Jurassic Stratigraphy of Mississippi

THEO H. DINKINS, JR.

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EDWARD MINIHAN

JULIUS M. RIDGWAY

BULLETIN 109

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LETTER OF TRANSMITTAL

Office of the Mississippi Geological, Economic and
Topographical Survey
Jackson, Mississippi

August 15, 1968

Mr. Henry N. Toler, Chairman, and
Members of the Board
Mississippi Geological, Economic and Topographical Survey

Gentlemen:

It is with pleasure that I transmit to you Bulletin 109 of the Mississippi Geological Survey, "Jurassic Stratigraphy of Mississippi," by Theo H. Dinkins, Marvin L. Oxley and others.

The Jurassic has become the prime objective for oil and gas exploration in Mississippi in the past few years. One paper is based primarily on sample work and the other on the use of electrical logs. The information developed from these two approaches should add much to the heretofore meager published data on the Jurassic of Mississippi and will be another aid in the search for oil and gas.

Respectfully submitted,

William H. Moore
Director and State Geologist

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JURASSIC STRATIGRAPHY OF CENTRAL AND SOUTHERN MISSISSIPPI

THEO H. DINKINS, JR.

ABSTRACT

The stratigraphic column in this report includes strata from the Eagle Mills formation of Triassic age to the Schuler formation of Jurassic age (Plate 1).

Lateral variations, facies changes and the time-transgressive nature of lithologic boundaries result in a multiplicity of lithologically based correlations. Stratigraphic cross-sections are provided to give the reader some idea of the writers concept.

From their known lithologies, the Eagle Mills, Werner, Louann and Norphlet sediments may never be seriously considered as deep exploration objectives, however, favorable source facies to reservoir facies relationships are present throughout the Smackover, Haynesville and Cotton Valley sediments.

Structural effects related to salt uplift have controlled the accummulation of vast quantities of hydrocarbons.

STRATIGRAPHY

GENERAL STATEMENT

The stratigraphic column in this report contains two descriptive localized terms, Pink Sandstone and Brown Dense Limestone Unit. These terms were first used by Mr. E. M. Rice of Trowbridge Sample Service, Jackson, Mississippi. By virtue of their long-standing local usage, they have become an integral part of the Jurassic nomenclature of Mississippi. In fact, the basis of present-day Triassic and Jurassic correlations in Mississippi and Alabama are directly related to Mr. Rice's correlations and concepts of these sediments.

The correlations used in this report are closely allied with those set forth by Mr. Rice. Correlations are based primarily on sample work and, therefore, do not necessarily correspond to correlations based on electrical log interpretations.

The time-transgressive lithologic boundaries of the Smackover, Haynesville and Cotton Valley sediments result in at least some time-stratigraphic equivalents being placed in adjacent formations.

Lateral variations and facies changes along strike are occasioned by lithologic changes resulting from the lateral shifting and progradation of deltaic depositional environments. River-derived clastics greatly affected sedimentation. Locally, unusually thick sequences of sandstone were deposited while limestone deposition predominated in adjacent areas.

A series of stratigraphic cross-sections, prepared with the help of Alvin R. Bicker, Jr., Staff Geologist, will give the reader some idea of the lateral and vertical variations and facies changes.

Contact relationships discussed in this report are based on extensive examination of samples. The writer's conclusions as to the nature of the contacts is, of necessity, based on the gross character of the sediments on either side of the contacts. Until such time as the contact zones are cored, actual contact relationships will be subject to conjecture.

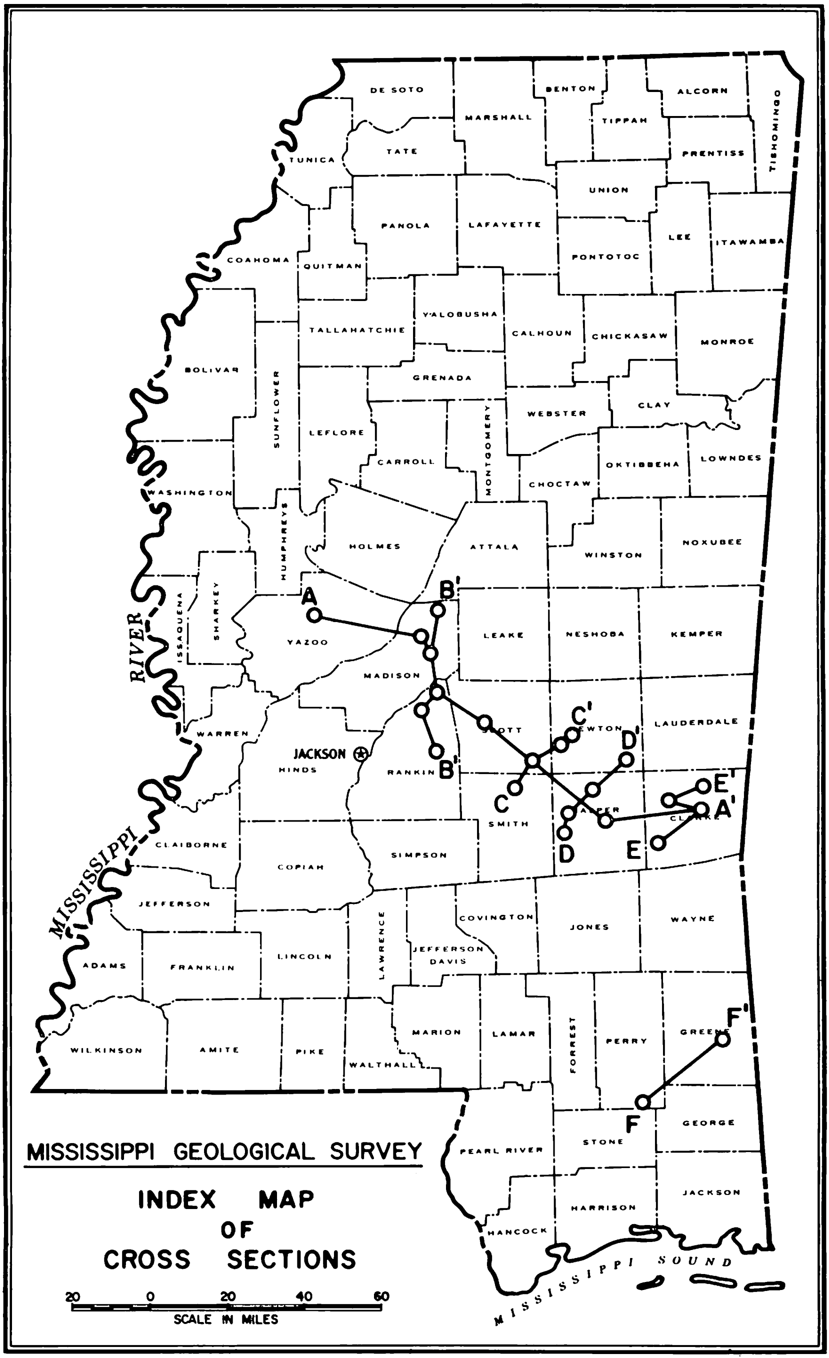

Figure 1.—Index to cross sections.

POST PALEOZOIC — PRE-NORPHLET SEDIMENTS

GENERAL STATEMENT

Post Paleozoic — Pre-Norphlet sedimentaries, Eagle Mills, Werner and Louann formations, consist of evaporitic rocks and predominantly red arenaceous-argillaceous strata. These sequences are not productive of oil or gas in this area, and from their known lithologies, they may never be seriously considered as exploration objectives. Well control, due to the pattern of Jurassic exploration in this area, is lacking to show the distribution and thickness of normal sequences of these sediments.

Within the salt basin, where salt-controlled structures are the prime objectives, deep Jurassic exploration ends when the top of salt (Louann) is encountered. To date, Eagle Mills and Werner strata have been recorded only in areas updip from the eroded edges of the Louann salt, where faulting and flexures affecting Paleozoic rocks controlled the sites of deposition. These Eagle Mills and Werner sediments occupy graben type areas, their presence here being related to the Ouachita structural belt. Recurrent movements undoubtedly have taken place along these faults resulting in slightly or weakly metamorphosed Eagle Mills sediments.

EAGLE MILLS FORMATION

The Eagle Mills formation of Triassic age is the oldest post-Paleozoic deposit recorded in the area covered in this report. Eagle Mills sediments were probably deposited in graben type areas along the Pickens-Gilbertown fault system, extending across Mississippi and into southwest Alabama where they rest unconformably on Paleozoic rocks. This belt of fracturing generally limits the inner extent of thick Jurassic sediments and is believed to have occurred in late Paleozoic or early Triassic time. Weak metamorphism in argillaceous Eagle Mills sediments is believed to be the result of recurrent movements along the system, as basin filling progressed.

Most of the Eagle Mills sedimentaries are fine alluvial clastics consisting of varying red and purple shades of shale, red, green and purple and pale-gray mudstone, red, pink and white very fine and very fine- to fine-grained sandstone and minor amounts of light-gray siltstone and quartzose sandstones. A few small siderite concretions are commonly associated with the gray and green mudstones. The thicker sequences of Eagle Mills, as in the States Exploration #1 Flora Johnson in sec. 21, T. 6 N., R. 10 E., Newton County, (Plate 3) usually contain zones of coarser clastics, in this instance quartz chips.

Later in the Triassic period the sea advanced. Fine red clastics and some predominantly red and pink limestones, their color probably due to precipitated colloidal oxides or incorporation of red detrital clays, were deposited during the transgression. These Eagle Mills carbonates are preserved in the Sun Oil Co. #1 Board of Supervisors "G" sec. 16, T. 3 N., R. 15 E., Clarke County (Plate 4).

WERNER FORMATION

Uplift with an accompanying basinward retreat of the sea ended Triassic deposition. Subsequent erosion removed an unknown thickness of Triassic deposits before the sea again spread northward.

Unconformably overlying the Eagle Mills is a sequence of conglomerate, red clastics and anhydrite. Where thicker Werner sequences have been recorded, the lower portion consists of conglomeritic strata with accompanying red clastics. This lower conglomeritic sequence is overlain by anhydrite with minor amounts of intercalated black shale and very fine-grained anhydritic sandstone. Such a sequence is found in the Union Producing Co. #1 Vanarsdale Unit, sec. 30, T. 12 N., R. 5 E., Madison County (Plate 3) lying below the stratigraphic position of the eroded Louann salt and overlain unconformably by lower Smackover clastics.

Depositional sites of recorded Werner sedimentaries were probably still associated with graben type areas. The coarse conglomeritic lower parts of the Werner probably represent alluvial fans or stream bed deposits from the adjacent highlands.

The sea spread landward covering the coarse alluvium and with the later regressive phase, deposited the zone of massive anhydrite with accompanying minor amounts of black shale and very fine-grained anhydritic sandstone.

LOUANN FORMATION

The sea continued to retreat basinward, exposing the Werner to erosion, of probable short duration, before the Louann sea spread inland. The land areas were evidently low and the supply of sediments all but abated as few impurities, other than disseminated anhydrite, were incorporated in the vast massive deposits of salt laid down in the Louann sea. The Louann is commonly a white massive crystalline halite, however, zones in which disseminated anhydrite is present may be varying shades of gray.

Uplift, spreading red alluvial clastics far basinward, marked the end of Louann deposition. Louann-Norphlet contact relationships are unknown at this time. Cored Louann-Norphlet contacts on salt-controlled structures indicate penetration of Norphlet sediments by the uplifting salt mass and steep dips are noted in the immediately overlying strata. Unconformable contacts are undoubtedly present near the eroded updip limits of the Louann, however, these unconformable conditions should diminish rapidly basinward.

In view of its known lithology, the Louann formation will never be considered as an exploration objective, however, structural effects related to salt uplift have controlled the accumulation of vast quantities of hydrocarbons.

NORPHLET FORMATION

The Norphlet is an interbedded sequence of predominantly "red" silty shales, siltstones and sandstones, however, subordinate amounts of white sandstone may be present. Norphlet shales vary in color from bright red to dark-red, are silty, finely micaceous and commonly sandy. Norphlet sandstones range from very fine- to medium-grained, though most are very fine- to fine-grained. The sandstones vary from well sorted to poorly sorted, though most are generally poorly sorted. Invariably, even the better sorted sandstones contain, at least, a few scattered "coarser" sand grains and occasionally small quartz pebbles. Individual sand grains, with the exception of the "very fines", tend to be sub-rounded. In some samples finely disseminated anhydrite and blebs of white and pink anhydrite are noted in the sands, silts and shales of the Norphlet.

The contact between the Norphlet and the overlying Smackover formation is believed to be conformable for the most part, throughout the greater part of the area covered in this report. While unconformable contacts are known to exist, cored contacts such as the one in the Chevron Oil Co. #1 J. O. Cox et al. in sec. 8, T. 7 N., R. 4 E., Rankin County, (Plate 3) indicate that deposition was essentially contemporaneous. A transitional zone of approximately nine feet exists between strata of definite Norphlet or Smackover lithology. This zone may represent a blended unconformity, however, the writer is of the opinion that this contact is transitional. Cuttings through such contacts do not reveal this relationship and such a contact appears to be sharp. In other wells where brown dense carbonates of the Lower Smackover overlie red sediments of the Norphlet; the Norphlet-Smackover contact is sharp and easily recognized.

Near its updip limit, the Norphlet is conglomeratic. A pre-Smackover conglomeritic zone composed of chips, pebbles, cobbles and boulder fragments of Paleozoic carbonates and cherts cemented with red very fine- and fine-grained calcareous sandstone was cored in the States Exploration #1 Flora Johnson in sec. 21, T. 6 N., R. 10 E., Newton County (Plate 3). For convenience and because of its distinctive lithology, this conglomeritic interval may be logged simply as a pre-Smackover "Rubble Zone". This "Rubble Zone" is Norphlet in age, however, the flood of Paleozoic conglomerate tends to mask the distinctive red bed sequence of the Norphlet. The lower half of the Norphlet section in this well consists of a sequence of light and bright red to dark-red finely micaceous shales and red, pink and white very fine- and fine-grained sandstone. This lithology is more representative of Norphlet sedimentation. This unusually thick accumulation, 380 feet, of Norphlet sediments was probably deposited rapidly into a downwarped area or graben system.

A tendency, in the past, to include all clastics below the dense limestones of the Lower Smackover in the Norphlet has led to miscorrelations which have tended to exaggerate the thickness of the Norphlet. This problem of miscorrelation will be discussed further in the section on the Lower Smackover. At present, data is not sufficient to reflect meaningful average thicknesses of the Norphlet sediments. Wells penetrating 100 feet of Norphlet sediments before encountering salt or Paleozoic strata are uncommon, however, up to 440 feet of Norphlet was penetrated in the Gulf Oil Corp. #1 Mrs. W. J. Clark 2-13 in sec. 2, T. 9 N., R. 9 W., Wayne County.

The prolific deep producer, the Shell Oil Co. and Love Petroleum Co. #1 W. D. Rhodes et al. Unit in sec. 18, T. 5 N., R. 5 E., Rankin County, is reportedly producing from sands of Norphlet age. The samples on this well were not available for examination and an opinion, by the writer, as to the age of the producing zone would be pure supposition based on surrounding deep control. If these productive sands are Norphlet in age, they must represent a rapid facies change from the generally recognized Norphlet sedimentation.

SMACKOVER FORMATION

GENERAL STATEMENT

A simple practical two-fold division of the Smackover formation, into Lower Smackover and Upper Smackover is utilized in this report. The Lower Smackover, as defined in this report, will be referred to as the Brown Dense Limestone Unit. The use of this informal descriptive term seems appropriate, as the distinctive light to dark-brown dense limestone characteristic of the Lower Smackover serves as the basis for differentiation of the Lower and Upper Smackover.

Early Smackover sedimentaries in the central parts of the State were predominantly clastics. Drainage systems were actively supplying clastics to both the eastern and western parts of the study area. Although some shifts occurred in these delta complexes, the drainage systems continued to influence this area throughout the Jurassic period. The rising sea level restricted the growth of the advancing delta complexes and widespread limestone deposition occurred. The brown dense limestones of the Lower Smackover and probably some of the Upper Smackover carbonates were deposited during the transgressive phase, however, much of the Upper Smackover appears to have been deposited during the regressive phase of the Smackover sea.

LOWER SMACKOVER (BROWN DENSE LIMESTONE)

Throughout much of the area covered in this report, the characteristic lithology of the Lower Smackover is a light-brown to dark-brown dense sub-lithographic and lithographic, occasionally very finely crystalline limestone with varying generally subordinate sandstone and dolomite development. Only occasional fossil fragments, casts or molds are noted in the Brown

Dense Limestone Unit. These occurrences have been restricted to the upper half of the Unit.

