anhydrite occurs 77 feet above base in southeastern part of county.	Present in all but northeastern corner of county. Thickens, darkens, and becomes more calcareous southward.
	Ferry Lake anhydrite	0-340	Anhydrite, streaks of shale and limestone.	Underlies all but northeastern corner of county. Thickens southward.
	Rodessa Pine Island Sligo	750-1,100	Upper part consists of red, gray and black shale; gray, oölitic, dense to porous limestone; and some sandstone. Local anhydrite stringers in upper part. Lower 400 to 450 feet consists of gray to brown limestone and shale.	Underlies entire county. Thickens and becomes darker southward and southeastward.
Hosston		900-1,900	Mainly shale and sandstone. Some limestone and dolomite streaks. Shale predominates toward top, sandstone toward base. Colors red and gray. Upper part reddest.	Thickens southward. Underlies entire county.
Cotton Valley		1,500-2,500+	Shale, sandstone, and some gray and red limestone. Lower part redder than upper.	Darker and more calcareous than Hosston formation. Underlies entire county.
Buckner		100-260	Anhydrite and red shale. Lower part contains some brown dolomite and dolomitic limestone.	Probably underlies most of county but locally absent.
Smackover		455+	Limestone, upper 40 to 70 feet oölitic, porous to dense, and contains some dolomite. Lower limestone is hard, dense, tan to gray.	Underlies entire county.

if the well records are not fairly detailed. The Buckner formation, consisting of anhydrite and red beds, is missing at many localities due to pre-Cotton Valley erosion. The Smackover limestone is dense to porous and becomes somewhat shaly toward the south. Its upper part is locally porous and oölitic. The Eagle Mills salt has been penetrated 1,290 feet in the northern part of the county and probably underlies the entire county. A summary of the general stratigraphy is given in Table 14.

MAJOR STRUCTURAL FEATURES

The major structural features of the Lower Cretaceous and Mesozoic formations of southern Arkansas (Pl. I) have been discussed by Spooner (44, p. 125-139), and his conclusions have been generally confirmed by the recent work of Weeks (51) and by the structural and isopach maps prepared for the present work. The relation of these structural features to the Ouachita belt of Paleozoic rocks and to the Paleozoic landmass, Llanoria, have been discussed and illustrated by Miser (31, fig. 2). The major structural features of southern Arkansas may be outlined as follows:

(1) A south and southwest inclined monocline (homocline), dipping from 50 to 150 feet per mile, striking east-west through Little River and Hempstead counties, and striking southeast in the counties farther east. The monocline is interrupted by local domes and anticlinal uplifts that were probably produced by differential warping of the basement floor.

(2) A syncline separating the monocline from the Sabine uplift, as defined by Harris (17, p. 27, fig. 1). It crosses southern Miller and Lafayette counties and then turns southeast between the Sabine Uplift, in northwestern Louisiana, and the Monroe Uplift, in northeastern Louisiana. It is sometimes designated as the eastern extension of the Cass County syncline of Texas.

(3) An east-west trending zone of normal faulting which is arcuate toward the north and has displacements of 400 to 1,200 feet in Lower Cretaceous rocks (less in Upper Cretaceous). It is probably continuous with the Balcones or Mexia fault zones of Texas and probably related genetically to a flexure in the basement rocks produced by downwarping of the Gulf of Mexico. This fault zone apparently marks the southern part of the flexure. Evidence indicates that the fault zone did not exist until the end of the Lower Cretaceous, but the isopach maps (Plates XIII and XIV) of the Cotton Valley and Hosston formations show that the position of the fault zone in Nevada and Ouachita counties was defined earlier by rapidly subsiding areas.

(4) A flexure, or steepening in slope, or the basement rocks in southern Arkansas and northeastern Louisiana, apparently paralleling the southern margin of the Ouachita Mountain folds. The position of this flexure is indicated by

(a) a pronounced erosional hiatus at the top of the Lower Cretaceous,
(b) thinning of Upper Cretaceous sediments,
(c) marked thinning of Lower Cretaceous sediments toward the north and east in contrast to great thickening toward the south and southwest, and
(d) lithologic changes from normal marine toward the south to marginal and littoral deposits toward the north and east.

The flexure formed the landward limit of the Eagle Mills salt, of the lower

Table 14. Summary of Lower Cretaceous and Jurassic stratigraphy of Union County

Formation	Thickness (in feet)	Lithologic features	Regional relationships
Mooringsport Ferry Lake anhydrite	?	Not definitely distinguished in wells.	May be present in extreme southwestern corner of Union county.
Rodessa Pine Island Sligo	0-1,100	Upper part consists of shale, limestone, and some anhydrite. Lower 500 feet consists of dark shale, sandy shale, and limestone.	Thins markedly toward north. Absent from northeastern third of county.
Hosston	400-1,900	Red and gray shale and sandstone. Some white sandstone. Intercalated limestone most common near middle. Some limestone and lignite. Locally a basal conglomerate	Thins northward. Becomes darker and more calcareous toward south. Difficultly distinguished from the red bed (Schuler) facies of the Cotton Valley formation.
Cotton Valley	1,600-2,550	Shale mainly red and gray; intercalated beds of sandstone and some limestone. Some lignite. Locally a basal conglomerate.	Beds darker and limestone more common toward south. Red bed facies somewhat darker and finer grained than Hosston red beds.
Buckner	60-190	Anhydrite; red, green, brown shale and sandstone.	Probably underlies most of county, but locally absent due to erosion previous to deposition of Cotton Valley formation.
Smackover limestone	680-925	Gray to brown limestone, upper 50 to 100 feet locally oölitic. Upper 400 to 500 feet varies from dense to porous, and contains shaly to sandy beds. Lower 300 to 500 feet consists mainly of dense limestone but contains some shaly beds in lower part.	Upper part becomes chalkier and lower part more dense northward.
Eagle Mills	1,000-1,290+	Mainly salt, some red shale at top and bottom; some anhydrite; basal conglomerate.	Probably underlies entire county.

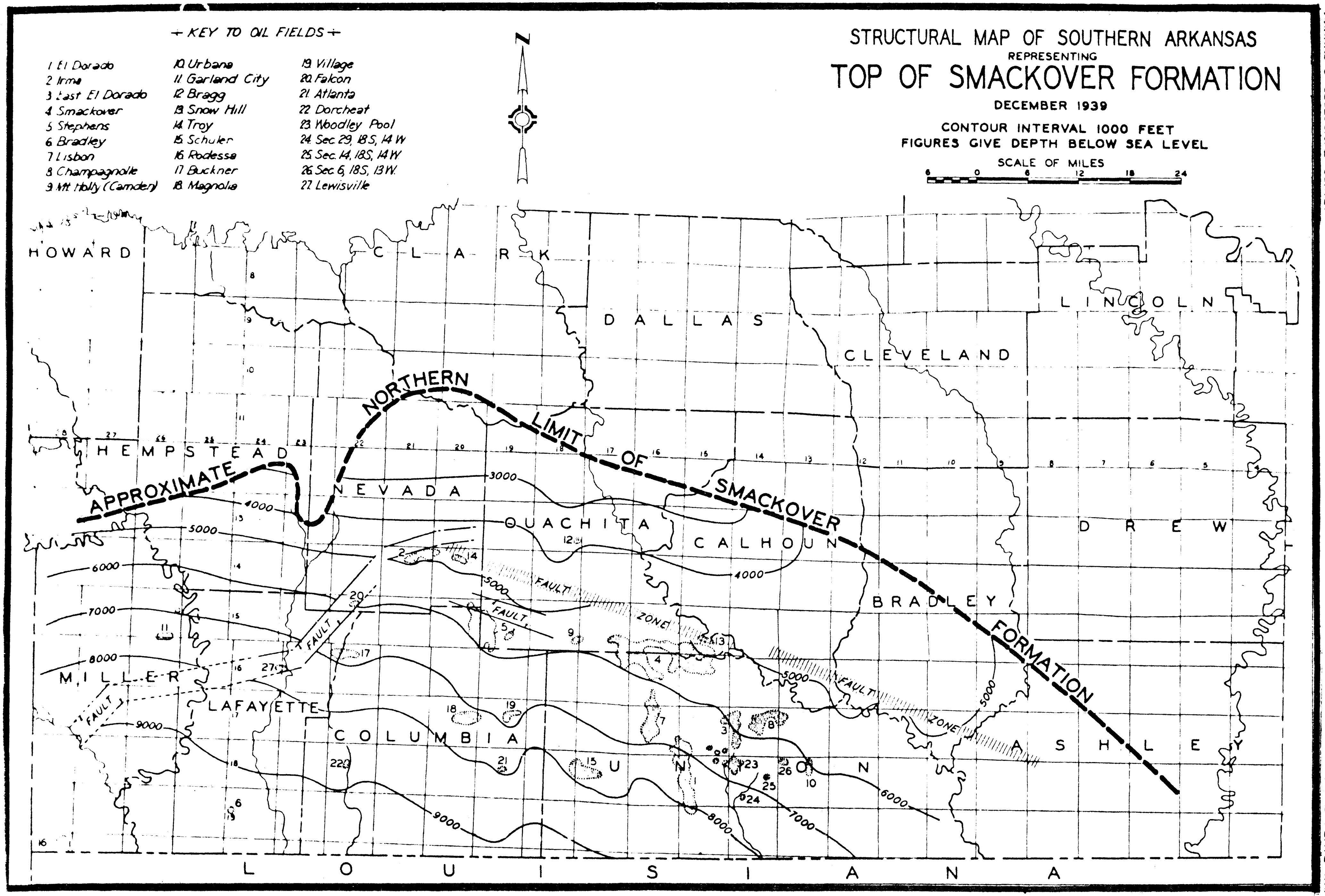
member of the Smackover limestone, and of the Buckner anhydrite. The Hosston and Cotton Valley formations become much thinner, coarser, and redder where they cross the flexure and evidently never extended farther north than the site of the Ouachita Mountains. The Sligo, Pine Island, Rodessa, and Mooringsport formations cross the flexure, but lose their marine characteristics. According to Spooner (44, p. 129) the pronounced tilting of the strata to the southwest shows that the most marked differential warping occurred at the end of the Lower Cretaceous and continued throughout the Upper Cretaceous. That warping occurred during the Lower Cretaceous and Jurassic is evident and is shown by the series of structural maps in the present report. Thus the regional trend of the formations from the Smackover limestone to the Ferry Lake anhydrite changes gradually from nearly east-west to southeast-northwest (Pls. XVII, XVIII, XIX, XX). If the warping had occurred only at the end of the Lower Cretaceous, there would not be a gradual change in regional trend.