Secondary dolomitic limestones and dolomites may occur randomly in subordinate amounts throughout the Brown Dense Limestone Unit or may predominate, as in the Brandon Co. #27-1 Unit, in sec. 27, T. 10 N., R. 6 W., Wayne County where both the Lower and Upper Smackover Units are extensively dolomitized. These dolomitic developments are predictable only on a local basis and cannot be projected with any degree of certainty. In some wells, dolomitic development is clearly associated with Lower Smackover sandstones and the sandstones contain varying amounts of dolomitic cement. Inclusions of secondary anhydrite are occasionally noted in association with these dolomitic carbonates and anhydrite crystals are noted in both the dolomitic carbonates and limestones.

These dolomites and dolomitic limestones are from very finely sucrosic to finely crystalline and generally some porosity, either pinpoint solution or intercrystalline, is present. Shows of oil have been noted in these dolomitic carbonates in several wells, and these zones of porosity may prove productive in areas where the Lower Smackover is extensively dolomitized, as in parts of Wayne County.

Present control indicates that sandstone distribution in the Lower Smackover is quite extensive. From all indications, sands were the initial Smackover deposit in most of the area covered in this report. Deep drilling has found Lower Smackover sands throughout Yazoo, Madison, Rankin, Scott, Smith, Jasper, Clarke, Wayne and Jones Counties. The basinward extent of these sands is not known, but these sands were probably distributed far basinward. A more recent deep discovery in Clarke County, the Getty Oil Co. #1 Jessie Allen, sec. 20, T. 1 N., R. 15 E., was completed in a Lower Smackover clastic section.[1] The extensive distribution and excellent reservoir characteristics of these Lower Smackover sands should prove to be productive of vast quantities of hydrocarbons.

Lower Smackover sandstones are porous to non-porous, varying in grain size from very fine to coarse, most being in the fine and medium grain range. Many of the individual sand grains are frosted or etched and all grain sizes, with the exception of the very fines, tend to be sub-rounded and rounded. Some of the sands exhibit fair sorting but almost without exception, contain a few scattered "coarser" sand grains or small quartz pebbles. Other sands are poorly sorted and conglomeratic.

In Rankin County the Smackover consists predominantly of sandstone with an upper sequence of dark dense carbonates and lighter colored dolomitic carbonates (Plate 3).

The thick predominantly clastic sequence is the product of a deltaic type deposition. The sediments were probably transported to the site of deposition by a distributary of the large drainage system whose course appears to have paralleled the present-day Mississippi River. The flood of fresh water and river-derived sediments entering the sea in the area tended to prevent limestone deposition and only a thin sequence of dark dense argillaceous carbonates was deposited, probably during a period of slack deposition when the sediment supply was all but abated and the sea transgressed the slowly subsiding delta.

Some parts of this sequence of dark dense carbonates may be related to the transgressive sea which deposited the brown dense limestones characteristic of the Lower Smackover in adjacent areas, however, the writer was not able to make a satisfactory correlation. For this reason, most Lower Smackover correlations in Rankin County are only approximate and should be considered as such.

Core evidence offers further proof that most of the Lower Smackover sands in Rankin County were probably deposited rapidly in deltaic environments, being distributed by waves and currents. The winnowing action of the waves and currents produced massive generally "clean" sub-rounded and rounded sands. These sands range from conglomeratic to fairly well-sorted and are porous to non-porous. The most common cementing material in these sands is a combination of silica and dolomite, however, there are areas and zones where either silica, calcite or dolomite appear to be the single cementing agent.

Deep exploration in the Rankin County area had proved disappointing. Thick clastic sequences, containing hundreds of feet of porous and permeable sands, tested tremendous reserves of non-inflammable gas, almost pure carbon dioxide, but only relatively minor amounts of oil. With the completion of the Shell Oil Co. and Love Petroleum Co. #1 W. D. Rhodes et al. Unit in sec. 18, T. 5 N., R. 5 E., in August, 1967, this thick Smackover clastic section has become a major exploration objective.

Thick sequences of quite sandy Lower Smackover strata are present in the southwest quarter of Jasper County (Plate 4). Here much of the Brown Dense Limestone Unit consists of very fine- to medium-grained porous to non-porous calcareous and dolomitic sandstones. These sands are from fairly well-sorted to conglomeratic. Invariably, even the better sorted sands contain a few scattered "coarser" sand grains or small quartz pebbles. All the sands, with the exception of the "very fines" tend to be sub-rounded to rounded. Brown dense limestones and brown dolomitic carbonates are associated with these sands.

Here the deposition is somewhat similar to that of Rankin County, the exception being that deposition of brown dense limestone in this carbonate-clastic sequence facilitates correlation of these Lower Smackover deposits with adjacent areas. The drainage system supplying this area with clastics may have been allied with the larger drainage system situated in the western part of Mississippi and eastern Louisiana, or possibly a distributary of the delta complex supplying sediments to Alabama and eastern Mississippi. If allied to the eastern delta complex, this distributary must have breached the Central Mississippi Uplift.

Shows of oil have been noted in these sands in several wells. These sands, associated with dense limestones which may function as a seal to form stratigraphic traps, should be considered in any future exploration programs.

Except in downdip areas, where the circulation was apparently more restricted, the Lower Smackover or Brown Dense Limestone Unit is generally easily recognized. In downdip areas, the Smackover carbonates are shades of dark-gray and black, are dense and sub-lithographic to lithographic. The dark color and the dense character of these carbonates creates a sequence of featureless rocks which are not recognizable as separate units based on distinctive crystallinity and color. Cores of the dark carbonates generally emit at least some hydrogen sulfide odor on fresh breaks. This sulfide content undoubtedly is responsible for the dark colors of these carbonates.

As previously noted, the dark dense nature of the carbonates in downdip areas creates a situation in which only approximate Lower Smackover correlations are possible. Similar difficulties are encountered in Yazoo County in the Tinsley Field area. Further downdip, the Lower Smackover in the Phillips Petroleum Co. #1 Josephine "A" in sec. 35, T. 1 S., R. 10 W., Perry County and the Shell-Placid #1 Barnes in sec. 26, T. 3 N., R. 6 W., Greene County is, for all practical purposes, only an approximated correlation point below the oolites and oolitic limestones of the Upper Smackover. This correlation undoubtedly will need revision as more deep control becomes available (Plate 5).

In the central parts of the State where thick sequences of the Lower Smackover are penetrated, the lower part of the Brown Dense Limestone Unit is commonly argillaceous, silty and occasionally finely disseminated pyrite is noted. Locally, the lower part is dolomitic. Dark brown dense limestones, finely laminated with darker argillaceous limestone, are characteristic of the lower part of the Brown Dense Limestone Unit in these thicker sequences. Locally, these laminated limestones alternate with sandstones in thin bedded sequences (See Plates 2 & 3).

In the past, Lower Smackover sandstones have been erroneously classified as Norphlet, in a number of wells. These miscorrelations resulted most frequently from electrical log interpretations where Lower Smackover sandstones rest directly on sandstones of Norphlet age. Also, when deep tests encountered a clastic sequence beneath dense Jurassic carbonates and above the salt, there was a tendency to classify the entire clastic sequence as Norphlet.

Where a Lower Smackover sandstone or dense carbonate rests directly on Norphlet clastics, no reliable electrical log correlation is possible. Sample work is the only reliable means of differentiating Norphlet and Lower Smackover clastics, as the predominantly "red" Norphlet sediments are striking in their contrast, to the Lower Smackover strata which contain no "red" sediments.

The Brown Dense Limestone Unit appears to thicken progressively downdip into what must have been a slowly subsiding basin. The contact of the Lower Smackover with the Upper Smackover appears to be conformable, even in those areas where much of the Upper Smackover is clastic. Deposition is believed to have been essentially contemporaneous throughout the Lower Smackover-Upper Smackover contact.

UPPER SMACKOVER

GENERAL STATEMENT

Within the area covered in this report, the Upper Smackover may consist almost entirely of either limestone, dolomitic carbonates or sands, and a combination of any two or all three of these rock types is common. In several areas, the formation of oolites was so prolific that the resultant rock is a lime cemented oolite.

UPPER SMACKOVER

Throughout Yazoo, Madison and Rankin Counties the Upper Smackover is quite sandy. In northeastern Yazoo and northwestern Madison Counties several deep tests have cored up to 400 feet of Upper Smackover sandstone before penetrating carbonate strata.

Throughout this area, Upper Smackover strata consists of fine- to coarse-grained, porous to non-porous, dolomitic and calcareous sandstones with sub-rounded and rounded grains. There are also some sandy oolitic * limestones and dolomitic carbonates present. On occasion, thin sandstones containing oolites are present. Rare traces of anhydrite are also noted in the Upper Smackover. Downdip wells in these counties generally contain more carbonates than updip wells, however, even in updip wells, the basal strata of the Upper Smackover is generally carbonate.

As mentioned previously in the discussion of Lower Smackover sediments, dark downdip carbonates necessitate only approximate differentiation of Lower and Upper Smackover sediments. Such is the case in the Tinsley Field area of Yazoo County.

* Oolite — a spherical to ellipsoidal body, 0.25 to 2.00 mm. in diameter, which may or may not have a nucleus and has concentric or radial structure or both.

Eastward in Scott and north central Smith Counties, the Upper Smackover is predominantly limestone and some dolomitic carbonates. Locally, Upper Smackover sediments consist predominantly of dolomitic carbonates and may contain minor amounts of secondary anhydrite. Sandy strata, either calcareous sandstones or sandy limestones and sandy dolomitic carbonates comprise the uppermost beds of the Smackover formation in Scott and north central Smith Counties.

Upper Smackover strata is comparatively thin in this area and oolitic limestones, characteristic of Upper Smackover carbonate sequences, are conspicuously absent in some wells. The absence of this oolitic strata may be due to erosion, prior to Haynesville deposition. Unusually thick sequences, up to 2700 feet of Haynesville complementing thin Smackover sequences are present in northern portions of Smith County.

In the southeastern half of Smith and the southwestern half of Jasper Counties, the Upper Smackover becomes quite sandy again. Unusually thick, complex, carbonate-clastic sequences, reflecting subsidence concurrent with rapid deposition are characteristic in this area. This flood of clastics was supplied by the same drainage system active in the area during Lower Smackover deposition. Subsidence combined with rapid deposition resulted in a thick complexly bedded carbonate-clastic sequence in which the time-transgressive nature of lithologic boundaries is evident (Plate 4). Some parts of the upper half of these complexly bedded carbonate-clastic sequences in Smith and Jasper Counties, are time-stratigraphic equivalents of Haynesville type sediments in adjacent areas. In some wells, the equivalency is evident, however, in other wells the time-transgressive nature of lithologic boundaries results in time-stratigraphic equivalents being placed in adjacent formations.

Salt movement, apparently related to increasing overburden, had a marked effect on local rates of accumulation and deposition of the sediments in this area. In some of the wells examined, unusually thick accumulations of Upper Smackover sediments are overlain by little or no Haynesville type sediments. In other wells, a thin Upper Smackover sequence is complemented by a relatively thick Haynesville; or both the Upper Smackover and the Haynesville appear anomalously thin.

Upper Smackover sediments on the up-thrown side of the Phillips Fault System,[2] in the northeastern half of Jasper County, are considerably thinner than those on the down-thrown side (Plate 4). Here the Upper Smackover sediments are commonly a sequence of oolitic, occasionally sandy limestones, dolomitic carbonates and some very fine to medium sub-angular to sub-rounded sandstones. Sandstone or sandy carbonates are present at the top of the Smackover in most of the wells in this area.

In anomalous areas situated along the Phillips Fault System, notably Pool Creek Field in Jones County and Heidelberg and Eucutta Fields in Wayne County, structural movements more or less concurrent with Jurassic deposition may have been initiated as early as the latter part of Smackover time. Salt uplift appears to have generally maintained the crests of these structures near the depositional interface from the end of Smackover time until late in Cotton Valley time. Thin sequences of Dorcheat (Upper Cotton Valley) sediments overlie what appears to be unaltered and non-eroded Upper Smackover limestones in most wells situated on the crests of these anomalous areas. Although the top of the Smackover appears to be unaltered and non-eroded on the crests of these structures, wells situated generally off the crests indicate that erosion did take place over these crestal areas.

A thin sequence of Haynesville strata, containing reworked limestone fragments and oolites, undoubtedly eroded Smackover sediments from the crestal area of Pool Creek Field, is present in the Sinclair Oil & Gas Co. #1 Masonite Corp., sec. 15, T. 9 N., R. 10 W., Jones County. The Upper Smackover sediments in this well consist of light-tan to gray sucrosic to very finely crystalline limestone, with a few thin zones of dim oolitic (?) bodies. This type of Upper Smackover sediments is to be expected in wells situated off the crest of anomalies, such as Pool Creek.

Further evidence of erosion over the crestal areas of these salt-cored anomalies is found in the Gulf Oil Corp. #1 Mrs. W. J. Clark 2-13, sec. 2, T. 9 N., R. 9 W., West Eucutta Field, Wayne County. Here, chalky to dense limestones altered to mottled shades of yellow and ochre indicate a weathered surface.

Although definite evidence exists that the top of the Smackover was eroded on the crests of these anomalies situated along the Phillips Fault System, the writer is of the opinion that many of these areas may not have been extensively eroded or exposed for long periods of time. Other anomalous areas within the Jurassic basin, in which both carbonate and clastic facies of the Upper Smackover are overlain by Haynesville or Buckner sediments also reflect unconformable Smackover contacts. At most Smackover-Haynesville contacts, deposition appears to have been essentially contemporaneous and resulted in conformable contacts, however, other contacts indicate unconformable conditions.

Jurassic exploration in Jones County has been centered around and on the Pool Creek structure. Upper Smackover strata at Pool Creek consists of oolitic limestones and lime-cemented oolites with a few scattered pisolites*, minor amounts of sandy limestone and a lower sequence of denser very finely crystalline limestones. Porosity is generally developed in the upper oolitic sequence, however, scattered solution type porosity may develop in the lower part of the Upper Smackover as in the Placid Oil Co. #22-1 Weems Unit, sec. 22, T. 9 N., R. 10 W., Pool Creek Field, Jones County. As mentioned previously, in wells situated off the crestal areas of the field, the upper part of the Smackover may consist of very finely crystalline and sucrosic limestone with only a few scattered zones of oolitic development, reflecting a quieter depositional environment. Shallow water depositional environments over the crestal areas of such uplifts resulted in lighter colored carbonates while darker colored carbonates were being deposited in deeper water environments off the flanks of these domes.

Upper Smackover strata in Wayne County varies from oolitic limestones, lime-cemented oolites, very finely sucrosic and crystalline limestone and subordinate dolomitic carbonates, as in the Gulf Oil Corp. #1 Mrs. W. J. Clark 2-13 Unit, sec. 2, T. 9 N., R. 9 W., West Eucutta Field, or predominantly crystalline dolomitic carbonates as in the Brandon Co. #27-1 Unit, sec. 27, T. 10 N., R. 6 W., Cypress Creek Field. Secondary anhydrite

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* Pisolite — a spherical or subspherical, accretionary body similar to an oolite, but over 2 mm. in diameter.

is noted throughout the dolomitic sequences. Good porosity is usually developed in the dolomitic carbonates, as well as, the oolitic carbonates. With the possibility of thick oil pay zones in these dolomitic carbonates, such as in the #27-1 Unit, as far south as the Pan Am #1 USA-Gallion, sec. 10, T. 7 N., R. 8 W., the Upper Smackover should continue to be the prime target in deep exploration in Wayne County.

The Upper Smackover in Clarke County consists almost entirely of carbonates. Sandy carbonates in the form of sandy limestones or oolitic limestones and lime-cemented oolites with sand grain nuclei and scattered pisolites and pelletal* bodies, are quite common. Thin calcareous, generally oolitic sandstones are also present in the Upper Smackover and are present at the top of the Smackover in several wells. Dolomitic carbonates and sandy dolomitic carbonates, usually present in subordinate amounts, were noted in a number of wells examined. Only in those areas where a thin veneer of Smackover strata was deposited on old topographic highs and subsequently dolomitized, does the percentage of dolomitic carbonates in the Upper Smackover exceed the carbonate percentage. Inclusions of secondary anhydrite may be common in the porous oolites and dolomitic carbonates. The lower part of the Upper Smackover is commonly a sequence of very finely sucrosic limestones.

In downdip areas, the dark dense character of the carbonates prevents reliable differentiation of the Smackover formation into lower and upper units. The dark color of these downdip carbonates suggests a quiet anaerobic depositional environment, however, deep Jurassic tests in Greene, Perry and Simpson Counties have encountered dark oolitic and/or oolitic-pisolitic strata indicating a high energy depositional environment. These dark carbonates have a faint to strong hydrogen sulfide odor on fresh breaks and the dark coloration is probably due to very finely disseminated pyrite.