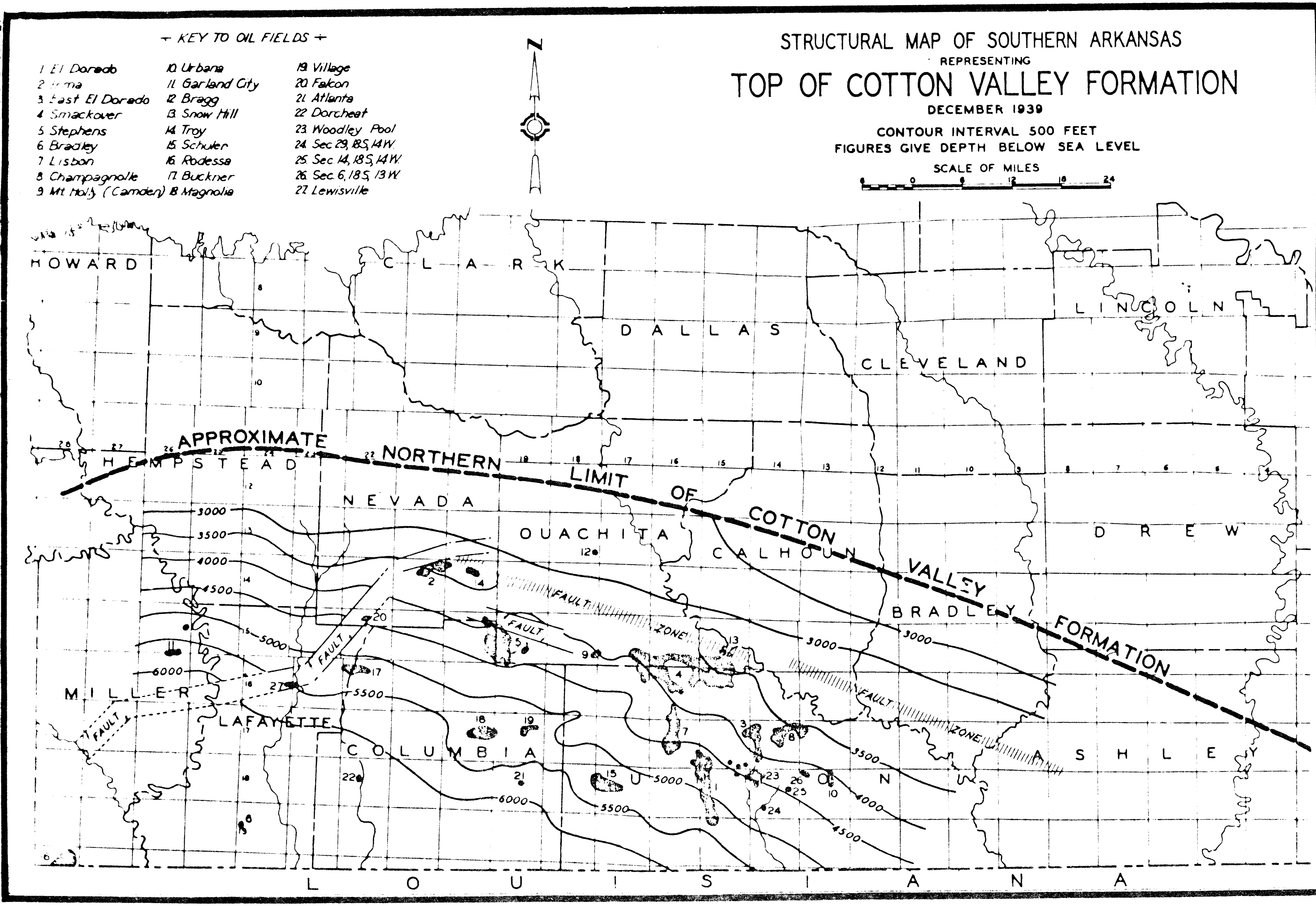
HISTORY

The Ouachita peneplain, eroded during early Mesozoic time across the folded rocks of the Ouachita geosyncline and the ancient crystalline rocks of Llanoria (29) (Pl. I), was slowly tilted southward during Middle Mesozoic time and submerged beneath the waters of the ancestral Gulf of Mexico. Subsequent depression of the bottom of the Gulf was accompanied by a supply of sediments adequate to keep the Gulf shallow and eventually led to the accumulation of about 13,000 feet of sediments by the end of Lower Cretaceous time. Encroachment of the water on the land masses occurred in an oscillating manner due to upward movements along the site of the Ouachita Mountains accompanying downward movements of the areas to the south. In Arkansas marine transgressions were generally limited on the north, until late Lower Cretaceous time, by a landmass in the region of the present Ouachita Mountains. In Mississippi marine transgression possibly extended farther north than in Arkansas. Important regressions occurred at the end of Buckner and Cotton Valley times when the Gulf waters receded from most of Arkansas. These regressions probably coincided with the late Oxfordian (middle Upper Jurassic) and Berriasian (earliest Cretaceous) regressions of the Mexican sea. At the end of the Lower Cretaceous period, southern Arkansas, northern Louisiana, and at least parts of Mississippi and Texas became land and underwent considerable erosion (Pl. XXI) before being covered by an early Upper Cretaceous sea. A more detailed history of the Jurassic and Lower Cretaceous marine invasions of Arkansas and adjoining states follows.

The earliest Mesozoic marine invasion across the Gulf Coastal region of the United States (Pl. XXII) gave rise to dark marine shales and siltstones, called the Morehouse formation. This formation, known only in northeastern Louisiana, was overlain conformably by deposits of red beds, rock salt, and anhydrite which are known as the Eagle Mills formation. In Arkansas the sea of early Eagle Mills time advanced over a surface consisting mainly of Paleozoic rocks, and reworked a mantle of igneous, metamorphic, and sedimentary rocks into a basal gravel. Some red mud and red sand were deposited with the gravel. Red mud deposition was soon followed offshore by the accumulation of 50 to 100 feet of anhydrite and then by hundreds of feet of rock salt with minor amounts of anhydrite. In some places salt appears to have been the first sediment deposited. In areas near shore only anhydrite and red beds were deposited. Still nearer shore only red beds were formed and these probably graded into terrestrial red beds. During Eagle Mills time the Gulf was surrounded by arid land masses and probably had small connections with the major oceans. Possibly the entire Gulf was the site of salt deposition.

Salt deposition ended rather abruptly due to deepening and widening of the Gulf and to a decrease in salinity of its waters. The decrease in salinity might have been produced by enlargements of the Gulf's connections with the oceans, or by an increase in rainfall on the surrounding land masses. Both possibilities seem likely. The salt and red beds of the Eagle Mills formation were overlain transgressively by the Smackover limestone in southern Arkansas; by Smackover dark shales and limestone in northwestern


STRUCTURAL MAP OF SOUTHERN ARKANSAS
REPRESENTING
TOP OF SMACKOVER FORMATION
DECEMBER 1939
CONTOUR INTERVAL 1000 FEET
FIGURES GIVE DEPTH BELOW SEA LEVEL
SCALE OF MILES
6 0 6 12 18 24
N
KEY TO OIL FIELDS
1 El Dorado
2 Irma
3 East El Dorado
4 Smackover
5 Stephens
6 Bradley
7 Lisbon
8 Champagnolle
9 Mt. Holly (Camden)
10 Urbana
11 Garland City
12 Bragg
13 Snow Hill
14 Troy
15 Schuler
16 Rodessa
17 Buckner
18 Magnolia
19 Village
20 Falcon
21 Atlanta
22 Dorcheat
23 Woodley Pool
24 Sec. 29, 18S, 14W
25 Sec. 14, 18S, 14W
26 Sec. 6, 18S, 13W.
27 Lewisville
APPROXIMATE NORTHERN LIMIT OF SMACKOVER FORMATION
HOWARD
CLARK
DALLAS
CLEVELAND
LINCOLN
HEMPSTEAD
NEVADA
OUACHITA
CALHOUN
DREW
BRADLEY
MILLER
LAFAYETTE
COLUMBIA
UNION
ASHLEY
LOUISIANA
FAULT
FAULT ZONE
3000
4000
5000
6000
7000
8000
9000


STRUCTURAL MAP OF SOUTHERN ARKANSAS
REPRESENTING
TOP OF COTTON VALLEY FORMATION
DECEMBER 1939
CONTOUR INTERVAL 500 FEET
FIGURES GIVE DEPTH BELOW SEA LEVEL
SCALE OF MILES
KEY TO OIL FIELDS
1 El Dorado
2
3 East El Dorado
4 Smackover
5 Stephens
6 Bradley
7 Lisbon
8 Champagnolle
9 Mt Holly (Camden)
10 Urbana
11 Garland City
12 Bragg
13 Snow Hill
14 Troy
15 Schuler
16 Rodessa
17 Buckner
18 Magnolia
19 Village
20 Falcon
21 Atlanta
22 Dorcheat
23 Woodley Pool
24 Sec 29, 18S, 14W
25 Sec 14, 18S, 14W
26 Sec 6, 18S, 13W
27 Lewisville
N
APPROXIMATE NORTHERN LIMIT OF COTTON VALLEY FORMATION
HOWARD
CLARK
DALLAS
CLEVELAND
LINCOLN
HEMPSTEAD
NEVADA
OUACHITA
CALHOUN
BRADLEY
DREW
MILLER
LAFAYETTE
COLUMBIA
UNION
ASHLEY
LOUISIANA
FAULT
FAULT ZONE
3000
3500
4000
4500
5000
5500
6000