In Greene County, the Upper Smackover sequence in the Shell Oil Co.-Placid Oil Co. #1 W. P. Barnes, sec. 26, T. 3 N., R. 6 W., consists of a 410 foot sequence of dark dense limestone and lime-cemented micro-oolitic strata and some dark sucrosic to

* Pellet — ovoid body, 0.25 mm. in diameter, lacking significant internal structure.

granular dolomite. Intercrystalline and solution porosity is developed in this dolomitic strata and additional deep drilling in this area may prove this zone to be productive of gases rich in hydrogen sulfide, as in the deep productive zone in the Phillips Petroleum Co. #1 Josephine "A" which tested gas with approximately 75% hydrogen sulfide content (Plate 5).

The Upper Smackover in the Phillips Petroleum Co. #1 Josephine "A" sec. 35, T. 1 S., R. 10 W., Perry County, consists predominantly of a 580 foot sequence of dark dense lime-cemented oolite. Some dark dense lime-cemented oolitic-pisolitic strata and dark dense lithographic and sub-lithographic limestone and subordinate amounts of crystalline dolomite are also present. Many of the nuceli in this oolitic and pisolitic sequence appear to be skeletal debris and compound nuceli are common. Rod-shaped crystals of anhydrite are common in these dense carbonates and spary calcite is present in the oolitic sequence, filling the pore spaces between oolites. Finely disseminated sulfur crystals were also noted in several core chips from cores 19,508-588′ and 19,690-752′.

The porous dolomitic interval from approximately 19,752-80′, from which rich hydrogen sulfide gases have been tested, is assigned to the basal part of the Upper Smackover. It should be emphasized again, that the dark dense character of these Jurassic carbonates prevents no more than approximate correlation points between the Lower Smackover and the Upper Smackover at this position in the basin. This secondary dolomitic development may be more than a local occurrence and could persist throughout the "Wiggins Anticline" area in Mississippi and extend eastward into Alabama.

The Phillips Petroleum Co. #1 Zellerbach "B", sec. 25, T. 1 N., R. 3 E., Simpson County penetrated a 1352 foot sequence of dark dense oolitic limestone with occasional pisolites, dark dense lime-cemented oolite and minor amounts of very fine- to medium-grain sandstone and some dark calcareous shale before reaching a total depth of 21,052 feet. Here too, as in the Phillips Petroleum Co. #1 Josephine "A" in Perry County, many of the nuceli in the oolitic strata appear to be skeletal debris. Occasional fossil fragments and finely disseminated pyrite were also noted in these dense carbonates. Some intervals of the oolitic sequence also contain spary calcite.

The Upper Smackover in the #1 Zellerbach "B" lies with apparent fault contact beneath Cotton Valley sediments. The entire Haynesville sequence and probably some of the Cotton Valley, as well as, some of the Upper Smackover appears to have been faulted out in this well. Slickensided limestone was noted in a number of samples at the top of the Smackover formation and for a short distance below the faulted contact. The unusually thick section of oolitic strata in this well is probably due to the structural attitude of the beds and does not represent a true stratigraphic thickness.

HAYNESVILLE

GENERAL STATEMENT

Lateral variations and facies changes in the sediments between the top of the Smackover formation and the base of the Cotton Valley group have prompted the use of dual terminology — Buckner formation and Haynesville formation. The use of this dual terminology has tended to obscure the stratigraphic equivalency of this laterally and vertically variable sequence of sediments.

Most of the sediments between the top of the Smackover and the base of the Cotton Valley group are not characteristic of the anhydritic red beds and basal anhydrite zone synonymous with the term Buckner formation, but rather are a variable lithologic sequence of carbonates and sands with varying amounts of disseminated and interbedded anhydrite and shale to which the term Haynesville formation is applied. Facies vary from a predominantly clastic sequence with subordinate amounts of shale, carbonates and anhydrite to carbonate strata with minor amounts of anhydrite.

Because of the approximate lateral equivalency of these variable facies, these terms are applied with equal rank, to those lithic sequences which they best describe.

The term Buckner Anhydrite has, on occasion, been applied to the basal Haynesville sequence comprised of anhydrite or predominantly anhydritic strata, which is common although not present everywhere in the lower part of the Haynesville. The absence of this anhydritic zone in most areas is due primarily to local uplift which maintained the sedimentary interface above the base level of deposition, either preventing deposition of the anhydritic strata or causing it to be eroded.

Anomalously thick, complexly interbedded sequences of sandstone, shale and carbonates, predominated by an abundance of anhydrite are a characteristic of graben-type deposits which appear to be local occurrences. The term Evaporitic Unit has also been used, in a descriptive sense, for these thick complexly bedded Haynesville sequences.

Because of the lateral and vertical variations, facies changes and generally unconformable contact of the Haynesville-Buckner sequence with the overlying strata of the Cotton Valley group, a multiplicity of lithologic tops exists. As a general rule, the top of the Haynesville-Buckner sequence is placed at the first occurrence, in cuttings, of anhydritic sediments, carbonates and/or oolitic, pseudo-oolitic* and/or sandy carbonates or dark-gray and black calcareous shales stratigraphically below the top of the Pink Sandstone facies of the Cotton Valley group in the central parts of the State or below massive Cotton Valley sands in downdip areas.

Near its updip limits, especially in the eastern half of the study area, very fine and fine-grained calcareous and limy, often anhydritic sandstones are present at the top of the Haynesville. Generally these finer sands lie stratigraphically below "coarser" sands of the Lower Cotton Valley and the contrast is usually evident.

HAYNESVILLE-BUCKNER

From Madison County westward, the sediments between the top of the Smackover formation and the base of the Cotton Valley group consist of an upper sequence of red anhydritic sediments with a basal anhydrite zone, often accompanied by minor amounts of carbonates.

East of Madison County and in more downdip areas, these sediments undergo lateral and vertical facies changes and grade

* Pseudo-oolite — rounded pellets with no peripheral layers or shape distinction between pellets and matrix.

downdip into dark carbonates, so that the term Buckner formation no longer seems appropriate.

Throughout the northern half of Rankin County and in Smith and Scott Counties the Haynesville is quite sandy. Thin oolitic and pseudo-oolitic, often sandy limestones are present at the top of the Haynesville except in a few areas in Scott County where oolitic sands or sandy anhydritic strata are present at the top of the formation. Generally minor amounts of oolitic and pseudo-oolitic limestones, sandy limestones and some dolomitic carbonates are present in the Haynesville, with increasing amounts being present downdip. Almost without exception, anhydrite and anhydritic sediments are confined to the lower part of the Haynesville in Scott County. Basal anhydritic zones also characterize the Haynesville sequence in Rankin and Smith Counties, however, varying amounts of disseminated and interbedded anhydrite are present throughout the formation, especially in Rankin County. Locally, abnormally thick, complexly bedded graben deposits of carbonates, sands and shales, predominated by anhydrite are present in the northern part of Smith County. Up to 2700 feet of Haynesville sediments were noted in the Pan American Petroleum Corp. #1 R. M. Thomas in sec. 13, T. 4 N., R. 7 E.

Thickening, indicative of subsidence concurrent with deposition, is evident in the Haynesville section of the California Co. #1 Forkville Unit, sec. 32, T. 7 N., R. 7 E., Scott County (Plate 2). Previous writers have included the upper part of this expanded section in the lower part of the Cotton Valley group, however, the writer believes the thin carbonate strata capping this sequence to be the product of a transgressive oscillation of the Haynesville sequence.

In the Tallahalla, Shongaloo and Sylvarena areas of Smith County, salt uplift beginning near the end of Smackover deposition or shortly thereafter is believed to have either prevented the deposition of anhydritic strata, caused it to be eroded or to be faulted out. Over these structures, the Haynesville consists of a relatively thin clastic sequence capped by thin oolitic, pseudo-oolitic and/or sandy limestones. This clastic sequence, capped by thin carbonates has been included in the lower part of the Cotton Valley group by several writers, however, this writer believes the sequence to be the result of a minor transgressive Haynesville cycle which did not include the deposition of anhydrite.

The Haynesville is quite sandy in Jasper County but sandy oolitic and pseudo-oolitic limestones along with some dolomitic carbonates have increased noticeably. The carbonate-sand ratio continues to increase eastward.

The basal anhydritic zone, generally characteristic of the Haynesville-Buckner sequences to the west, has not been recorded in Jasper County, however, anhydritic strata and interbedded anhydrite are present, in varying amounts, throughout the Haynesville, except in a few wells in Bay Springs Field and the surrounding areas. Thin non-anhydritic Haynesville sections in some wells in the Bay Springs area, such as in the Shell #1 C. E. Brown (Plate 4) are attributed to much the same history of uplift and non-deposition or erosion with subsequent sedimentation of non-anhydritic Haynesville as wells in the Tallahala, Shongaloo and Sylvarena area of Smith County. In other wells examined, uplift appears to have maintained the sedimentary interface above base level of deposition throughout the Haynesville, so that Lower Cotton Valley sediments unconformably overlie Smackover carbonates.

No Haynesville sediments appear to be present on the crestal areas of the salt-controlled Pool Creek structure, in northeast Jones County. Here Upper Cotton Valley sediments overlie what appear to be uneroded Smackover carbonates. However, evidence of erosion, probably submarine erosion, of the crestal area of the dome is evident in the Sinclair #1 Masonite, sec. 15, T. 9 N., R. 10 W., where eroded carbonate fragments and oolites are incorporated in a thin Haynesville sequence.

In the southern part of Clarke County, (Plate 4) the relatively thick Haynesville formation consists of an upper predominantly clastic sequence, containing minor amounts of thin bedded sandy pseudo-oolitic limestone, shale and traces of anhydrite, in the lower part and a lower predominanatly carbonate sequence with minor amounts of anhydrite and shale. Locally, the upper clastic section contains thin sandstones with scattered oolites and pseudo-oolites. Gross lithology of the sediments at the Haynesville-Lower Cotton Valley contact, in some wells, indicates essentially contemporaneous sedimentation occurred and that conformable contacts may be present in the southern part of the County. Only subordinate amounts of anhydrite were noted in the basal Haynesville in the southern part of Clarke County. Here again, the absence of a basal anhydritic zone is probably local, being due to non-deposition or subsequent erosion over structurally high areas.

Updip, the Haynesville thins and the thick lower carbonate sequence, typical in the southern part of Clarke County, is not present in wells in the Quitman Field area (Plate 4). Here the Haynesville consists almost entirely of sandstone, with subordinate amounts of interbedded shales and thin-bedded sandy and oolitic limestones, and varying amounts of anhydrite and anhydritic strata confined to the basal part of the formation. The oolitic character of these thin-bedded limestones is not easily apparent in washed and dried cuttings, but must be viewed in wet samples.

In Quitman Field, carbonates are rarely present at the top of the Haynesville formation, so that in most cases the top of the Haynesville is picked on an increase of "finer"-grained white sandstones stratigraphically below the "coarser"-grained pink and white sandstones of the lower Cotton Valley group.

Further updip in Clarke County only a thin remnant of Haynesville sediments, products of local depositional thinning and subsequent erosion, is present in the Sun Oil Co. #1 Longbell Petroleum Co. in sec. 34, T. 4 N., R. 16 E. (Plate 4).

Presently available sample information indicates that salt uplift, in Wayne County, initiated possibly as early as late Smackover time, resulted in Haynesville sediments being absent or anomalously thin over the crests of salt-controlled structures. Where present, these thin sequences of Haynesville sediments consist of interbedded sandstones, shales, sandy pseudo-oolitic and oolitic limestones and anhydrite and appear to be products of upper Haynesville deposition. While Haynesville sediments are thin or absent on structure, thick sequences are expected to be found off structure.

Variations in the rate and extent of uplift, both periodic and concurrent with deposition, are reflected in the unconformable contacts of Upper Smackover carbonates with younger sediments over the crestal areas of the uplifts.

Downdip in Greene and Perry Counties, the Haynesville formation is predominantly dark dense featureless sub-lithographic to lithographic limestone with subordinate amounts of anhydrite, lighter colored dolomitic carbonates and scattered intervals of pseudo-oolitic and oolitic strata (Plate 5).

The Haynesville formation in the Phillips Petroleum Co. #1 Josephine "A" in sec. 35, T. 1 S., R. 10 W., Perry County, is probably more representative of Haynesville sequences in these downdip areas. The excessive thick interval in the Shell Oil Co.-Placid Oil Co. #1 W. P. Barnes in sec. 26, T. 3 N., R. 6 W., Greene County, probably does not represent a true stratigraphic sequence but is rather due to the structural attitude of the beds. No sharp break is evident between definite Haynesville and Lower Cotton Valley strata in the #1 Josephine "A" and the contact appears to be transitional. Even though the Haynesville formation has graded downdip into a carbonate facies, a basal zone of predominantly anhydritic strata characteristic of more updip Haynesville sequences is still present in the #1 Josephine "A".

As mentioned previously in the discussion of the Smackover, the Haynesville formation is apparently faulted out in the Phillips Petroleum Co. #1 Zellerbach "B", sec. 25, T. 1 N., R. 3 E., Simpson County, however, Haynesville sequences in this downdip position are probably similar to that of the #1 Josephine "A" or the #1 W. P. Barnes.

COTTON VALLEY GROUP (SCHULER FORMATION)

GENERAL STATEMENT

Cotton Valley sedimentation was initiated by the renewal of subsidence. This thick predominantly clastic sequence of sediments between the subjacent Haynesville formation and the overlying Hosston formation (Lower Cretaceous) are assigned to the Schuler formation. The Schuler is comprised of two members, a lower Shongaloo member and a upper Dorcheat member, both of which are distinguishable by reasonably obvious gross lithologic characteristics in the central part of the State. In downdip areas differentiation becomes more difficult.

Schuler sediments thin updip as a result of both erosion and depositional thinning. Locally, salt movement and old topographic highs, cause considerable thinning and thickening of the Schuler sediments.

Regional lateral variations and facies changes have effectively masked the identity of the stratigraphic lithic equivalents of the Bossier formation of Louisiana. While the lithic equivalents of the Bossier formation are probably represented basinward by varying thicknesses of the Haynesville and Shongaloo as defined in this report, no practical purpose would be served by attempting a time-rock correlation in this sedimentary sequence which obviously is best subdivided on a rock unit basis.

SCHULER FORMATION

SHONGALOO MEMBER

In the central part of the State, the regressive deposits of the Shongaloo consist of a sequence of white, red and pink fine to coarse sub-angular to rounded rarely lignitic occasionally calcareous and commonly conglomeritic sandstones, some dark-red, maroon and purple silty micaceous occasionally sandy shales, minor amounts of vari-colored mudstones and a few thin streaks of lignite. Generally, the sandstones tend to be better sorted in the west central and central parts of the State, becoming progressively conglomeratic toward the eastern part of the State.

Throughout central Mississippi, the Shonagloo is characterized by a distinctive pink sandstone facies, referred to locally by the descriptive term "Pink Sandstone" (Plate 2). This distinctive sequence is characterized by an abundance of pink and red fine- to coarse-grained commonly conglomeritic sandstones, although subordinate amounts of white fine- to coarse-grained sandstones and minor amounts of shale and mudstone also occur in the section. Noticeable variations in the percentage of white sandstones to pink or red sandstones occur downdip and along strike. Basinward thickening of the Shongaloo between the top of the Pink Sandstone and the base of the Dorcheat is primarily due to the presence of younger beds in the top of the Shongaloo (Plate 4). Varying thicknesses of these younger beds were removed by pre-Dorcheat erosion, so that in the central part of the State, the Dorcheat may rest directly on the Pink Sandstone. Present control indicates that generally more than one-half of the thickness of the Shongaloo, even in basinward areas, consist of the Pink Sandstone.

In the central part of the State, the distinctive character of the Pink Sandstone usually provides a more useful correlation point than the top of the Shongaloo. In actual practice, this writer does not use the top of the Shongaloo as a correlative point, preferring instead the top of the Pink Sandstone.

Basinward the lithology of the Shongaloo undergoes little overall change. As the Shongaloo thickens progressively basinward, only minor amounts of dark-gray and black shales are encountered. "Coarser" commonly conglomeritic sandstones grade into "finer" generally better sorted sandstones. More calcareous siltstones are encountered, however, they still represent only minor intervals of the Shongaloo. The generally vari-colored mudstones present in the central part of the State grade basinward to shades of gray and pale-green.

DORCHEAT

GENERAL STATEMENT

Dorcheat sedimentation was ushered in by a transgression which spread a basal clastic section, of fine- to coarse-grained commonly conglomeritic sands. Because of the similarity of this basal clastic section to that of the underlying Shongaloo, it is commonly correlated as uppermost Shongaloo rather than basal Dorcheat.

DORCHEAT MEMBER

Throughout the central parts of the State, the upper part of the Dorcheat is characterized by vari-colored mudstones, the pale-gray, light-gray and light-green shades commonly bearing small sideritic concretions and very fine and fine-grained sandstones, commonly containing small siderite concretions and incipient siderite concretions. Light-gray, pale-gray and light-green mudstones are characteristic of the Dorcreat in the west central parts of the State, the red, purple and ochre colors becoming prominent in the central and east central parts of the State.