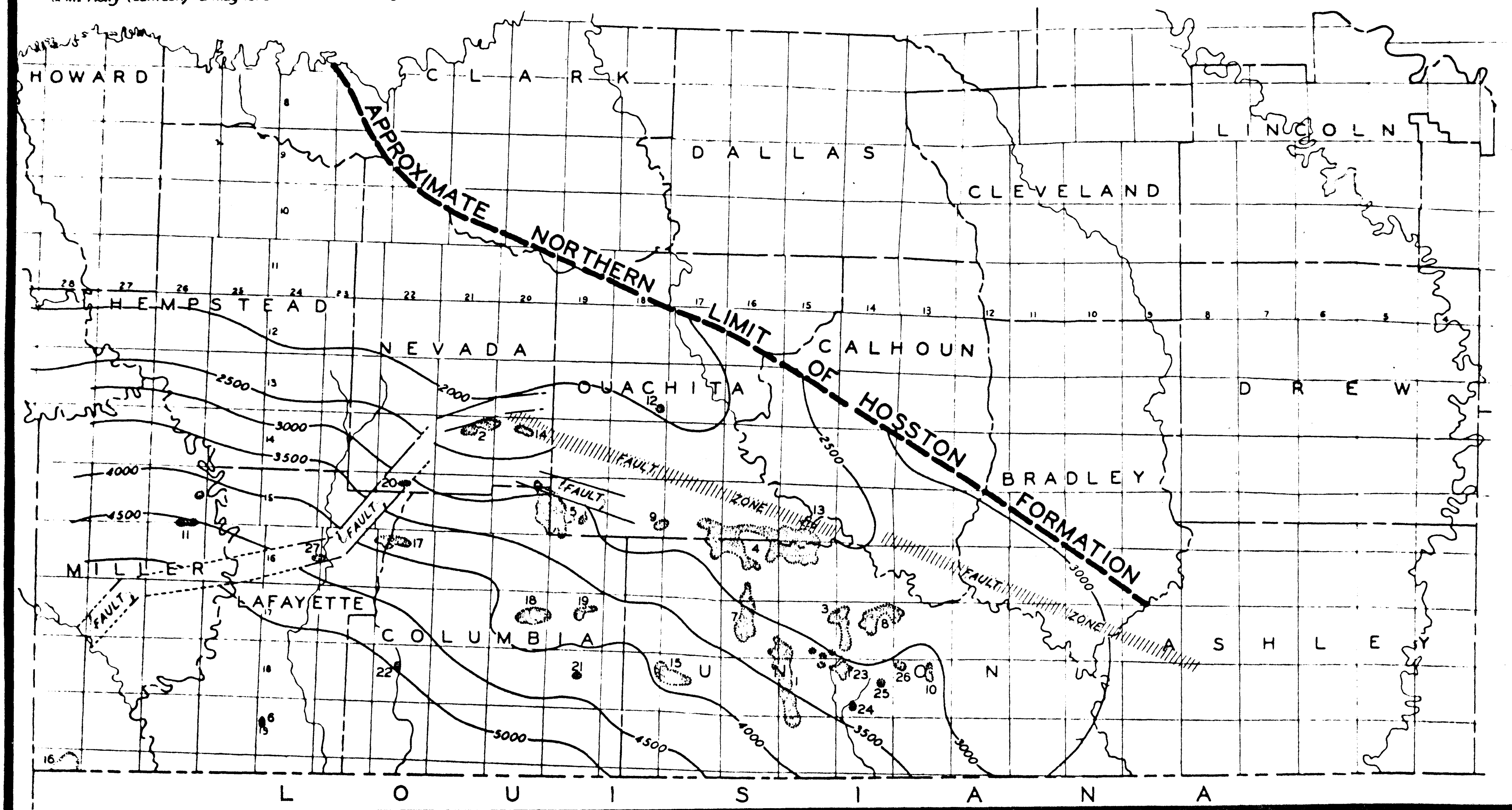
STRUCTURAL MAP OF SOUTHERN ARKANSAS
REPRESENTING
TOP OF HOSSTON FORMATION
DECEMBER 1939