In the east central part of the State, the Dorcheat sediments consist of light-red and dark-red, maroon and purple shales, vari-colored mudstones, generally "finer" grained red to white sandstones and some vari-colored thin bedded limestones and nodular limestones. Dorcheat sandstones are predominantly in the very fine- to medium-grained range, however, some zones of coarser conglomeritic sandstone are present in the central parts of the State. Small vari-colored chert and quartz chips and pebbles are commonly associated with these zones of "coarser" sands and many of the "finer" sands contain vari-colored chert grains.

Fragments, pebbles and cobbles of Paleozoic carbonates are also commonly noted in wells located near the Central Mississippi Uplift centered in Leake and Neshoba Counties. Basal conglomerates, usually lime-cemented strata consisting of Paleozoic pebbles, cobbles and chips, are usually present just above bedded Paleozoic strata and beneath Dorcheat sediments in wells situated on the uplift (Plate 3).

A large drainage system, probably an ancient course of the present-day Mississippi River, continued to supply sands and fine clastics to the western part of the study area; so that Dorcheat in this area consists predominantly of "finer" deltaic sands with some interbedded shales and mudstones and minor amounts of lignitic strata (Plate 2).

The drainage system supplying clastics to the eastern part of the study area shifted farther eastward. With this eastward shift in drainage, the east central part of the State became an inter-deltaic area, buffered on the north by the carbonate terrain of the Central Mississippi Uplift. Although tongues of coarse conglomeritic sands extended eastward into the east central part of the State, (Plate 2) the sediments supplied to this sheltered inter-deltaic area were predominantly silt and clay sizes, with some "fine" sands continuing to be supplied to the area.

With the continuing advance of the sea and the abated supply of clastics, the near-shore areas between the two drainage systems became the site of limestone deposition. In this neritic shelf environment, deposition of vari-colored limestones, often containing rounded sand grains and interbeds of vari-color mudstones and "red" shales, predominated (Plate 4). The varied pastel colors of the limestones are probably due to the precipitation of colloidal oxides and/or the incorporation of vari-colored detrital clays during deposition of the limestone. These limestones become thinner and fewer in number as they grade basinward into shales and mudstones with interspersed fine sands and silts.

Basinward from the central parts of the State more marine conditions prevailed and gray, dark-gray and black shales, calcareous and fossiliferous shales and some thin pale-gray to gray argillaceous fossiliferous limestones begin to appear in the Dorcheat sediments. The percentage of shale to sandstone also becomes greater basinward. Vari-colored mudstones, present in the central parts of the State grade into more subdued shades of grays and greens, although purple shades are also noted. Sands grade into the finer grain sizes and porosities decrease basinward. A declining percentage of "red" sandstones is also noted. Some of the very fine-grained sandstones and siltstones are calcareous and fossiliferous. A totally marine facies of the Dorcheat has not been penetrated in Mississippi, as even during this transgressive phase, deltaic sediments, lignitic strata, fine clastics and minor amounts of coarser sands, continued to be spread far basinward.

Near the close of Dorcheat sedimentation uplift to the east, accompanied by basinward tilting and subsidence, ended the inland advance of the sea, marking the close of Jurassic deposition in this area. No record of the former strandline of the transgressive Dorcheat sea exists, the sediments having been removed during the regressive cycle which followed. Some evidence does exist that these eroded sediments were the products of a neritic shelf environment in which vari-colored argillaceous limestones were common. The nodular limestone fragments common to the succeeding Lower Cretaceous sediments, were once a part of these widespread shelf sediments.

OIL AND GAS

From their presently known lithologies, the Eagle Mills, Werner, Louann and Norphlet sediments may never be seriously considered as exploration objectives, however, favorable source facies to reservoir facies relationships are present throughout the Smackover, Haynesville and Cotton Valley sediments.

Structural effects related to salt uplift have controlled the accumulation of vast quantities of hydrocarbons in the Smackover, Haynesville and Cotton Valley sediments. Time and rate of growth of these salt uplifts are the prime controlling factors in the amount of hydrocarbon accumulation. Optimum conditions prevailed when timely uplift proceeded at a slow gradual pace, allowing broad gentle warping to take place before the salt pierced the overlying strata. Conversely, rapid growth allowed the salt to pierce overlying sediments early and resulted in only slight structural uplift and the accumulation of only a relatively small amount of hydrocarbons.

At present, Jurassic production is confined to the central parts of the State with production from both carbonate and sandstone reservoirs. Gases, unusually rich in hydrogen sulfide, have been encountered in carbonate reservoirs in the Smackover formation at the Phillips Petroleum Co. #1 Josephine "A", in sec. 35, T. 1 S., R. 10 W., Perry County. Although technical problems have delayed production, development drilling is already in progress. While carbonate reservoirs, their porosity and permeability enhanced by secondary dolomitization, will probably be the prime objective of deep Jurassic tests in the southern parts of the State, the basinward extent of the thick Lower Smackover sandstone sequence is not known and should not be overlooked in any future deep exploration program. The excellent reservoir characteristics of these basal Smackover sands should prove to be productive of vast amounts of hydrocarbons when salt controlled structures with favorable time of uplift and rate of growth are encountered.

REFERENCES

1. Southeastern Oil Review: Vol. 30, No. 30, p. 1, 1968.
2. Oxley, M. L., Minihan, E. and Ridgway, J. M., A study of the Jurassic sediments in portions of Mississippi and Alabama: Gulf Coast Assoc. Geol. Socs. Trans., Vol. 17, Fig. 1, p. 25, 1967.

A STUDY OF THE JURASSIC SEDIMENTS IN PORTIONS OF MISSISSIPPI AND ALABAMA

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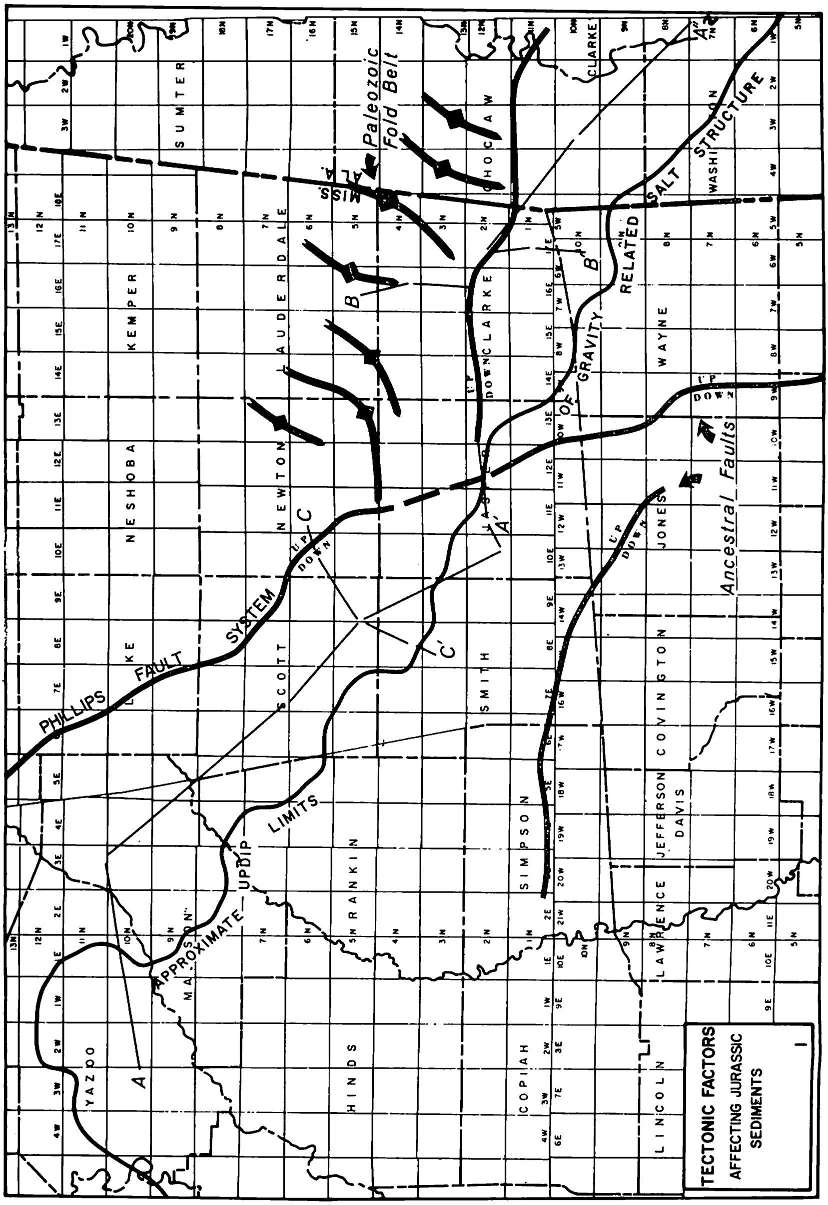
INTRODUCTION

The object of this study was to research and prepare a regional isopachous, lithofacies, and stratigraphic report on the Smackover, Haynesville and Cotton Valley sediments in the anticipated producing trend of Mississippi and Alabama. Basic data sources utilized were the electric log and the sample log. Every electric log within the study area has been examined and correlated. In addition, all available Trowbridge Sample Logs (approximately 75%) were used.

Information from every Jurassic test completed on or before October 1, 1966, is included in the report. Supplementary information is supplied from seismic profiles, gravity interpretations, previous articles from other areas and by personal communication.

Figure 1A is a location map of the study area. The numbered triangles reveal the location of the individual wells referred to in the text. Arrows indicate the occurrence of carbon dioxide in the Jurassic sediments. The circles locate eighteen Jurassic fields and show whether the fields produce from the Cotton Valley, Haynesville or Smackover. These fields represent every Jurassic discovery in Mississippi and Alabama as of April 1, 1967, with the exception of Black Creek Field, Perry County, Mississippi, which is beyond the limits of the map.

Since the discovery of sweet crude at Bienville Forest in late 1963, Jurassic oil production in Mississippi has jumped from slightly over 500,000 barrels per year in 1964 to an estimated 8,000,000 barrels in 1967. This production rise is projected to reach a peak of approximately 25,000,000 barrels per year sometime in 1969 or 1970.


TECTONIC FACTORS
AFFECTING JURASSIC
SEDIMENTS
PHILLIPS FAULT SYSTEM
APPROXIMATE UPDIP LIMITS
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JASPER
SMITH
SIMPSON
COPIAH
LINCOLN
LAWRENCE
JEFFERSON DAVIS
COVINGTON
JONES
WAYNE
WASHINGTON

TECTONIC FACTORS AFFECTING JURASSIC SEDIMENTS

In the course of this study it was noted that several tectonic factors had apparently influenced the deposition and diagenesis of Jurassic sediments. This influence was manifested in the subcrop pattern of the sediments, facies variations, and in non-deposition.

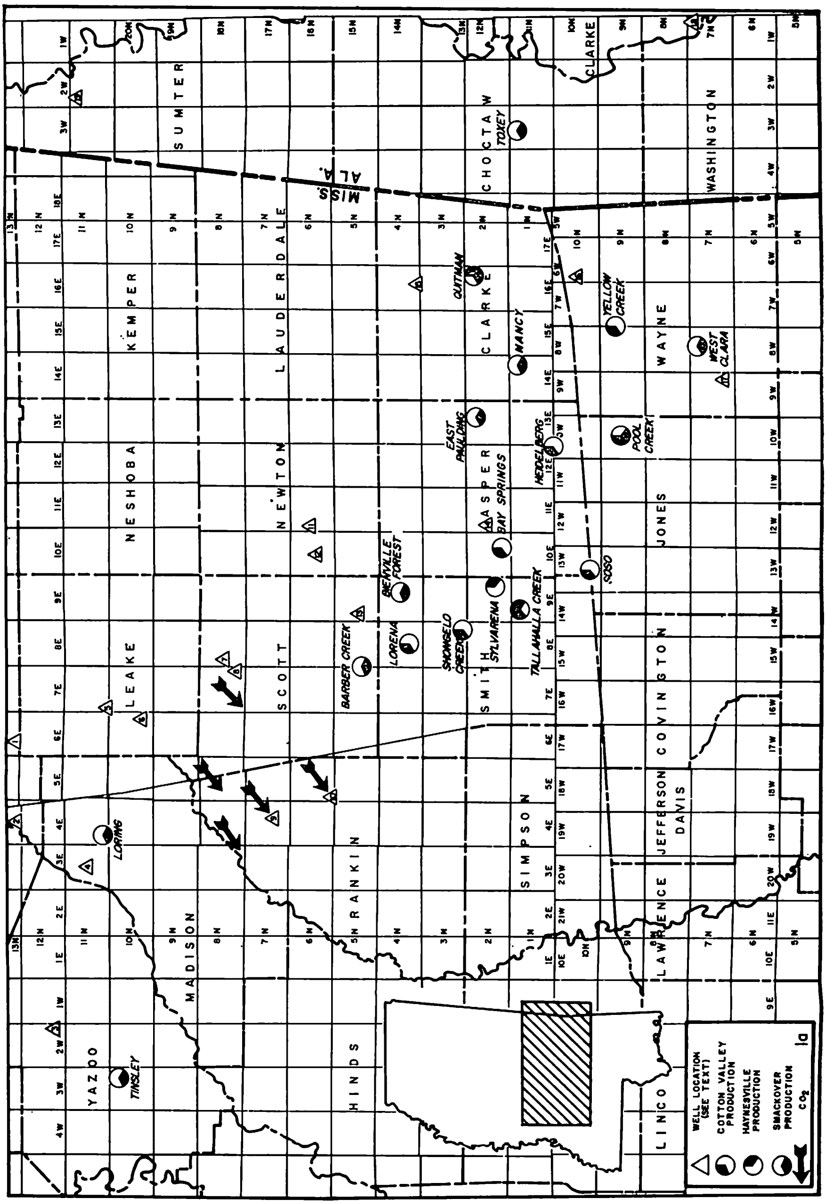
Figure 1 shows elements of the three major tectonic factors which affected Jurassic deposition. They include the southwestward extension of the folded Appalachians, the regional fault zone, and salt uplift. There were indications that other factors, primarily volcanism, were active; but these three, are shown to have imposed major variations on the sediments being studied.

PALEOZOIC FOLD BELT

The broad arcuate arrows extending southwestward along the Mississippi-Alabama state line are interpreted representations of a belt of Paleozoic ridges which are believed to be ancestrally related to the Appalachian Mountains. This presumption is based on the general alignment of these trends (N. 30° E.), their straight line extension into the area of the Sequatchie Anticline, and the presence of older Paleozoic sediments on the crests of these structures.

The direct effect of these folds on Jurassic deposition can be seen in the fluctuation of thickness in the Cotton Valley in Clarke, Lauderdale and Newton Counties. Similar effects are noted in the isopachs of the Upper Smackover and Haynesville, plus the lithofacies relationships of the Middle Smackover, Haynesville and Schuler facies.