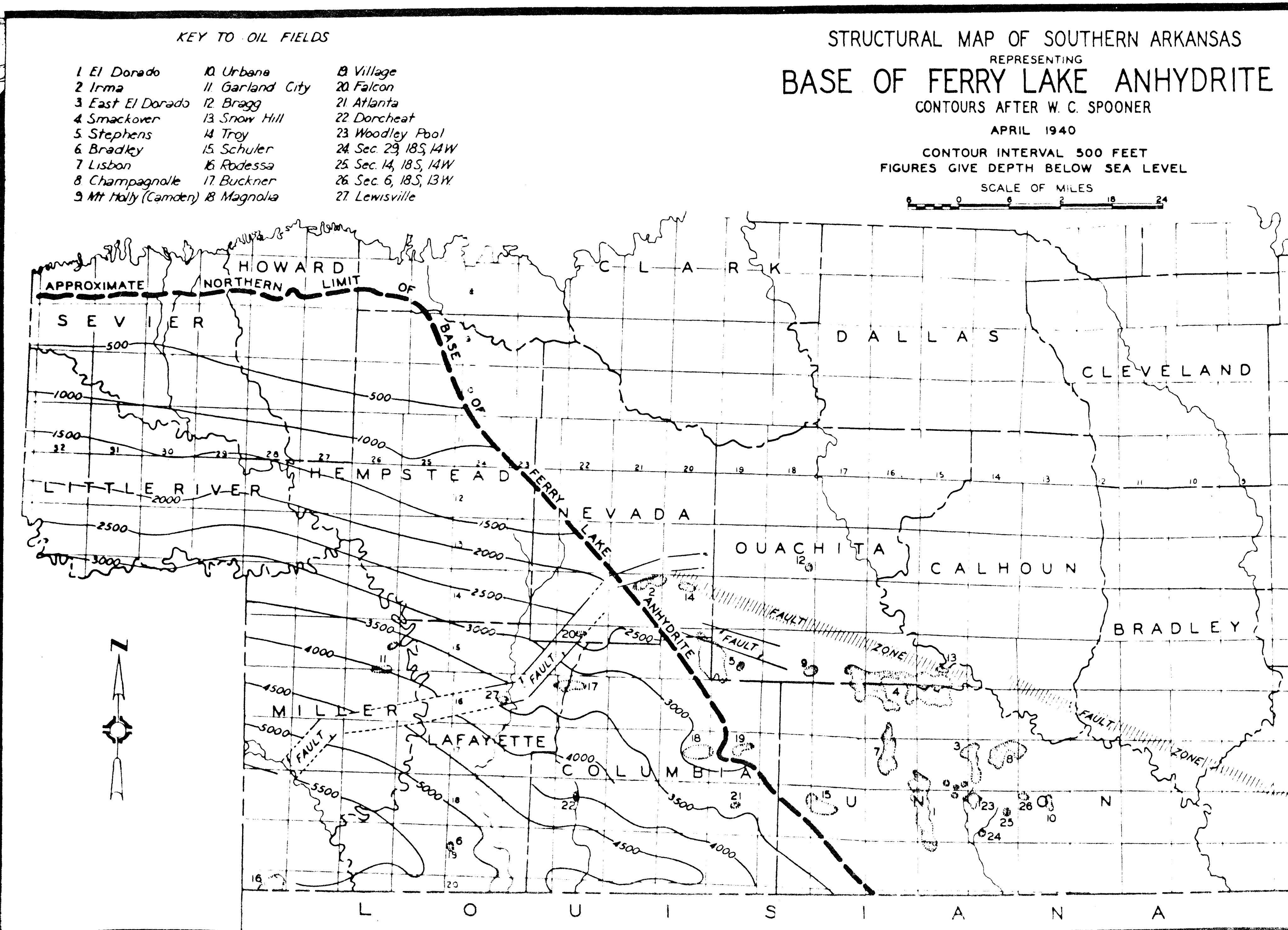
CONTOUR INTERVAL 500 FEET
FIGURES GIVE DEPTH BELOW SEA LEVEL

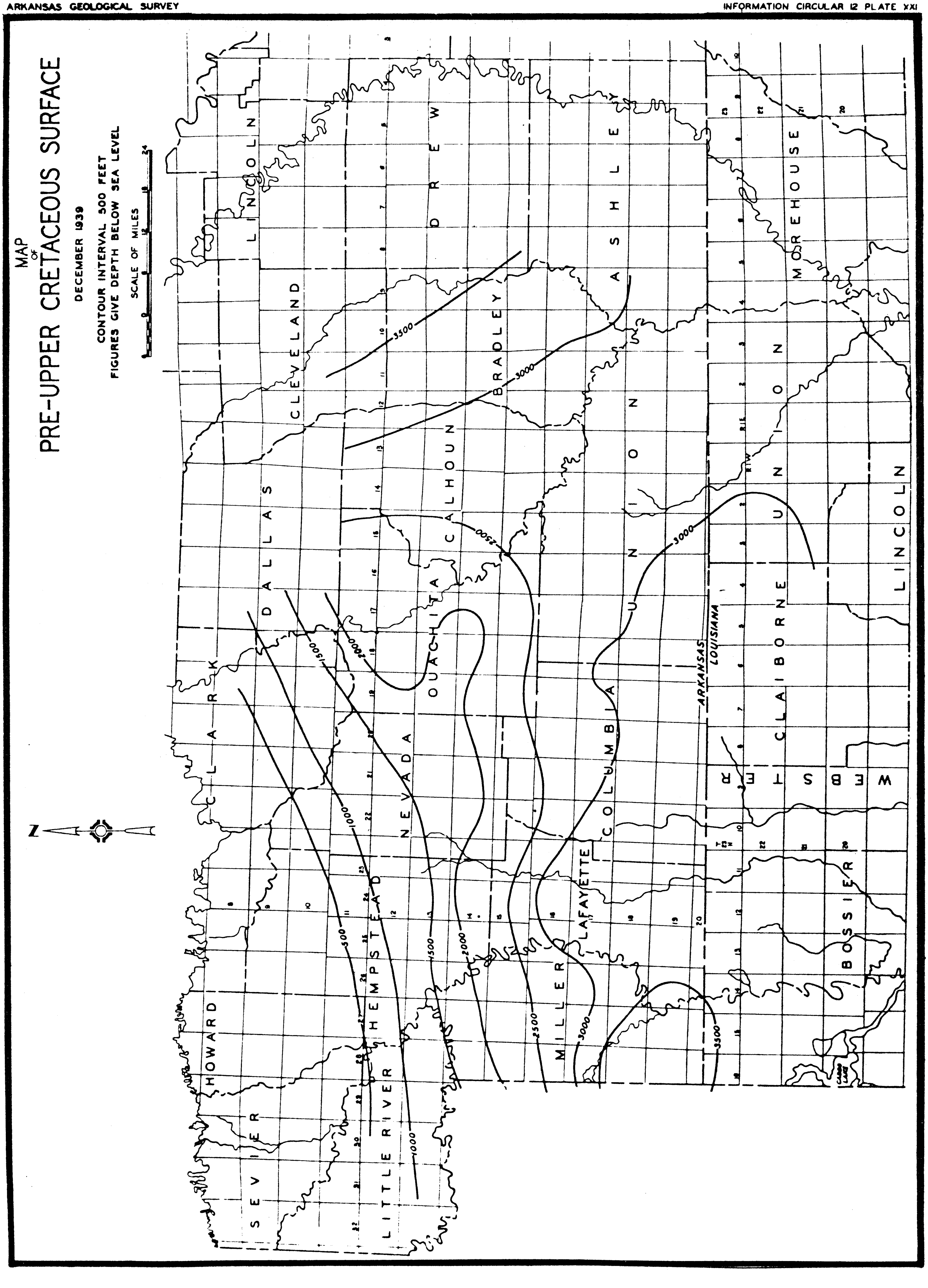
SCALE OF MILES

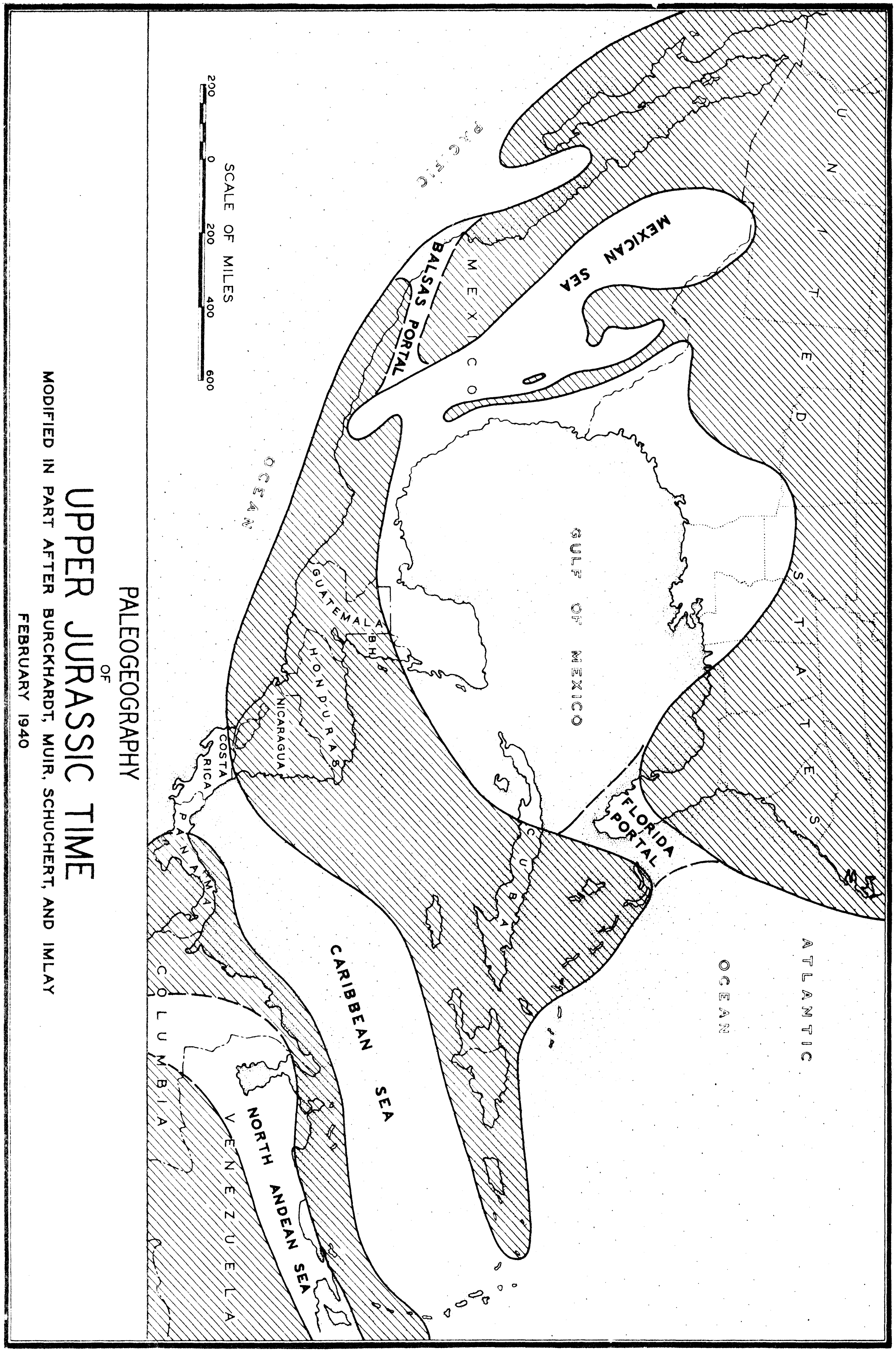
÷ KEY TO OIL FIELDS ÷

1. El Dorado
2. Irma
3. East El Dorado
4. Smackover
5. Stephens
6. Bradley
7. Lisbon
8. Champagnolle
9. Mt Holly (Camden)
10. Urbana
11. Garland City
12. Bragg
13. Snow Hill
14. Troy
15. Schuler
16. Rodessa
17. Buckner
18. Magnolia
19. Village
20. Falcon
21. Atlanta
22. Dorcheat
23. Woodley Pool
24. Sec. 29, 18 S, 14 W.
25. Sec. 14, 18 S, 14 W.
26. Sec. 6, 18 S, 13 W.
27. Lewisville




STRUCTURAL MAP OF SOUTHERN ARKANSAS
REPRESENTING
BASE OF FERRY LAKE ANHYDRITE
CONTOURS AFTER W. C. SPOONER
APRIL 1940
CONTOUR INTERVAL 500 FEET
FIGURES GIVE DEPTH BELOW SEA LEVEL
SCALE OF MILES
KEY TO OIL FIELDS
1 El Dorado
2 Irma
3 East El Dorado
4 Smackover
5 Stephens
6 Bradley
7 Lisbon
8 Champagnolle
9 Mt Holly (Camden)
10 Urbana
11 Garland City
12 Bragg
13 Snow Hill
14 Troy
15 Schuler
16 Rodessa
17 Buckner
18 Magnolia
19 Village
20 Falcon
21 Atlanta
22 Dorcheat
23 Woodley Pool
24 Sec. 29, 18S, 14W
25 Sec. 14, 18S, 14W
26 Sec. 6, 18S, 13W
27 Lewisville
APPROXIMATE NORTHERN LIMIT OF BASE OF FERRY LAKE ANHYDRITE
HOWARD
SEVIER
CLARK
DALLAS
CLEVELAND
HEMPSTEAD
LITTLE RIVER
NEVADA
OUACHITA
CALHOUN
BRADLEY
MILLER
LAFAYETTE
COLUMBIA
UNION
LOUISIANA
FAULT
FAULT ZONE
N


MAP OF PRE-UPPER CRETACEOUS SURFACE
DECEMBER 1939
CONTOUR INTERVAL 500 FEET
FIGURES GIVE DEPTH BELOW SEA LEVEL
SCALE OF MILES
N
LINCOLN
DREW
ASHLEY
MOREHOUSE
CLEVELAND
BRADLEY
UNION
CALHOUN
DALLAS
OUACHITA
CLARK
NEVADA
COLUMBIA
CLAIBORNE
LINCOLN
WEBSTER
HOWARD
HEMPSTEAD
LAFAYETTE
MILLER
BOSSIER
SEVIER
LITTLE RIVER
ARKANSAS
LOUISIANA
CADDO LAKE
500
1000
1500
2000
2500
3000
3500



PALEOGEOGRAPHY OF UPPER JURASSIC TIME

MODIFIED IN PART AFTER BURCKHARDT, MUIR, SCHUCHERT, AND IMLAY

FEBRUARY 1940

Louisiana and probably most of east Texas; and by Smackover sandstone, shale, and limestone in northeastern Louisiana. The lower part of the Smackover limestone of Arkansas probably accumulated mainly as chemical precipitates in shallow waters of above normal salinity. Equivalent dark-colored deposits of northern Louisiana accumulated in normal marine waters. The upper member of the Smackover limestone was deposited over a larger area than the lower member and in shallow, much agitated, and normally marine waters. These conditions favored the growth of fringing coralline reefs, the accumulations of oölites, and the formation of chalky and dolomitic beds. The Smackover limestone of Arkansas probably accumulated on a gently dipping coastal shelf which was not supplied by sediments from large rivers. Similar conditions apparently prevailed on the west side of the East Texas basin. In the region of northeastern Louisiana the conditions of deposition during Smackover time were modified by the influx of large amounts of sand, silt, and clay from some river to the east or northeast. The presence of clay prevented the growth of coralline masses, but did not prevent the formation of some oölitic and chalky limestones. The total thickness of sediments deposited ranged from about 450 feet in Arkansas to over 900 feet in Louisiana.

Toward the end of Smackover time and shortly thereafter subsidence of the sea bottom was so slow that the shallow waters near shore were filled with terrigenous deposits and the sea thereby crowded back for many miles. This period of slow subsidence was introduced by the 100 feet of Reynolds oölite and by a few feet of dolomitic beds at the top of the Smackover limestone. During succeeding Buckner time these dolomitic beds were overlain gradationally by 300 feet of anhydrite and red beds in southern Arkansas. This series is clearly regressive and probably becomes younger toward the south. The anhydrite and associated red beds formed in highly saline waters, but some of the highest red beds probably formed in brackish waters. South of the area of Smackover limestone, the deposition of Buckner red beds and anhydrite ceased within a narrow zone and was replaced southward by normal marine dark shales. This abrupt lithologic change was due apparently to a change in slope of the coastal shelf and shows that the Buckner formation like the Smackover limestone was restricted to the most gently sloping part of the shelf. Deposition of typical Buckner anhydrite and red beds to a thickness of about 500 feet occurred in northeastern Louisiana where the Smackover limestone facies was not developed. Evidently the presence of clays which prevented coralline growths in that area during Smackover time did not prevent the formation of anhydrite during Buckner time. The somewhat greater thickness of the Buckner formation in northeastern Louisiana than in Arkansas may have been due to its position nearer to the main source of sediments or to less erosion before Cotton Valley time.

The end of Buckner time was marked by a break in deposition over the area where the Buckner anhydrite and red beds had been deposited. South of this area deposition was apparently continuous into Cotton Valley time. The time interval represented by the break, or disconformity, must have been short as the same species of <u>Estheria</u> occurs in both formations, but the time was sufficient for erosion to remove the Buckner formation and some of the Smackover limestone from certain areas in southern Arkansas.

The beginning of Cotton Valley time was marked by the sinking of the Gulf floor, which allowed the sea to transgress northward again, and by the rising of the land along the site of the Ouachita Mountains. Erosion of the rising land furnished large amounts of gravel consisting of chert, quartzite, and novaculite which were swept as far south as northern Louisiana. The nearness and adequacy of the source of the gravels in Arkansas is shown by their composition, their large range in size, their poor degree of rounding, and their vertical range throughout as much as 450 feet in some sections. Deposition of the gravels and sands occurred northward beyond the eroded limits of the underlying Buckner, Smackover, and Eagle Mills formations, but marine waters probably never extended beyond the site of the Ouachita Mountains. The basal gravels and sands were succeeded upward by sands, silts, clay, and some dolomitic or calcareous beds of shallow water origin. The red beds of Arkansas were probably deposited under brackish water conditions where organic matter which might have reduced the ferric iron was not abundant. Increasing amounts of sand toward the north and northeast show that most of the sediments in Arkansas and northern Louisiana came from these directions. The amount of deposition increased toward the south and reached a maximum thickness of about 3,200 feet in north-central Louisiana. The climate of the surrounding land masses was probably fairly dry and hot.

At the end of Cotton Valley time the sea again withdrew briefly from part of southern Arkansas as the area of the Ouachita Mountains arose. The advancing sea of Hosston time again encountered large amounts of gravels derived from the mountain and spread them throughout most of southern Arkansas. At the same time sands were spread throughout northern Louisiana. The gravels were succeeded upward by sands, silts, and clays, of which the latter form the bulk of the sediments. Most of the clays and silts were reddish, and most of the sands were white. In Arkansas and Mississippi the reddish color persisted after consolidation, but along the border region of northern Louisiana, the sediments darkened and graded southward into gray to black clay and limestone. The persistence of the red color in the sediments of Arkansas is ascribed to deposition in brackish waters which were deficient in organic matter that would have reduced the iron. The increase in thickness of the Hosston formation from about 50 feet at the outcrop in Arkansas to over 2,000 feet in northern Louisiana shows that the basin of deposition sank much more rapidly in Louisiana than in Arkansas. It is doubtful if the Hosston sea ever extended north of the region of Pike and Howard counties of Arkansas (Pl. XXIII). The source of the sediments was probably from the north and northeast. The climate of the surrounding land masses must have been arid.

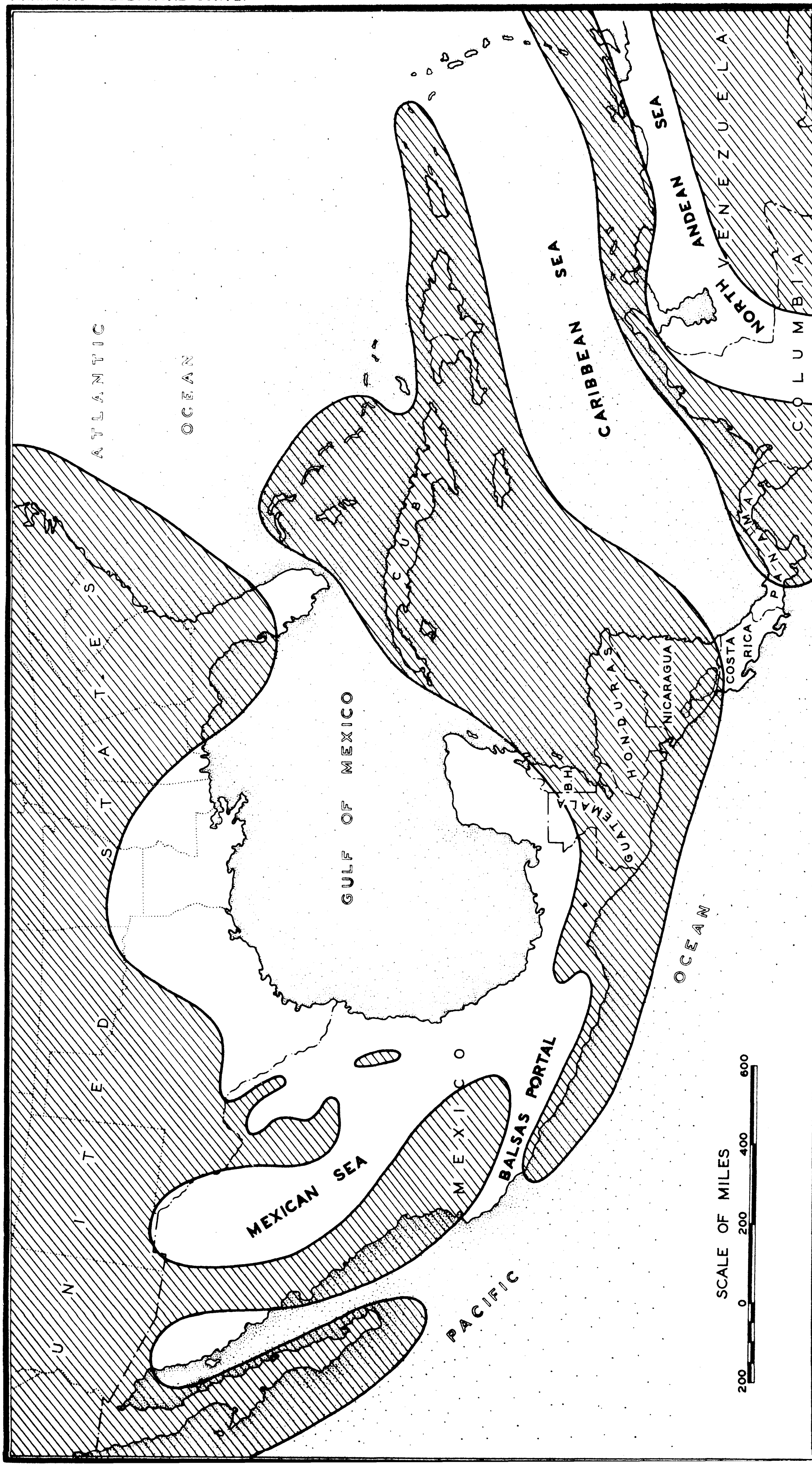
The brackish-water sediments of the Hosston formation were succeeded transitionally and transgressively by normal marine fossiliferous sediments of the Sligo, Pine Island, and Rodessa formations which consisted of interlensing oölites, coquinas, marls, dark silt and clay, dark lime mud, and sands. These were formed in shallow, much agitated, and oscillating waters. Toward the end of Rodessa time several widespread anhydrite layers were formed during temporary shoaling of the waters. The source of the sediments lay to the north and east as indicated by their coarsening and reddening in those directions. Marked thinning of sediments in Pike, Howard, and Sevier counties, Arkansas, suggests that the Gulf never extended much farther north (Pl. XXIV). The regions of Louisiana and east Texas sank more rapidly than southern Arkansas resulting in a maximum thickness of over 1,200 feet of consolidated sediment in northern Louisiana and only about 350 feet at the outcrops in Arkansas. The climate was probably arid to semi-arid and fairly hot.

During the Ferry Lake time there occurred a marked shoaling of the waters on the coastal shelf of the Gulf. This led to the formation of a vast sheet of anhydrite, containing minor amounts of clay and lime, which occurs in Arkansas, northern Louisiana, eastern Texas, and probably central Mississippi. It is possibly continuous laterally with equivalent deposits in west Texas and northern Mexico. It is presumably of lagoonal origin although no barrier has been discovered.