A recent article on paleogeomorphology in the October, 1966, AAPG Bulletin (Rudolph Martin p. 2302) describes Lower Cretaceous and Jurassic age sediments that have accumulated in valleys controlled by Paleozoic topography. Several recent wells in Newton and Lauderdale Counties have found unusually thick Jurassic strata in the valleys or grabens between the Paleozoic ridges shown on Figure 1. Older wells, drilled on the crests of these ridges, encountered a comparatively thin section in the Jurassic. Additional well control will surely prove that the Paleozoic fold belt had a pronounced effect on the shoreline of the Jurassic seas.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LAUDERDALE
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NEWTON
JASPER
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LEAKE
SCOTT
SMITH
COVINGTON
MADISON
RANKIN
SIMPSON
JEFFERSON DAVIS
YAZOO
HINDS
LINCOLN
LAWRENCE
TOXEY
QUITMAN
YELLOW CREEK
NANCY
WEST CLARA
EAST PAULDING
HEIDELBERG
POOL CREEK
BAY SPRINGS
SOSO
BIENVILLE FOREST
SYLVARENA
TALLAHALLA CREEK
SHOWSELO CREEK
LORENA
BARBER CREEK
LORING
TINSLEY
WELL LOCATION (SEE TEXT)
COTTON VALLEY PRODUCTION
HAYNESVILLE PRODUCTION
SMACKOVER PRODUCTION
CO_2
1a

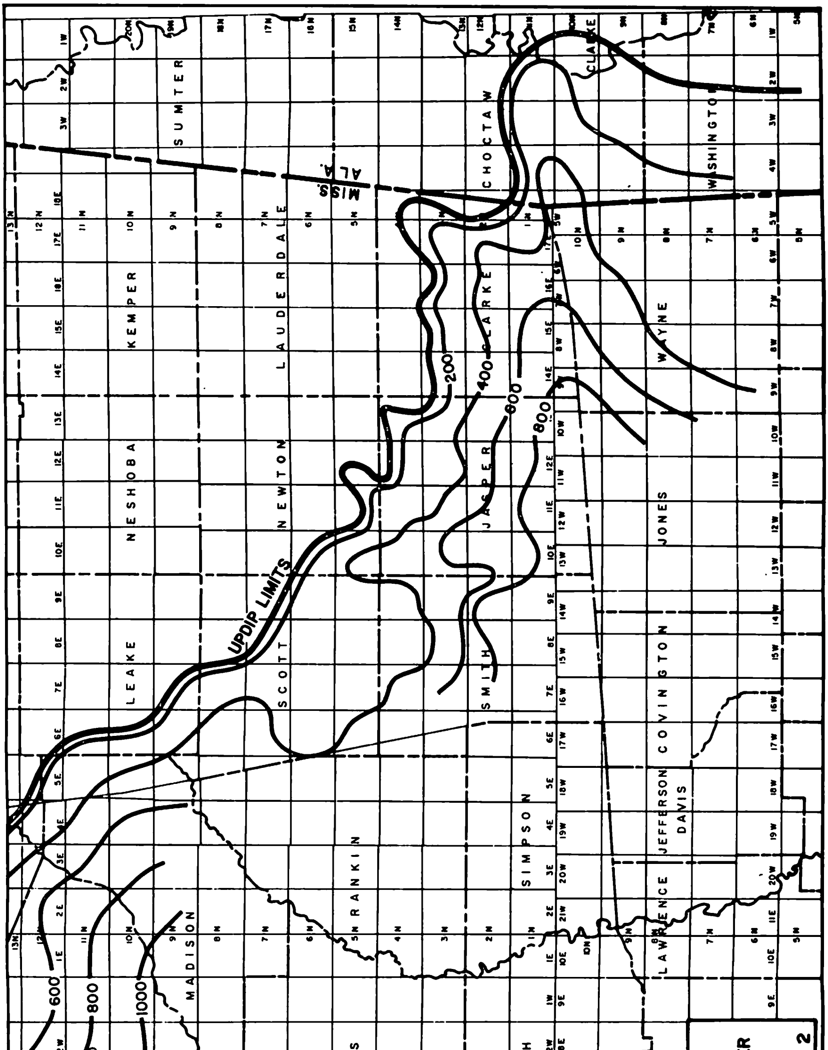
REGIONAL FAULTING

Three fault systems are shown in Figure 1. These fault systems are quite similar to other faulting in the area except for their unusual length. The dominant alignment is found in the north-south fault extending across the map from the northwestern corner of Leake County to Sandhill in Greene County.

Because of its regional characteristics, its effect on Jurassic sedimentation and its influence on subsequent structural patterns, this fault system is considered to be deserving of a name by which it can be referred to and recognized for discussion. In agreement with the Nomenclature Committee of the Mississippi Geological Society, I now suggest the designation of "Phillips Fault System."

The age of occurrence of the Phillips Fault System is uncertain. Stratigraphic evidence indicates that it moved intermittently during Jurassic time. From regional tectonic patterns and subsurface structural interpretations it is assumed that it post-dates the earliest Appalachian folding in the area. The curvature of the Paleozoic folds closest to the Phillips Fault System indicate the possibility of a strike-slip component. A maximum amount of fault throw as evidenced by missing section in several wells would include a fraction of the Ordovician, all of the Silurian, Devonian, Mississippian, Pennsylvanian and part of the Jurassic. This could amount to over 10,000 feet of throw, however, it is unlikely that this much vertical displacement was ever in existence at one time.

Referring to Figure 1A, the Phillips Fault System has been interpreted to pass between the Continental No. 1 Sudduth (well 1) and the Occidental No. 1 Burrell (well 2) in Attala County, the Carter No. 1 Denkman (well 5) and the Occidental No. 1 Reimers (well 6) in Leake County, the Southeastern No. 1 Eley (well 7) and the States Exploration No. 1 Worrell (well 8) in Scott County, and between the Texaco No. 1 Everett (well 11) and the States Exploration No. 1 Johnson (well 12) in Newton County. The wells on the upthrown side of the fault have been named first in each county. In every case, the upthrown wells passed from an unusually thin Cotton Valley section into Paleozoic carbonates while the downthrown wells drilled a complete


ISOPACH MAP
MIDDLE & LOWER SMACKOVER
2
UPDIP LIMITS
MISS.
ALA.
200
400
600
800
1000
SUMTER
CHOCTAW
CLARKE
WASHINGTON
KEMPER
LAUDERDALE
CLARKE
WAYNE
NESHOBA
NEWTON
JASPER
JONES
LEAKE
SCOTT
SMITH
COVINGTON
JEFFERSON DAVIS
SIMPSON
RANKIN
MADISON
YAZOO
HINDS
COPIAH
LAWRENCE
LINCOLN

section of Cotton Valley, Haynesville and Smackover sediments before entering Pennsylvanian shales.

From subsurface and gravity interpretations, it is assumed that this fault system is a series of en echelon normal faults, downthrown to the south and west. The limits of subsurface recognition of the Phillips Fault System are reached just south of the Newton-Jasper County line. At this point the system passes beneath the subcrop limits of the Louann salt.

Fault displacement, beneath the salt, is manifested in linear anomalies at the top of the salt. One such anomaly is the Heidelberg-Sand Hill Salt Ridge. This salt ridge is in excess of fifty miles in length and, at its northern extremity, points directly at the southernmost recognized limits of the Phillips Fault System. Consequently, the Phillips Fault System is believed to underlie the Heidelberg-Sand Hill Salt Ridge along its entire length.

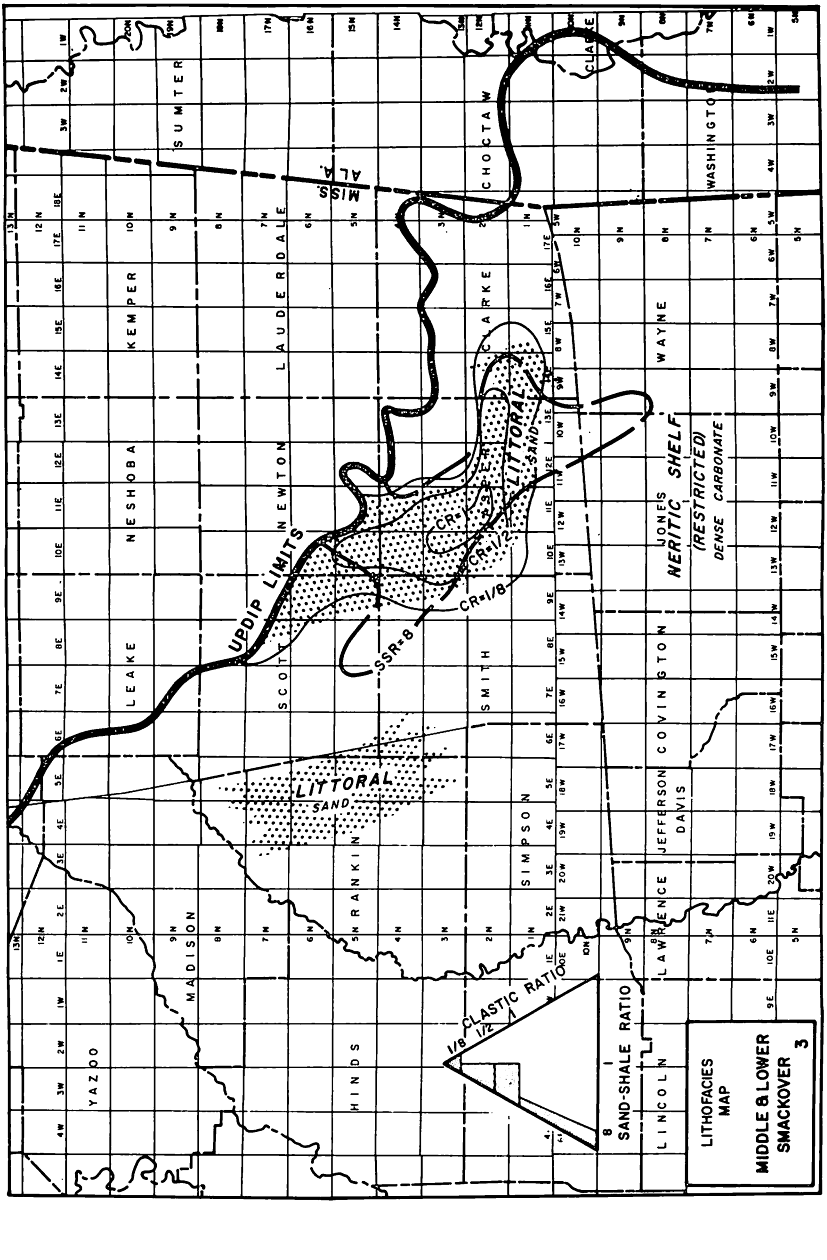
From this, it is also assumed that the two east-west trending salt uplifts and fault zones shown on Figure 1 have also been triggered by regional basement faults. Jurassic oil production at East Paulding, Quitman and Toxey fields is associated with the easternmost of these two faults.

The Phillips Fault System has served as the updip limits of the Norphlet, Smackover, Haynesville and most of the Cotton Valley northward from Newton County. In restricted areas along the system, its upthrown block has served as a source of sediments for the Cotton Valley. The fault system through Clarke County has apparently acted as the updip limits of the Louann salt in that area. Both fault systems will be shown to have caused certain facies variations in the Smackover and Haynesville.

There is much stratigraphic evidence indicating that faulting penecontemporaneous with Jurassic deposition occurred on a considerably wider scale than has just been described. Although localized, the additional faulting is also believed to be related to the regional fault systems.

SALT UPLIFT

The Louann salt has approximately the same distributional pattern as the overlying Jurassic sediments. The Louann, how-


LITHOFACIES MAP
MIDDLE & LOWER SMACKOVER
3
UPDIP LIMITS
LITTORAL SAND
LITTORAL SAND
NERITIC SHELF
(RESTRICTED)
DENSE CARBONATE
CR=1
CR=1/2
CR=1/8
SSR=8
CLASTIC RATIO
1/8
1/2
1
SAND-SHALE RATIO
8
MISS.
ALA.
SUMTER
CHOCTAW
CLARKE
WASHINGTON
KEMPER
LAUDERDALE
CLARKE
WAYNE
NESHOBA
NEWTON
JASPER
JONES
LEAKE
SCOTT
SMITH
COVINGTON
SIMPSON
JEFFERSON DAVIS
MADISON
RANKIN
LAWRENCE
YAZOO
HINDS
LINCOLN

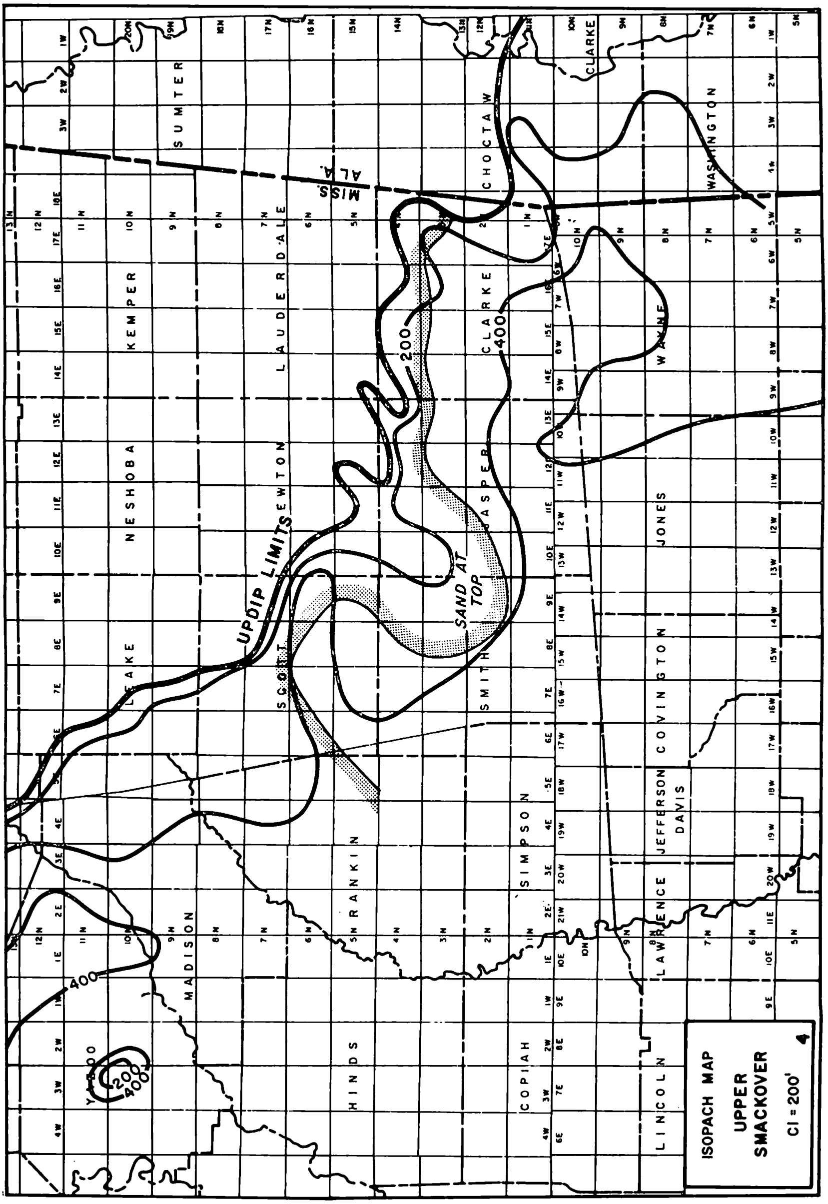
ever, thins rapidly as it approaches its updip limits and is always overlapped by the Jurassic. The structural effects of the salt are both widespread and complex. It may be said that salt uplifts are intrusive into overlying sediments and that they are not intrusive, that salt movement occurred as early as Smackover time and as late as Recent, that salt structures are related to regional tectonics and that they are simply the result of halokinetics, that they are faulted and that they are not faulted. Relating this to Jurassic producing structures, several general statements appear to be applicable.

First, the thickness or the amount of salt supply controls the intensity of salt movement. Thin salt areas are usually characterized by less faulting, incomplete graben systems and the absence of salt intrusion. Salt intrusion usually occurs in the downthrown or graben fault blocks and intrusion in one fault block certainly does not condemn production possibilities in another.

It is obvious that early structural movement is the essential prerequisite of a Jurassic prospect. Although this early structural movement was undoubtedly influenced by salt tectonism, regional rejuvenation and structural adjustment of the sediments underlying the salt had a far greater effect on Jurassic structure.

Fields such as Eucutta, West Clara, Heidelberg and Pool Creek afford conclusive proof that local structures were active and growing during the Jurassic depositional process. These structures had a maximum of 1500 feet of sediments overlying the salt when uplift first began. It is highly improbable that the salt would have sufficient bouyancy to produce these anomalies with such a thin section overlying it. Undoubtedly, these early uplifts were triggered by movement within the underlying Paleozoic sediments. They are characterized by the absence of the Haynesville and most of the Cotton Valley section over the crest of the anomalies. In most instances, a thin section of the Dorcheat facies directly overlies the Smackover with no evidence of the erosion of the Smackover surface. Apparently, uplift was contemporaneous with deposition.

Exploration Surveys, Incorporated of Dallas, Texas, has furnished data which indicate the approximate updip limits of


ISOPACH MAP
UPPER SMACKOVER
CI = 200'
4
UPDIP LIMITS
SAND AT TOP
MISS.
ALA.
SUMTER
CHOCTAW
CLARKE
WASHINGTON
KEMPER
LAUDERDALE
CLARKE
WAYNE
NESHOBA
NEWTON
JASPER
JONES
LEAKE
SCOTT
SMITH
COVINGTON
JEFFERSON DAVIS
SIMPSON
RANKIN
MADISON
LAWRENCE
YAZOO
HINDS
COPIAH
LINCOLN
200
400

gravity related salt uplift. In the area south of the line shown on Figure 1 all gravity minima are believed to represent salt uplift. In the area north of this line the gravity minima probably do not represent salt uplift.

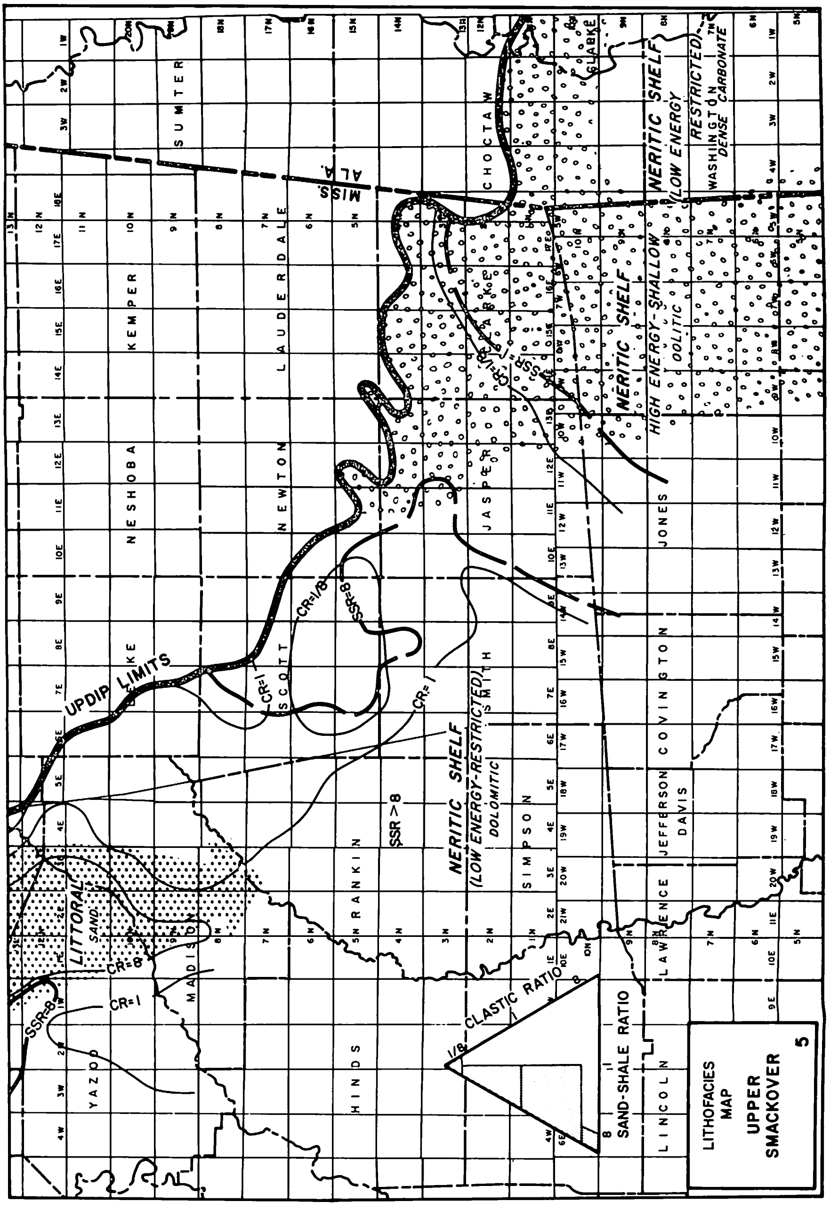
Many of the Smackover structures north of this line have been represented as being anticlinal features on the downthrown side of a semi-regional, strike aligned, normal fault. This is in opposition to the observation that most of the structures south of this line are represented by complex graben faulting and anticlinal closure on the upthrown side of one or more normal faults. It is believed that the primary difference between these two types of observed structures is found in the amount of salt uplift and the relative timing of salt movement. Both factors are directly affected by the thickness of salt underlying the structures.

STRATIGRAPHY

Inasmuch as no means were available for determining actual age relationships of the sediments under study, the approach used in this report will be to delineate the strata on the basis of facies relationship. The apparent formational boundaries shown on the forthcoming cross sections, isopachs and lithofacies interpretations have unquestionably transgressed time lines. This approach provides an easily recognizable concept for the well-site geologist and can be utilized for regional correlations along depositional strike. In the absence of isochronic determinations it must also be used for interpretive purposes. Facies relationships are meaningful in other facets of our exploration picture also, for seismic reflections must come from sedimentary variations and not geologic time lines.

Isopachous and lithofacies interpretations are presented for each stratigraphic unit. Two of the isopachous, Figures 4 and 6, also contain certain stratigraphic information which was more germane to the isopachous data. Only regional structural influences are illustrated, with salt intrusions, local structures and faulting having been eliminated from the interpretations.

Each of the lithofacies maps contains the conventional triangle comparing the clastic ratio to the sand-shale ratio. The stippled area of each triangle indicates that part of the triangle


LITHOFACIES
MAP
UPPER
SMACKOVER
5
SAND-SHALE RATIO
CLASTIC RATIO
UPDIP LIMITS
MISS.
ALA.
NERITIC SHELF
(LOW ENERGY-RESTRICTED)
DOLOMITIC
NERITIC SHELF
HIGH ENERGY-SHALLOW
OOLITIC
NERITIC SHELF
(LOW ENERGY
RESTRICTED)
DENSE CARBONATE
LITTORAL
SAND
SSR > 8
CR=1
CR=1/8
SSR=8
CR=8
KEMPER
LAUDERDALE
NESHOBA
NEWTON
SCOTT
RANKIN
HINDS
MADISON
YAZOO
SMITH
SIMPSON
JASPER
JONES
COVINGTON
JEFFERSON DAVIS
LAWRENCE
LINCOLN
CLARKE
WASHINGTON
CHOCTAW
SUMTER

occupied by the sediment under discussion. The manner in which the ratios were subdivided for study is also indicated.

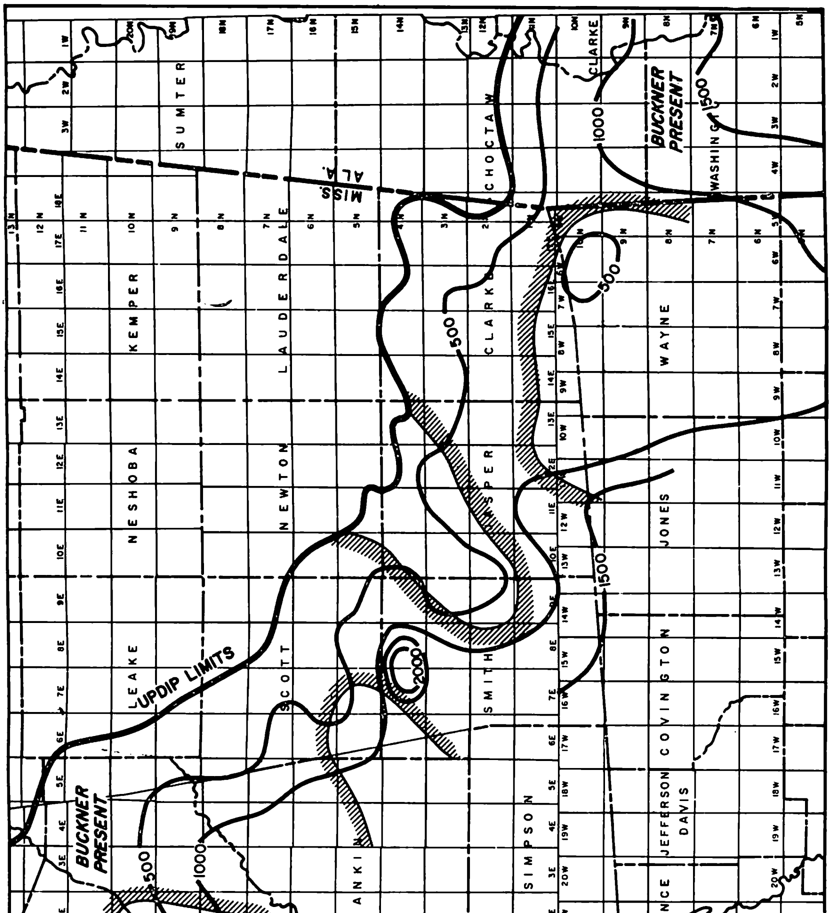
LOUANN SALT

For the purpose of all current exploration efforts in the Mississippi Salt Basin, the Louann salt is an effective basement. It is an homogenous, crystalline mass which will readily flow under pressure. Thickness variations are extreme, with salt intrusions masking regional isopachous gradients. However, on the basis of recently examined seismic profiles it is estimated that original depositional thicknesses of 5,000 feet or more were not uncommon.

Age of salt deposition has never been conclusively established. An age of Middle or Lower Jurassic as interpreted by William F. Bishop (pp 244-249, Volume 51, No. 2, AAPG Bulletin) in February, 1967, is accepted for this report. It is possible, however, that salt deposition also transgressed time lines. In certain areas, the salt appears to have an updip facies equivalent which consists of a red beds section (Cross sections B-B′ & C-C′). In wells such as the Sun No. 1 Longbell (well 15) in Clarke County, the States Exploration No. 1 Johnson (well 12) in Newton County and the Occidental No. 1 Burrell (well 2) in Attala County this section consists of red to grey shale, pink or brown to grey poorly sorted sandstones, vari-colored limestones, anhydrite and conglomerates. Halite has also been reported in inclusions within shale. The depositional environment of the clastics and the limestone in this section is interpreted to be terrestrial with the limestones being deposited as a conglomerate from the Paleozoic surface.

The contact relationships between the salt and the overlying Jurassic sediments vary considerably. In the absence of evidence of intrusion, the Louann is normally overlain by Norphlet sand. However, there are areas where Norphlet is not present and the basal Smackover does not appear to be intruded (Cross section C-C′). Where the Louann has intruded the overlying Jurassic sediments, the contact is normally "clean" with little evidence of secondary crystallization at the contact.

There are areas, however, where a thick anhydrite caprock overlies the salt. The presence of an anhydrite caprock is interpreted to represent intrusion soon after deposition at a time


ISOPACH MAP
HAYNESVILLE
CI = 500'
6
UPDIP LIMITS
BUCKNER PRESENT
BUCKNER PRESENT
MISS.
ALA.
SUMTER
CHOCTAW
CLARKE
WASHINGTON
KEMPER
LAUDERDALE
CLARKE
WAYNE
NESHOBA
NEWTON
JASPER
JONES
LEAKE
SCOTT
SMITH
COVINGTON
JEFFERSON DAVIS
MADISON
RANKIN
SIMPSON
LAWRENCE
YAZOO
HINDS
COPIAH
LINCOLN
500
1000
1500
2000

when the sediments, usually Cotton Valley sands, still contained fresh water. This is further evidence of salt movement under a comparatively thin overburden. Excellent examples of this relationship are found in the Gulf No. A-1 H. A. Chapman (well 16) and the Pan American No. 1 U. S. A. — Continental (well 17) both in Wayne County. Other examples may be found in Scott and Smith Counties.

NORPHLET

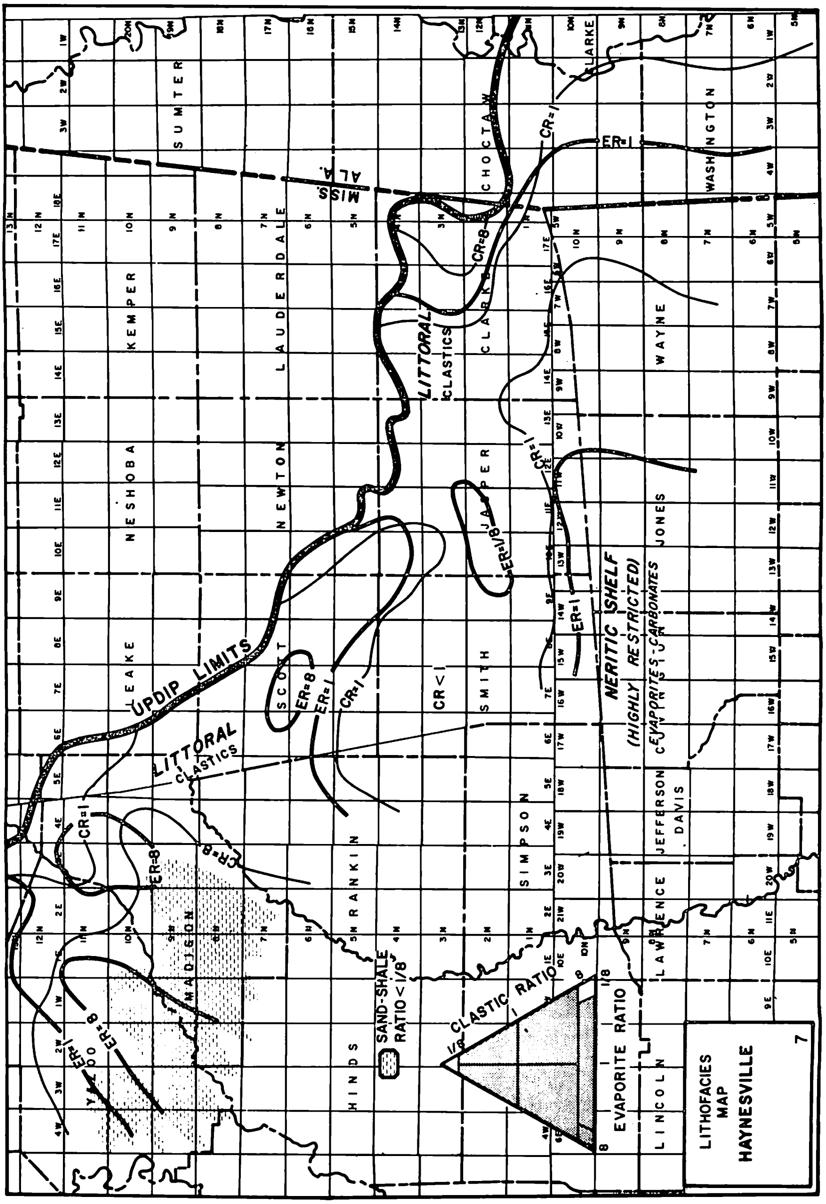
The Norphlet is a pink to red, poorly sorted shaley sandstone and red sandy shale. The sands are usually porous and permeable. Oil shows have been reported from the Norphlet in the Austral No. 1 Eichelberger (well 13) in Scott County and the C. F. Hayes No. 2 Blue in Pool Creek Field, Jones County.

Thickness and lithologic variations in the Norphlet appear to be minor. Present well control indicates an approximate average thickness of 110 feet. Unfortunately, the available well control is inadequate for the development of meaningful maps. Because of this, no interpretation of the Norphlet has been prepared.

MIDDLE AND LOWER SMACKOVER

Several previous reports have attempted to separate the Middle and Lower Smackover into two lithologic units. This was usually done on the basis of the Middle Smackover being a dense or finely crystalline limestone and dolomite while the Lower Smackover was a dark colored, thinly laminated or "varved", finely crystalline limestone with very few fossils. This distinction was readily apparent in some areas. In many sample log descriptions, however, no such distinction was apparent and separation of these units became difficult. For this reason, the Middle and Lower Smackover are treated as a single unit.

Figures 2 and 3 show the isopachous and lithofacies interpretations for the Middle and Lower Smackover. The isopachous data indicate a progressive basinward thickening of the unit and suggest that the Mississippi Salt Basin was subsiding during this period of deposition. The only significant anomaly is the thin area in south central Scott County which appears to separate the two areas of sand occurrence in this unit.