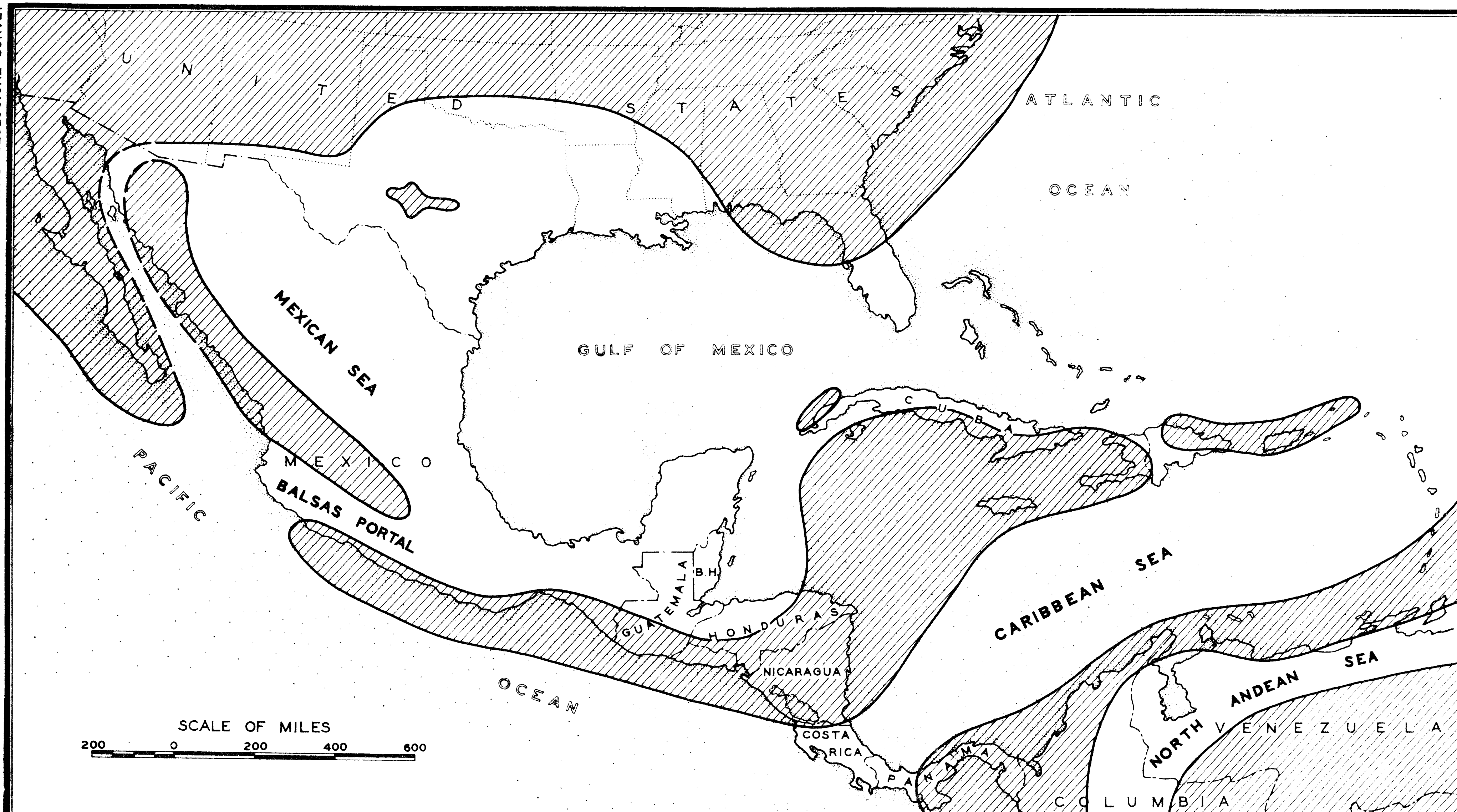
The Ferry Lake anhydrite was overlain conformably by dominantly marine clay, silt, lime mud, and some sand, which is called the Mooringsport formation. The shallow water origin of the formation is indicated by ripple marks, sun cracks, fossils, some sands, oölites, and by a few thin layers of anhydrite. This type of deposition prevailed until the end of Trinity time in parts of Louisiana and Texas, but was replaced northward in the region of western Arkansas and adjoining eastern Texas by coarse nearshore deposits which are called the Paluxy formation.

The Paluxy formation was deposited as variegated clay and sand in brackish, or semi-brackish waters. It overlies the Mooringsport formation regressively and was probably formed during a time when the rate of supply of sediments more than balanced the rate of subsidence of the sea floor. Determination of the amount of subsidence of the sea floor involves consideration of the combined thicknesses of the Paluxy and Mooringsport formations as they were deposited, in part, contemporaneously. The combined thicknesses range from about 250 feet in Sevier, Howard, and Pike counties, Arkansas, to 1,600 feet in northern Louisiana. The reddish color of the Paluxy formation and of some beds of the Mooringsport formation indicates aridity on the bordering land masses.

Deposition of the Paluxy sands and clays was followed by a minor time break, or



PALEOGEOGRAPHY
OF
COAHUILA TIME
MODIFIED IN PART AFTER BURCKHARDT, KELLUM, SCHUCHERT, MUIR, AND IMLAY
FEBRUARY 1940



PALEOGEOGRAPHY OF TRINITY TIME

MODIFIED IN PART AFTER BURCKHARDT, ADKINS, MUIR, AND SCHUCHERT

FEBRUARY 1940

disconformity, along the northern margin of the Gulf of Mexico including areas in Arkansas and northern Texas. The disconformity was probably due to non-deposition rather than to erosion. No interruption in sedimentation is evident for northern Louisiana.

Early in Fredericksburg time the sea transgressed northward (Pl. XXV) over a low plain mantled with Paluxy sand. Banks of shells and layers of yellow clay marl, called the Walnut formation, formed the basal deposits. These were overlain by gray, sandy lime muds and white, chalky lime muds, called the Comanche Peak (Goodland) limestone, which were deposited nearshore. Then followed marly clays, lime muds, and shell aggregates of the Kiamichi formation which was probably deposited in shallower water than the Goodland limestone. The combined thicknesses of these formations in Arkansas range from about 70 feet at the outcrop to about 300 feet in the subsurface. They were probably overlain by younger Lower Cretaceous deposits as about 100 feet of shale and limestone of Washita age has been reported from the subsurface of southwestern Arkansas.

Successive uplifts along northwest-southeast lines in southeastern Arkansas and northeastern Louisiana gradually shifted the regional trend of the formations from nearly east-west in Smackover time to nearly northwest in Trinity time. However, the main uplift occurred at the end of the Lower Cretaceous period, causing a pronounced southwestward tilting of the strata and withdrawal of the sea far south of Arkansas. This regional uplift was accompanied by the inception of extensive normal faulting along an east-west trending zone across southern Arkansas. During the faulting Lower Cretaceous and older rocks were displaced as much as 400 to 1,200 feet before Upper Cretaceous time. Many local domes and anticlinal uplifts were probably initiated at this time by differential warping of the basement floor. Following withdrawal of the sea, the area of Arkansas, northern Louisiana, Mississippi, and east Texas was subjected to extensive erosion which reduced the newly elevated hilly surface to a fairly low plain before Upper Cretaceous time. The magnitude of the erosion is shown by approximately 10,000 feet of rocks in the southwestern part of Arkansas which are progressively truncated northeastward within a distance of a hundred miles (51, p. 956).

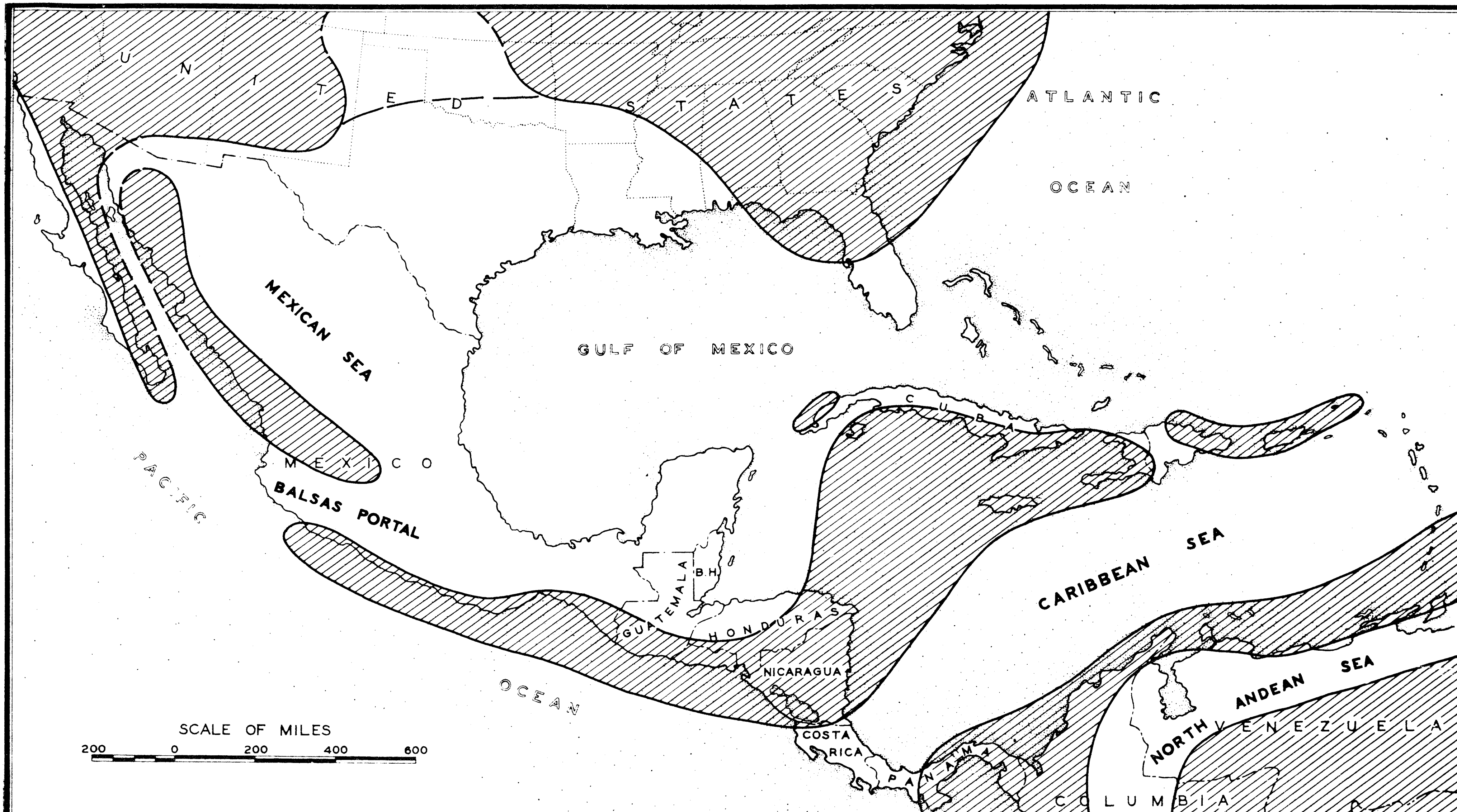
A summary of the lithology, correlation, and historical development of Lower Cretaceous and Jurassic formations of southern Arkansas is set forth in Table 15.