LITHOFACIES
MAP
HAYNESVILLE
7
UPDIP LIMITS
LITTORAL CLASTICS
NERITIC SHELF
(HIGHLY RESTRICTED)
EVAPORITES-CARBONATES
MISS.
ALA.
CLASTIC RATIO
EVAPORITE RATIO
SAND-SHALE RATIO < 1/8
CR=1
CR=8
CR<1
ER=1
ER=8
ER=1/8
SUMTER
CHOCTAW
CLARKE
WASHINGTON
KEMPER
LAUDERDALE
CLARKE
WAYNE
NESHOBA
NEWTON
JASPER
JONES
LEAKE
SCOTT
SMITH
COVINGTON
JEFFERSON DAVIS
SIMPSON
RANKIN
MADISON
HINDS
LAWRENCE
LINCOLN
YAZOO

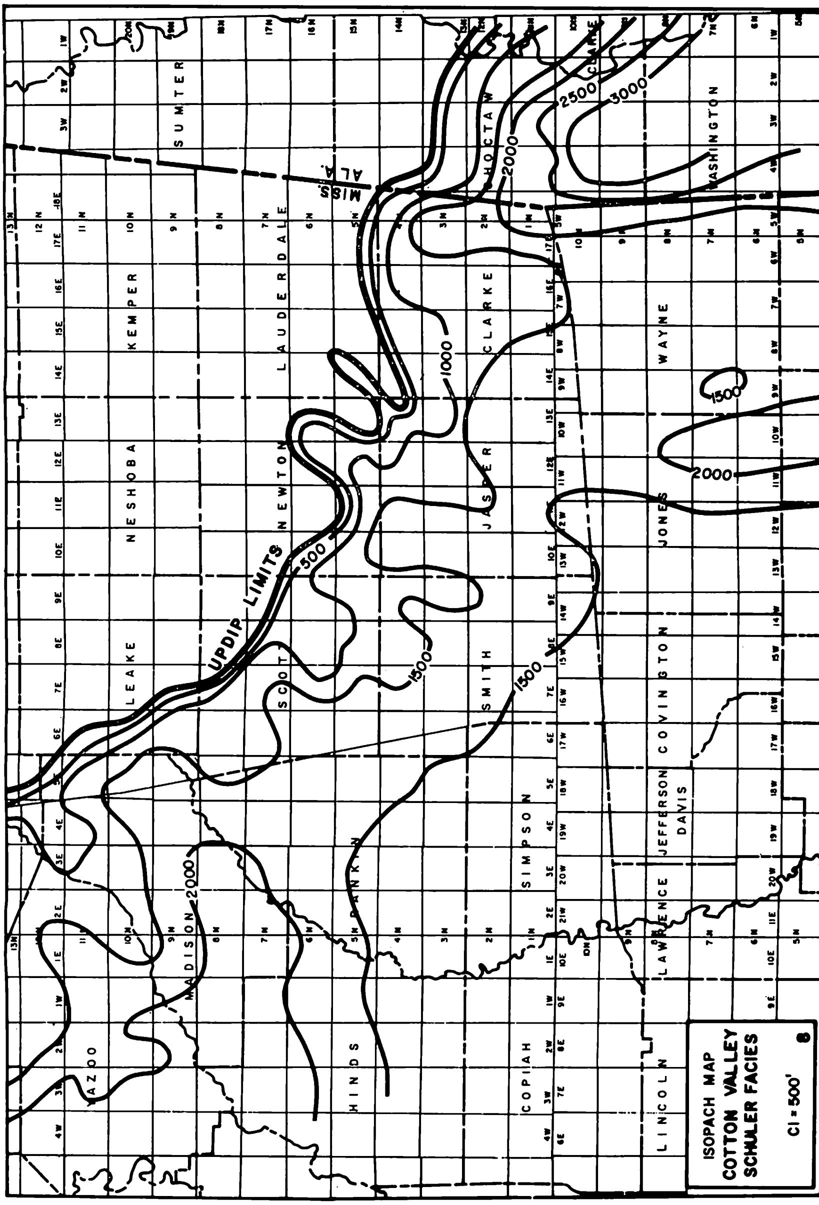
The Middle and Lower Smackover can be characterized as a dense carbonate, deposited on a neritic shelf in restricted seas. Although the distribution of dolomite was quite extensive, no pattern was noted to relate it to structural activity. Consequently, it is assumed that most of the dolomites in this section are primary or depositional dolomites.

The top of the Middle Smackover is locally called the "Brown Dense" limestone. Over a large portion of the area of interest this is an apt description. The limestone is dark brown to dark grey, dense to finely crystalline, locally dolomitic, anhydritic, and non-porous. Normally, this section grades downward into a dark grey to black, dense, argillaceous, thinly laminated, pyritic limestone.

In central Jasper County and again in Rankin County this relationship is broken by a littoral facies of sand and conglomerate. Lithofacies data in Figure 3 clearly indicate the area of sand occurrence. The distribution pattern for this sand appears to emerge from the updip limits of the Smackover and follow a southerly course through central Jasper County, then turn east into Clarke County.

The Shell Oil Company No. 1 McNeill (well 14) represents a type log for the sand facies of the Middle and Lower Smackover. The section is described as a sub-angular and sub-rounded, fine to medium grained, porous sand with inclusions of conglomerate. The poor sorting characterizing this sediment indicates a distributary origin. However, until sufficient control is available to relate this area to the sand deposits found in the Lion No. 2 Denkman (well 9) and the Tidewater No. 1 Gooch (well 10) of Rankin County, it will be difficult to interpret the source and environmental factors affecting this facies.

The line showing the eastern limits of the Middle and Lower Smackover is interpretive and admittedly conjectural. However, the thin limestone from 12950 to 13079 feet in the Danciger No. 1 York (well 18 and Cross section A′-A″) more closely resembles the sediments of the Upper Smackover in correlatable wells. The possibility remains, that the sand, immediately below this limestone, which has been previously assigned to the Norphlet, may actually represent a littoral facies of the Middle and


ISOPACH MAP
COTTON VALLEY
SCHULER FACIES
CI = 500'
8
UPDIP LIMITS
MISS.
ALA.
SUMTER
CHOCTAW
CLARKE
WASHINGTON
KEMPER
LAUDERDALE
NESHOBA
NEWTON
JASPER
WAYNE
LEAKE
SCOTT
SMITH
JONES
COVINGTON
JEFFERSON DAVIS
SIMPSON
RANKIN
MADISON
YAZOO
HINDS
COPIAH
LAWRENCE
LINCOLN
500
1000
1500
2000
2500
3000

Lower Smackover. If this proves true then the present interpretation would need drastic revision.

UPPER SMACKOVER

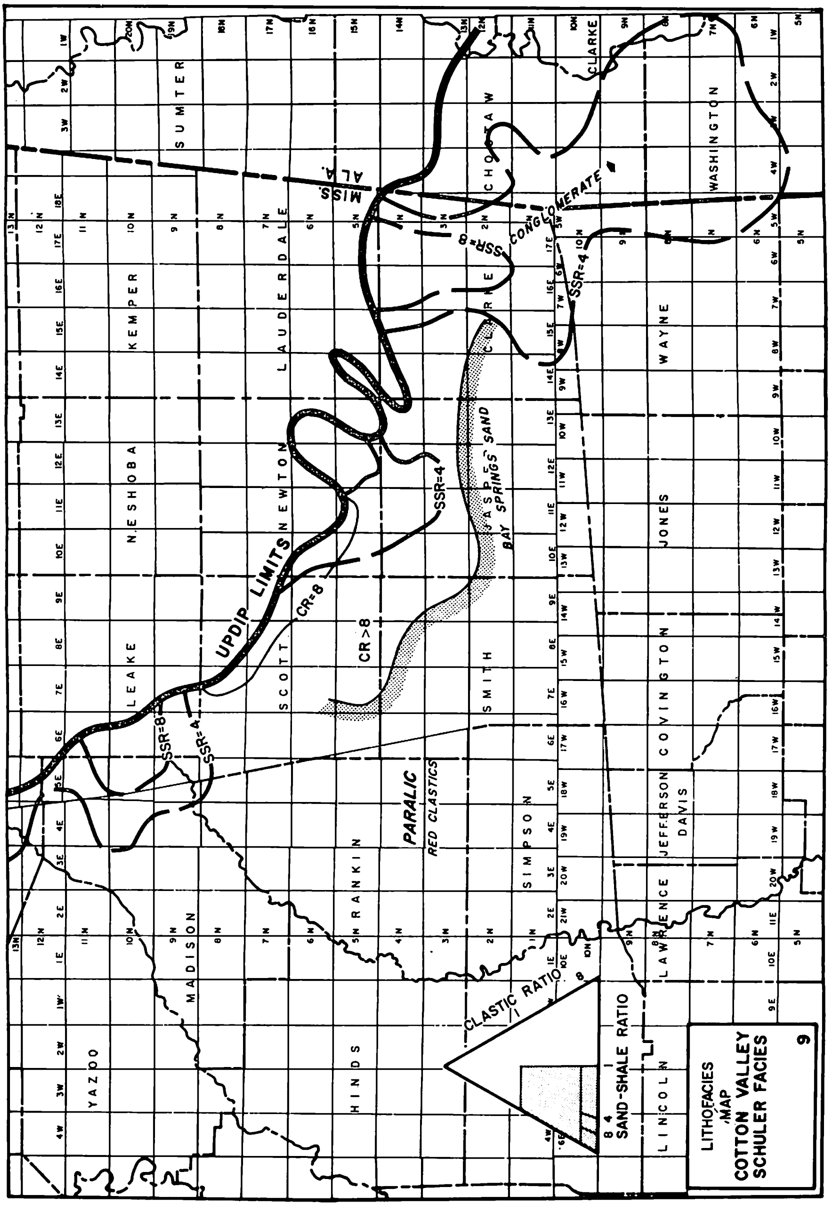
The lithology of the Upper Smackover is somewhat more inconsistent than that of the Middle and Lower Smackover. It varies from oolitic to dense and dolomitic limestone, to sand within the study area. Locally, the limestone facies of the Upper Smackover is topped by a thin fine-grained sand and in one well, the Continental Oil Company No. 1 Ella Fruedenberg (well 3), igneous material was reported in this section.

Figures 4 and 5 are isopachous and lithofacies interpretations of the Upper Smackover. They depict a deposit of rather uniform thickness with a contrastingly variable lithologic content. From its updip limits, the Upper Smackover thickens rapidly to approximately 300 feet. Seldom however, does its thickness exceed 400 feet. This seems to indicate a shallow, slowly subsiding basin during this depositional period.

A thin isopachous anomaly trends southwesterly through Jasper and Smith Counties. The Haynesville isopach is also thin through this area and the basal Buckner anhydrite is absent. These data seem to indicate that this was a period of rejuvenation for the Paleozoic Fold Belt.

The stippled pattern on the isopach map (Figure 4) defines the basinward limits of the thin sand which occurs at the top of the Upper Smackover. The limits of this sand are apparently correlatable to the isopachous contours of the Upper Smackover and to the absence of Buckner anhydrite in the Haynesville (Cross section A-A′). Possibly, this sand represents a regressive shoreline at the conclusion of Smackover deposition.

A second anomalous area is found along the west line of Wayne County. Its western boundary is correlatable to the Phillips Fault System, shown in Figure 1, and with the occurrence of oolites in the Upper Smackover lithofacies interpretation. In the oolitic area of Wayne and Clarke counties, the Upper Smackover is a grey, porous, fossiliferous, oolitic limestone. The pore space surrounding the oolites is partially filled with crystalline calcite and on recognized structures the oolitic section is often found to have been dolomitized. Random void


MISS.
ALA.
UPDIP LIMITS
CONGLOMERATE
SSR=8
SSR=4
CR=8
CR>8
BAY SPRINGS SAND
PARALIC
RED CLASTICS
CLASTIC RATIO
SAND-SHALE RATIO
SUMTER
CHOCTAW
CLARKE
WASHINGTON
KEMPER
LAUDERDALE
NESHOBA
NEWTON
JASPER
WAYNE
JONES
LEAKE
SCOTT
SMITH
COVINGTON
JEFFERSON DAVIS
SIMPSON
RANKIN
MADISON
YAZOO
HINDS
LAWRENCE
LINCOLN
LITHOFACIES MAP
COTTON VALLEY
SCHULER FACIES
9

spaces formed by fractures or solution have also been noted. A core from one well in Quitman Field revealed a fossilized 1 X 2 inch wood fragment as well as a small pelecypod cast.

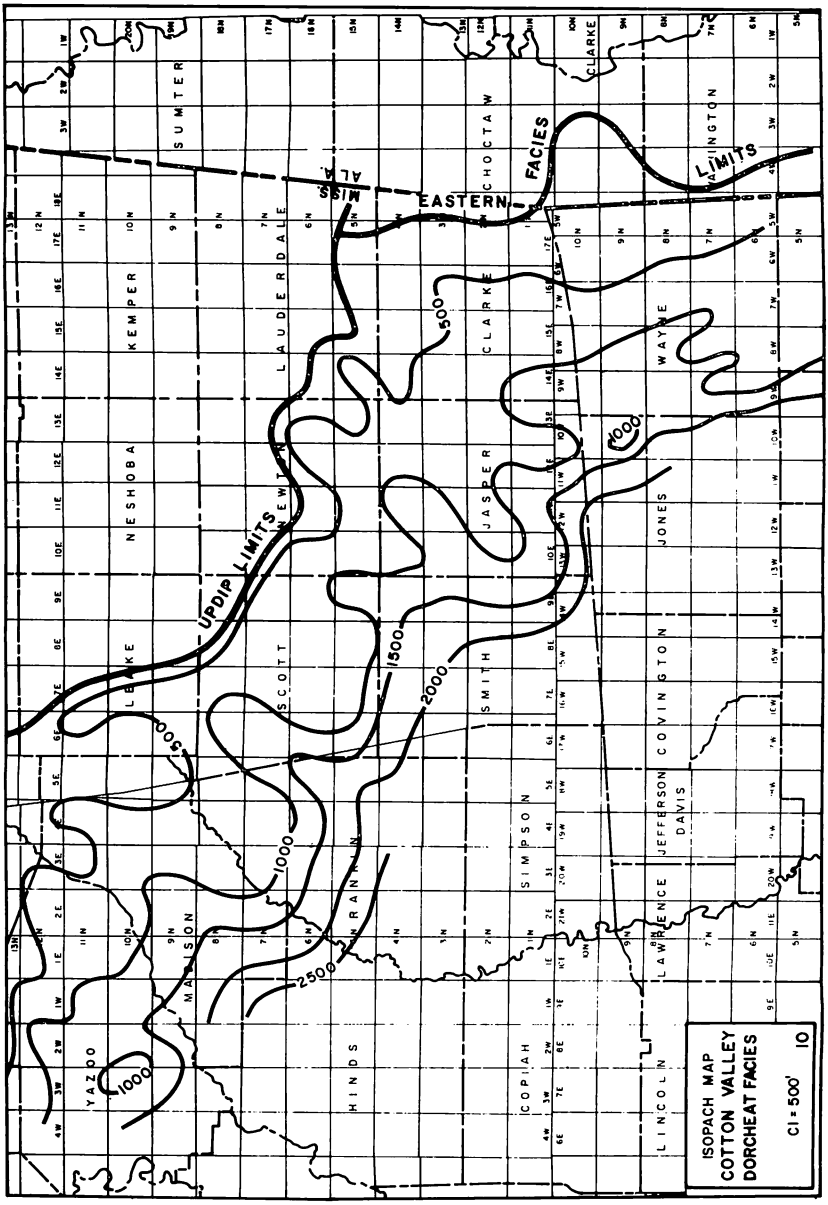
The environment of deposition for the oolite facies is interpreted to be a neritic shelf, possibly a tidal flat. The shallow waters and high energy are believed to result from the subsea platform formed by movement along the Phillips Fault System.

It is within the area of this subsea platform where, to date, all occurrences of structural growth contemporaneous with Jurassic deposition have been found. These structures, as typified by Pool Creek Field, have a thin Dorcheat Cotton Valley facies resting directly on a non-eroded Smackover section. It is believed that salt uplift maintained these structures in a position which allowed neither erosion nor deposition from the end of Smackover time until near the finish of Cotton Valley deposition.

The sand facies of the Upper Smackover is generally delineated by the dotted pattern on Figure 5 indicating a littoral environment. The sand is characterized by the section found in the Carter Oil Company No. 1 Board of Supervisors (well 4). It consists of a greenish grey, fine to coarse grained, porous, poorly sorted, sub-angular and sub-rounded sandstone with some of the coarser grains having a pink, red or black coloration. Near its lateral extremities the sand is laminated with dolomite or limestone and is less porous. Thickness of the Upper Smackover and facies sometimes exceeds 300 feet. Loring Field, the first Smackover production found in Mississippi, produces from this sand. It should be noted that the source of these sediments does not appear to lie to the east, but rather to the northwest, parallel to what is assumed to be the coastline. Because of the character of this sand and the apparent direction of source area, it is assumed that these clastics came from volcanoes associated with the Cary and Midnight Domes.

The problem of determining the direction to the source area occurs again in the Haynesville and Dorcheat lithofacies interpretations. In each case, the area of maximum sand deposition has its locus six to twenty miles basinward from the faulted updip limits of the sediments involved.

It is possible that an ancestral Mississippi River carried sediments to the sea which were then distributed by longshore


ISOPACH MAP
COTTON VALLEY
DORCHEAT FACIES
CI = 500'
10
UPDIP LIMITS
EASTERN FACIES LIMITS
MISS.
ALA.
SUMTER
CHOCTAW
CLARKE
KEMPER
LAUDERDALE
NESHOBA
NEWTON
JASPER
WAYNE
JONES
LEAKE
SCOTT
SMITH
COVINGTON
JEFFERSON DAVIS
SIMPSON
RANKIN
MADISON
YAZOO
HINDS
COPIAH
LAWRENCE
LINCOLN
500
1000
1500
2000
2500

currents. It is also possible that movement along the Phillip's Fault System resulted in the presence of a topographically low area immediately in front of the fault scarp. In the presence of shallow seas, this would necessitate a high energy area or beach zone, at some location, basinward from and parallel to the fault scarp. Since the Phillips Fault System evidenced movement during the Upper Smackover, Haynesville and Dorcheat, this interpretation seems valid.

The low energy neritic shelf deposits, which comprise the remainder of the Upper Smackover, generally lack the porosity found in the oolitic and sand facies. They consist of tan to grey, dense to finely crystalline limestone and dolomite. The porosity zones are thin and occur in an apparently unpredictable fashion in the section. Much of the dolomitization is concentrated in south central Scott County where the Clastic Ratio is less than 1/8. South of this area of dolomite the Upper Smackover limestone assumes a sandy texture and porosity thicknesses increase.