OIL AND GAS POSSIBILITIES

The possible oil and gas producing areas of Arkansas have been discussed by Spooner (44, p. 152-153) and Branner (8). Of the various areas delimited by them, only that area which lies south and west of the northern and easternmost limits of the Eagle Mills formation offers any chance for the accumulation of oil or gas in commercial quantities from Lower Cretaceous and older Mesozoic rocks. This area (see Pl. XXVI), during recent years, has been subjected to exploration and development and at the present time, fifteen fields within it are producing, or have produced, from rocks older than Upper Cretaceous. A compilation of statistics of these oil fields to December 31, 1938, has been made by the Arkansas Geological Survey and is shown in Table 16. The limits of possible and most favorable areas for oil production are shown in Plate XXVI.

The Eagle Mills formation of Arkansas is apparently unfavorable for oil production. Only its red bed facies in a strip about 40 miles wide along the northern margin of the formation appears to have oil possibilities and this facies apparently lacks both source beds and suitable reservoir beds. The occasional red beds of red argillaceous sandstone in the Eagle Mills formation have low porosity and high density. Due to the close folding and metamorphism of the underlying Paleozoic rocks, it would appear that these offer only the remotest chance for oil production.

The Smackover limestone is the oldest oil producing formation of Mesozoic age in Arkansas and has proved productive only where it is distinctly oölitic and coralline. Commercial quantities of oil have thus far been found only in its upper part which has a relatively high porosity. Production from the upper part of the Smackover limestone has been obtained from eight fields, including Atlanta, Big Creek, Buckner, Magnolia,



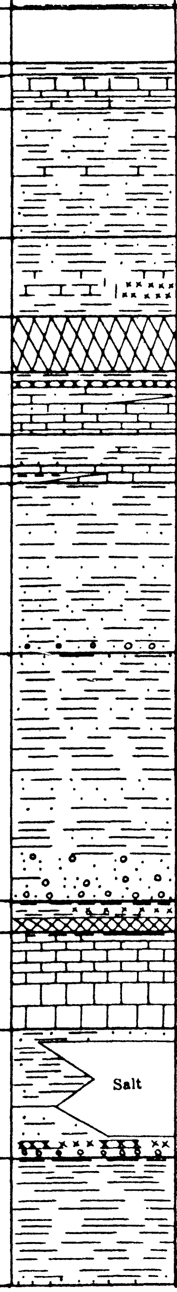
PALEOGEOGRAPHY OF FREDERICKSBURG TIME

MODIFIED IN PART AFTER BURCKHARDT, MUIR, AND SCHUCHERT

FEBRUARY 1940

TABLE 15. SUMMARY OF THE LITHOLOGY, CORRELATION, AND HISTORICAL DEVELOPMENT OF THE LOWER CRETACEOUS AND JURASSIC FORMATIONS OF SOUTHERN ARKANSAS.

	European equivalents	Gulf Coast and Mexican groups	Formations in southern Arkansas	Columnar section	Lithologic characteristics of formations in southern Arkansas	Historical development during Lower Cretaceous and Jurassic times
Lower Cretaceous	Upper Albian	Lower Washita				Uplift, folding, faulting, erosion, probable volcanism. Withdrawal of sea south of Arkansas.
	Middle Albian	Fredericksburg	Kiamichi sh. 100' Gatesville fm. 70' to 300'		Shales and limestone Marls and shales Shell beds, clay marls, and limestone	Shallow, transgressing sea. Minor withdrawal of sea.
	Lower Albian	Trinity	Paluxy formation 160'—1200'		Shales, red, brown, and gray; streaks of gray limestone and fine white sand.	Deposition of variegated clays and sands in brackish waters. Sea probably retreating southward. Climate probably arid.
			"Glen Rose" Mooringsport formation 30'—730'		Shale and marl, gray to brown; streaks of dense limestone and fine sand; thin anhydrite stringers about 160 and 260 feet above base in southwest corner of state; grades to red shales northward.	Very shallow, brackish and marine waters. Temporary shoaling accompanied by anhydrite deposition.
			"Glen Rose" Ferry Lake anhydrite 3'—500'		Anhydrite, finely crystalline, thin-to-thick-bedded, white to gray; minor amounts of interbedded dolomite, limestone, and shale.	Marked shoaling of sea. Deposition of anhydrite from saline waters, probably in broad, marginal lagoon.
			"Glen Rose" Rodessa formation 200'—600'		Limestone and calcareous shale; two anhydrite stringers. Limestone commonly oölitic to coquinoid. Mainly gray, some red. Becomes redder and coarser northward.	Transgressing, shallow, agitated, normal marine waters. Temporary shoaling accompanied by anhydrite deposition. Climate probably fairly arid.
	Aptian		"Glen Rose" Pine Island formation 60'—300'		Shale, gray to brown mainly; some limestone.	
			Sligo fm. 120'—150'		Shale, dark; lenses of limestone and sandstone.	
	Neocomian: Barremian, Hauterivian, Valanginian, Berriasian	Coahuila	Hosston formation 1600'±		Shale, red and gray; interbedded lenses of white sandstone becoming more common toward base; some dolomite beds: pebbles of novaculite and quartzite in basal 100 feet. Darkens southward.	Transgressing sea. Highlands on site of Ouachita Mountains contribute much gravel, sand, silt and clay to sea. Brackish water conditions throughout most of southern Arkansas. Aridity on land masses. Withdrawal of sea from most of Arkansas
Jurassic	Insufficient fossil evidence for definite correlation of Arkansas Jurassic formation with European stages.	Not named	Cotton Valley formation 1400'—2275'		Shale and sandstone, red and white, interbedded; locally a basal conglomerate. Sandstones become more abundant northward. Passes southward in Louisiana into dark shales, limestones, and sandstones.	Transgressing sea. Deposition of sand and gravel derived from highlands on site of Ouachita Mountains. Brackish waters throughout most of Arkansas. Aridity on land masses. Withdrawal of sea from most of Arkansas.
			Buckner formation 100'—275'		Red shale at top; anhydrite at base.	Regression of sea. Probably marginal lagoons.
			Smackover formation 450'—900'		Limestone, oölitic to chalky, white to brown, porous; some coralline layers. Limestone, dense, gray to brown, some argillaceous partings.	Shallow, agitated, normal marine waters. Fringing coral reefs widespread. Chemically precipitated limestone in Arkansas grading basinward into dark shales. Abrupt termination of salt deposition.
			Eagle Mills formation 1000'—1200'		Red shale, sandy shale, and sandstone shoreward. Salt basinward. Basal conglomerate locally. Some anhydrite.	Submergence of region of southern Arkansas beneath sea. Aridity on bordering land masses. Deposition of red beds and anhydrite near shore and of rock salt basinward.
			Morehouse formation 1190'+ (Known only in northeast Louisiana		Shale and siltstone, gray and black mainly, some red. Some gray sandy shale and sandy limestone.	Sea transgresses northward across Ouachita peneplain and deposits normal marine sediments in northeastern Louisiana. Probably extended into Arkansas.



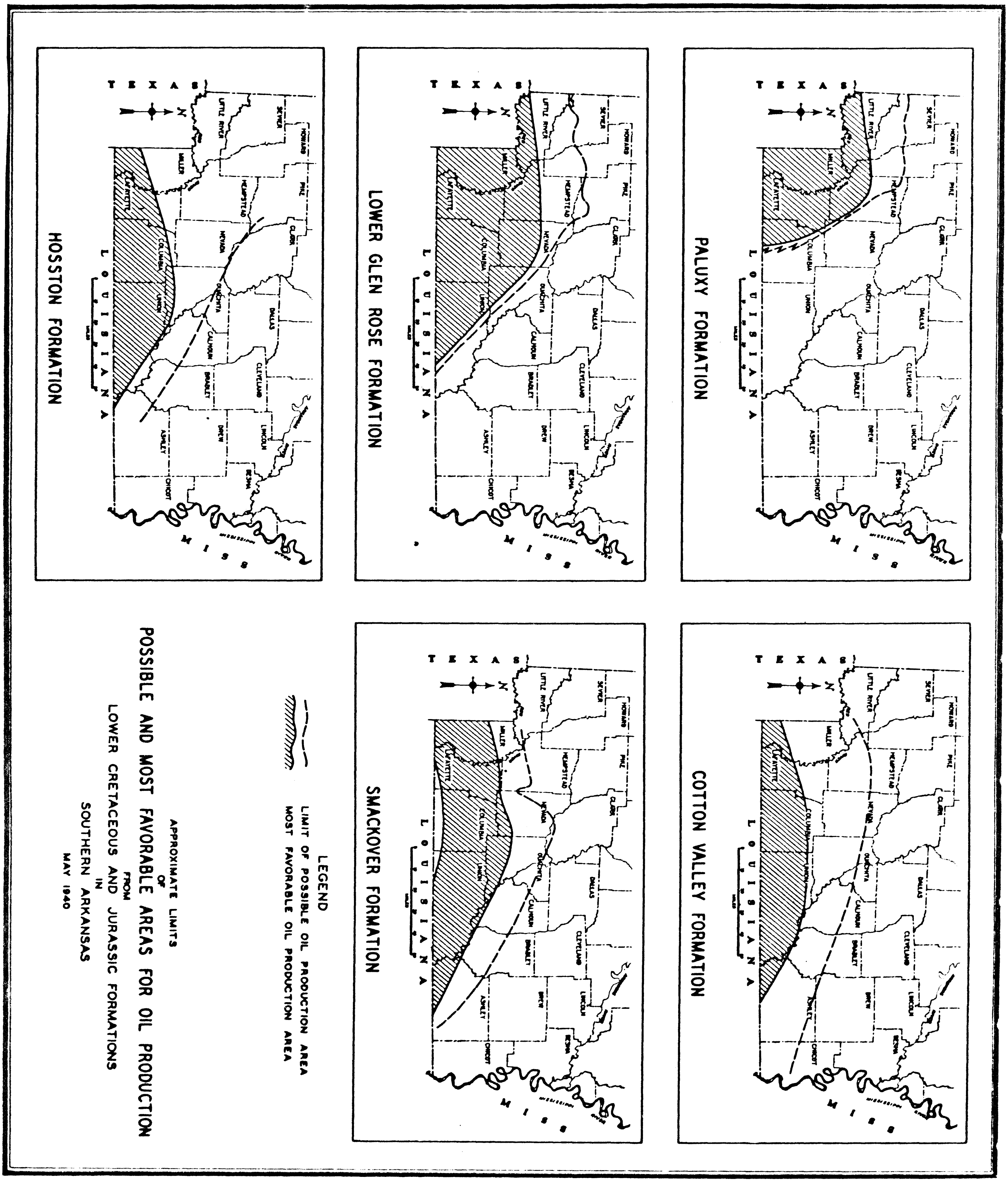

PALUXY FORMATION
LOWER GLEN ROSE FORMATION
HOSSTON FORMATION
COTTON VALLEY FORMATION
SMACKOVER FORMATION
TEXAS
LOUISIANA
MISS
LEGEND
LIMIT OF POSSIBLE OIL PRODUCTION AREA
MOST FAVORABLE OIL PRODUCTION AREA
APPROXIMATE LIMITS
OF
POSSIBLE AND MOST FAVORABLE AREAS FOR OIL PRODUCTION
FROM
LOWER CRETACEOUS AND JURASSIC FORMATIONS
IN
SOUTHERN ARKANSAS
MAY 1940

Table 18. Data on oil fields of southern Arkansas producing from Lower Cretaceous and Jurassic formations
(Compiled by the Arkansas Geological Survey)

Field	County	Date of discovery	Gravity of oil	Depth to pay sand	Producing rock type	Formation	Total productive acreage	Total Production
Atlanta[1]	Columbia	1938	44	7,900[6]	oōlitic limestone	Smackover	240	90,140
Buckner[1]	Columbia & Lafayette	1937	32.5	6,900[6]	" "	"	760	1,014,678
Magnolia[1]	Columbia	1938	38	7,100[6]	" "	"	3,249	3,846,707
Champagnolle[2]	Union	1927	22.3-34	3,000-3,400	sand	Hosston	2,000	14,166,000[5]
Lenz[2]	Miller	1930	30.5[3]	2,853	limestone	Glen Rose	10	
Garland City[2]	Miller	1932	31.7	2,900-4,200	sand	Trinity	290	1,819,000[5]
Rodessa[2]	Miller	1937	41	5,800-6,100	sand & lime	Lower Glen Rose	1,740	5,037,000[5]
Schuler[2]	Union	1937	41	5,559	sand	Cotton Valley	300	1,815,000[5]
Schuler (Jones)[1]	Union	1937	34	7,300[6]	tight limestone	" "	2,830	10,778,149
Schuler (Lime)[1]	Union	1937	38	7,600[6]	oōlitic limestone	Smackover	646	1,353,155
Snow Hill[2]	Ouachita	1936	36.2	4,900	oōlitic lime	Smackover	100	132.480[4]
Urbana[2]	Union	1929	18.9	3,535	sand	Hosston	350	4,914,000[5]
Village[1]	Columbia	1938	41	7,050[6]	oolitic lime	Smackover	440	369,490
Mount Holly[2]	Ouachita	1929	31	2,860	sand	Lower Glen Rose	85	
Dorcheat[1]	Columbia	1939	56.6	8,600[6]	oōlitic limestone	Smackover	120	42,823
Lewisville[1]	Lafayette	1939	37	3,075	oōlitic lime	Lower Glen Rose	320	144,603
Big Creek[3]	Columbia	1939	Distillate	7,976	" "	Smackover	40	

1/ "Arkansas' Conservation Act", by A. M. Crowell, Ark. Oil & Gas Comm., Oil & Gas Journal 2-15-40. (Production to Jan. 1, 1940)
2/ Report of Investigations, "Survey of the Crude Oils of the Producing Fields of Arkansas", by O. C. Blade & G. C. Branner.
3/ Arkansas Geological Survey logs.
4/ "Snow Hill Pool", by Warren B. Weeks, Guide Book, Fourteenth Annual Field Trip, Shreveport Geological Society. (Production up to Jan. 1, 1939)
5/ "Review of Conservation and Proration in Arkansas Oil Fields", by A. M. Crowell, El Dorado Daily, Jan. 28, 1940. (Production up to Jan. 1, 1940)
6/ Sub-Sea

Schuler, Snow Hill, Village, and Dorcheat. All of these fields are located south of the zone of normal faulting. Northward the porosity of the limestone appears to be reduced (35, p. 115). This may be due, in part, to the secondary deposition of calcite, and would be expected to apply to the vicinity of faults and in the area where the limestone underwent erosion at the end of Lower Cretaceous time. Accordingly, it appears that the Smackover limestone north of the fault zone is somewhat less favorable for oil accumulation than it is south of the fault zone. Southward in northern Louisiana, the Smackover limestone becomes shaly and has not yet been found to be oil-bearing. The eastern and western extensions of the limestone in Arkansas are possible areas for oil production which are now being explored. The overlying dense limestones of the lower part of the Smackover formation appear to be mainly chemical deposits and, on the basis of past drilling, are not petroliferous.

The Cotton Valley formation is oil-productive in the Schuler field in Arkansas and in the Shongaloo and Cotton Valley fields in northern Louisiana. The most favorable area for oil accumulation appears to be near the border of Arkansas and Louisiana, apparently because of the presence of many sand lenses associated with dark marine shales which it is assumed serve as source beds. Northward in Arkansas, the formation appears to become less favorable for commercial oil accumulation as it contains fewer beds which may provide a source of petroleum. Southward in northern Louisiana, the Cotton Valley formation is probably less favorable because its sandstone lenses become thinner and denser. The eastern and western extensions of the Cotton Valley formation have not been investigated sufficiently to permit an opinion to be stated in any detail concerning their possibilities.

The Hosston formation is oil-productive in the Champagnolle (Rainbow City) and Urbana fields in Arkansas and in the Pine Island, Cotton Valley, and Sugar Creek fields in northern Louisiana. In all these fields oil occurs at the top or within the upper few hundred feet of the formation. However, at Champagnolle and Urbana, part of the Hosston formation has been removed by erosion, and, therefore, the producing sands may be lower stratigraphically than in the other fields. The most favorable areas for oil accumulation in the Hosston formation in Arkansas now appear to be Miller, Lafayette, Columbia, and Union counties.

The Rodessa, Pine Island, and Sligo formations have yielded commercial quantities of oil in the Rodessa, and Mount Holly fields in Arkansas, and in the Pine Island, Lisbon, Rodessa, Shreveport, Sligo, and Sugar Creek fields in northern Louisiana. Production comes from porous lenses and tongues of sandstone and limestone. The area of possible production may extend as far north as southern Hempstead and Little River counties.

The Ferry Lake anhydrite has not been oil-productive in Arkansas, but in the Pine Island field of Louisiana small production was obtained for several years from broken anhydrite (13, p. 7).

No commercial production has been recorded from the Mooringsport formation in Arkansas. This is possibly due to lack of suitable reservoir rocks.

The Paluxy formation is oil-productive in the Garland City field in Arkansas and in the Ferry Lake, Dixie, Pleasant Hill and Red River-DeSoto fields in Louisiana. The reservoir rocks are lenticular sands in the upper part of the formation. Commercial production from the Paluxy formation does not appear to be favorable north of Miller County, because the source of the oil is probably marine shales which do not extend that far north.

The approximate limits of areas favorable for oil production, as discussed in the preceding paragraphs and as shown graphically on Plate XXVI are based on consideration of the presence of (1) source beds and (2) beds suitable as reservoirs for oil and gas.

Within the areas favorable for oil production the factors that control accumulation are principally (1) structure and (2) lenticularity of beds possessing sufficient porosity and permeability. The relation of these factors to oil accumulation is indicated in Table 17. The lenticularity of the oil-bearing beds is particularly marked in the Cotton Valley and Smackover formations. The extent of these lenticular beds cannot be predicted, except in a regional manner, from present knowledge of subsurface stratigraphy. In contrast, the controlling factor of structure can be approximately determined by seismograph surveys. Studies by petroleum geologists have shown that most of the oil fields of southern Arkansas that are producing from Lower Cretaceous and older Mesozoic rocks are definitely located on structural "highs." At least some of the "highs" overlie gentle anticlinal folds (44, p. 146, 148) and it seems likely that most of them are the higher parts of long sinuous folds that roughly parallel the trend of the ridges which are exposed in the Ouachita Mountains to the north.

Table 17. Relation of structure and lithology to accumulation of oil and gas in southern Arkansas

Field	Type of structure	Factors controlling accumulation
Atlanta	Probably an anticline	Structure
Buckner	Anticline	Accumulation apparently controlled mainly by structure
Magnolia	Probably an anticline	Accumulation controlled mainly by structure
Champagnolle	Terrace on an anticline	Accumulation probably determined by the lenticularity of the producing sands
Garland City	Elongated east-west "nose"	Accumulation controlled partly by structure and partly by lenticularity of the sands
Rodessa	Faulted anticline	Accumulation occurs on the upthrown side of major fault
Schuler	Anticline	Accumulation controlled by lenticularity of sands, by porosity of sands, and by structure
Snow Hill	Anticline	Accumulation controlled by structure
Urbana		Accumulation probably determined by the lenticularity of the producing sands
Village	Probably a dome	Porosity erratic. Accumulation probably controlled mainly by structure
Mount Holly	Terrace near a fault	Lenticularity of sands (?)
Dorcheat	Anticline	Structure
Big Creek	Anticline	Structure

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