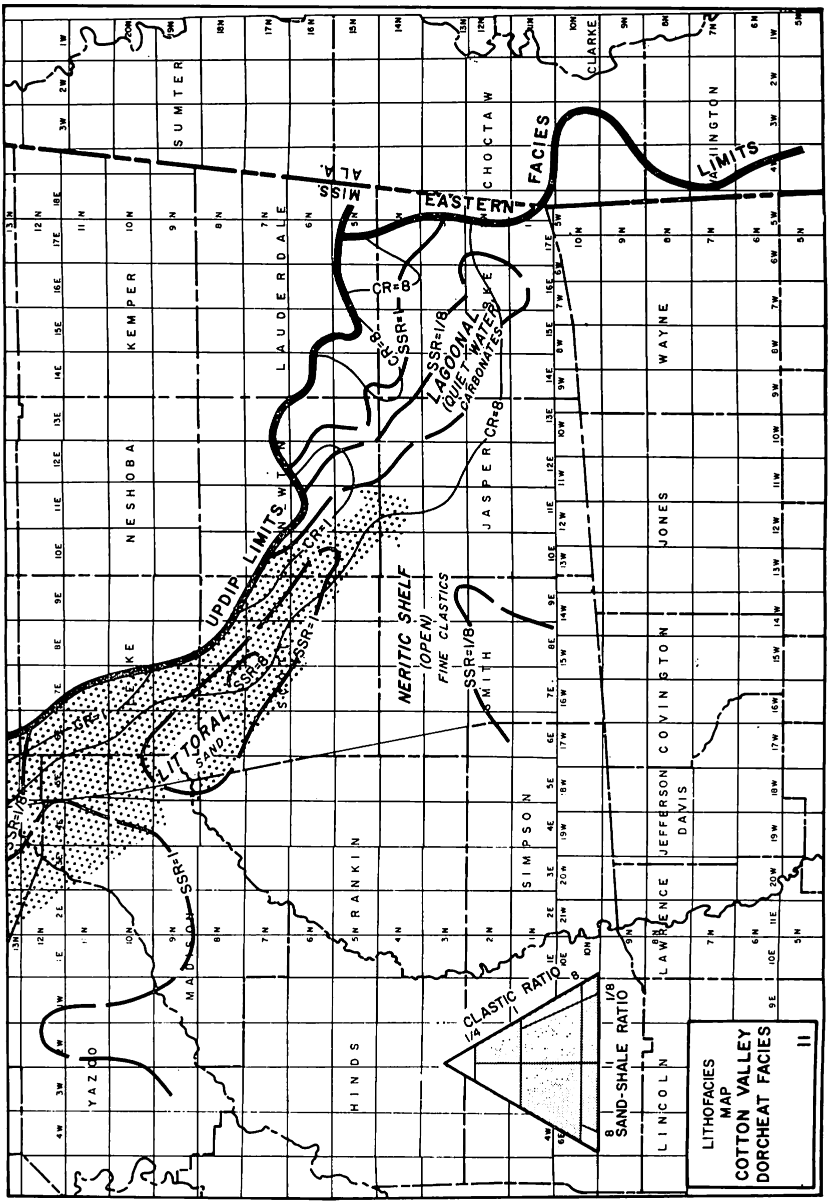
HAYNESVILLE

Previous investigations have referred to the sediments lying between the base of the Cotton Valley and the top of the Smackover as the Buckner or the Haynesville. Confusion has been added by assigning member status to one or the other of these names or by introducing new names such as the Ivy Formation.

The Buckner was originally defined by Weeks (1938, p. 966) to consist of a lower bedded anhydrite, a middle red shale containing inclusions of pink finely crystalline anhydrite, and an upper red shale with thin sandy layers. Today, the word Buckner is still synonomous with anhydrite and red beds.

Unfortunately, the described interval covers a far greater variety of lithologies than can be found in the original definition. In agreement with later authors, notably Forgotson (1954), and McKee, et al (1956), the term Haynesville was used here to avoid the connotation of the word Buckner. At the same time, a basal anhydrite member of the Haynesville is recognized and defined as Buckner.

Figures 6 and 7 illustrate the isopachous and lithofacies relationships of the Haynesville. Included on the isopachous interpretation are data indicating the approximate areal distri-


LITHOFACIES
MAP
COTTON VALLEY
DORCHEAT FACIES
11
CLASTIC RATIO
SAND-SHALE RATIO
UPDIP LIMITS
EASTERN FACIES LIMITS
MISS.
ALA.
LITTORAL
SAND
NERITIC SHELF
(OPEN)
FINE CLASTICS
LAGOONAL
(QUIET WATER)
CARBONATES
SUMTER
CHOCTAW
CLARKE
KEMPER
LAUDERDALE
NESHOBA
JASPER
WAYNE
JONES
SMITH
COVINGTON
JEFFERSON DAVIS
SIMPSON
RANKIN
MADISON
YAZOO
HINDS
LINCOLN
LAWRENCE

bution of the Buckner member. The Buckner is shown to be present inside the hatchured lines. Shoaling conditions were probably active along the seaward margin of the Buckner.

Lithology and thickness variations in the Haynesville indicate that this was a time of extensive local structural growth and salt movement. In excess of 2000 feet of Haynesville sediments are present in northern Smith County in an area where 1000 feet might be considered a normal thickness. Undoubtedly, this abnormal thickness of Haynesville sediments is located on the downthrown side of a fault which was growing during Haynesville deposition. Additional well control should provide many other areas similar to this.

As in the case of the Upper Smackover isopach, the Wayne County platform is anomalously thin. Apparently, only minor amounts of Haynesville sedimentation occurred on the Wayne County shelf area. Salt uplifts such as Pool Creek, Eucutta and Heidelberg have no Haynesville sediments on their crests.

Another thin area extends southwesterly through Jasper and Smith Counties. This anomaly is correlatable to a similar one on the Upper Smackover isopach. It also coincides with the absence of Buckner anhydrite. This is accepted as further evidence of the influence of the Paleozoic Fold Belt on Jurassic deposition.

The Buckner is a predominantly white anhydrite, usually sandy, with colorations of pink, reddish-brown and grey. It is sometimes intercalated with limestone or dolomite. Thickness of the Buckner ranges from a few tens of feet to more than 200 with the areas of unusually thick deposition being somewhat restricted.

Although control is meager, definite evidence exists that the Buckner anhydrite member has a downdip facies limitation. Areas in Yazoo, Madison, Rankin, Scott and Wayne Counties have what appears to be a downdip facies equivalent. For the most part these sediments consist of dense limestone or shale.

The lithofacies interpretation of the Haynesville is dependent on both environmental and structural factors. The environmental factors consist of a progressive shoreward alteration from restricted shelf to littoral and possibly terrestrial. The

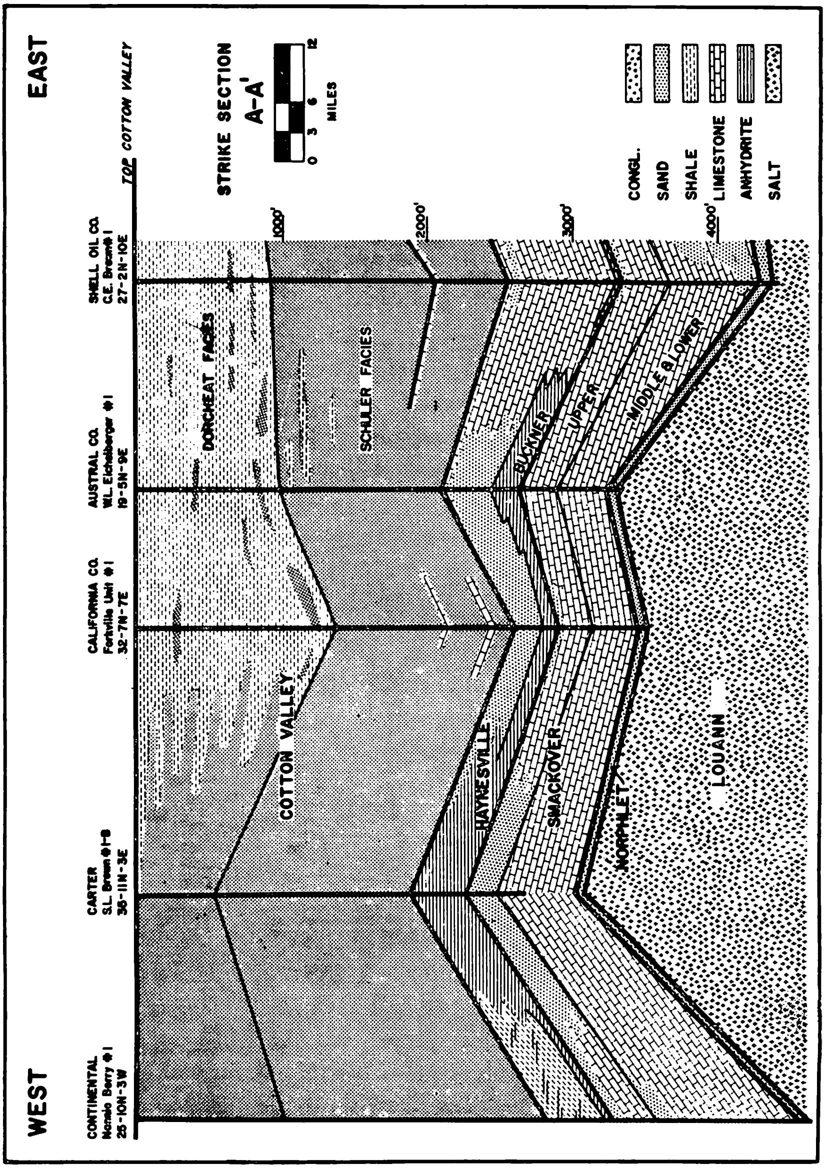

WEST
EAST
STRIKE SECTION
A-A'
0 3 6 12
MILES
TOP COTTON VALLEY
CONTINENTAL
Nanabo Berry #1
25-10N-3W
CARTER
S.L. Brown #1-B
36-11N-3E
CALIFORNIA CO.
Fortville Unit #1
32-7N-7E
AUSTRAL CO.
W.L. Eichelberger #1
19-5N-9E
SHELL OIL CO.
C.E. Brown #1
27-2N-10E
1000'
2000'
3000'
4000'
CONGL.
SAND
SHALE
LIMESTONE
ANHYDRITE
SALT
DORCHEAT FACIES
SCHULER FACIES
COTTON VALLEY
HAYNESVILLE
BUCKNER
UPPER
MIDDLE & LOWER
SMACKOVER
NORPHLET
LOUANN

Figure 12.

structural factors consist of the deposition of additional thicknesses of sediments, usually anhydrite or clastics on the downthrown side of penecontemporaneous faulting.

In the restricted shelf environment, the Haynesville is a light colored, fine grained, often porous limestone or dolomite. The dolomites are sucrosic or sandy while the limestones are usually oolitic or sandy. Anhydrite may be interspersed throughout the section and, with the exception of Buckner anhydrite, its greatest concentration is at or near the top.

Shoreward, this facies becomes argillaceous and grades into a predominantly sandstone lithology. The sand is usually tan to reddish-tan. It is within the littoral environment that the Haynesville reaches its greatest economic potential. High porosities, relatively thick pay zones and shallow objective depths promise that this may be one of the more lucrative Jurassic trends. The Quitman discovery in Clarke County was the first such field in this trend.

Locally, the pattern of restricted shelf to littoral deposition is broken. In Madison and Yazoo counties, the Haynesville consists almost entirely of red shale with some anhydrite and scattered sand inclusions. (Cross section A′-A″). This is also true of the Haynesville in the Soso area where a thick, predominantly evaporitic section exists.

It is believed that the presence of Haynesville age reef or shoal sediments will soon be proven. An unusual limestone buildup at the top of Smackover was noted in the discovery well of West Clara Field. This limestone, more than 100 feet thick, fell in the proper stratigraphic, structural and geologic setting for a reefal deposit. Unfortunately, samples are not yet available on this well.

COTTON VALLEY

Previous workers have attempted to subdivide the Cotton Valley on the basis of age relationships or on numerous environmental factors. One of the better papers is a recent one by Thomas and Mann (1964, p. 143). It presents an evolution of Cotton Valley nomenclature together with a convincing interpretation of relationships found in North Louisiana.

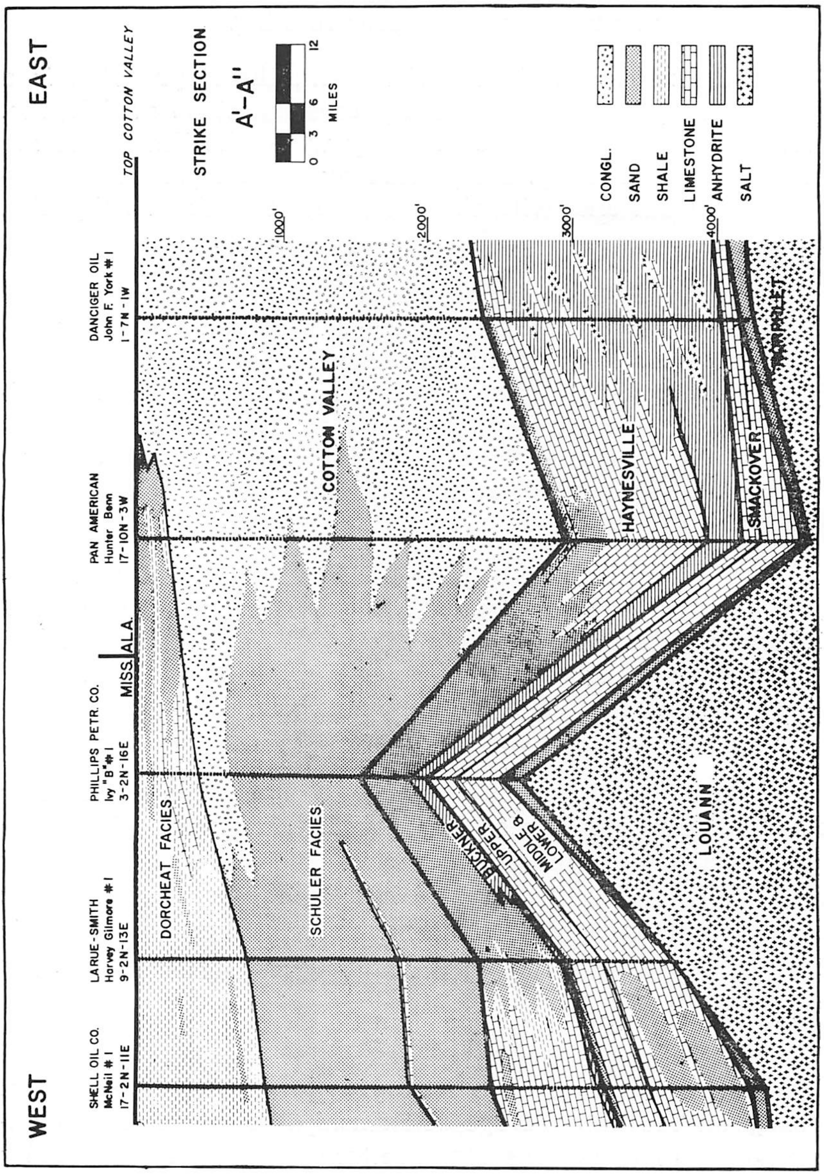

WEST
EAST
SHELL OIL CO.
McNeil # 1
17-2N-11E
LARUE-SMITH
Harvey Gilmore # 1
9-2N-13E
PHILLIPS PETR. CO.
Ivy "B" # 1
3-2N-16E
MISS
ALA.
PAN AMERICAN
Hunter Benn
17-10N-3W
DANCIGER OIL
John F. York # 1
1-7N-1W
TOP COTTON VALLEY
STRIKE SECTION
A'-A''
0 3 6 12
MILES
1000'
2000'
3000'
4000'
CONGL.
SAND
SHALE
LIMESTONE
ANHYDRITE
SALT
DORCHEAT FACIES
SCHULER FACIES
COTTON VALLEY
HAYNESVILLE
BUCKNER
UPPER
MIDDLE & LOWER
SMACKOVER
LOUANN

Figure 13.

The term Schuler was originally used by Shearer (1938, p. 724) while referring to red beds between the Travis Peak and Buckner formations. This usage continued until 1944, when additional well control allowed Swain (p. 579) to subdivide the Schuler formation. He recognized a near-shore facies of pastel, vari-colored shale and sandstone and equivalent offshore fossiliferous grey shale, sandstone and limestone which he called the Dorcheat member. He also defined the Shongaloo member as being a near-shore red shale, sandstone and conglomerate and equivalent offshore fossiliferous grey shale, limestone, sandstone and basal conglomerate.

It seems obvious that these definitions ignore regional facies variations inherent in sedimentation in an attempt to maintain a formation concept. Unfortunately, this does not appear to be possible in the Cotton Valley group in Mississippi. For this reason, the words Schuler and Dorcheat are used here to denote the facies for which they were originally defined.

Within the area of investigation the Cotton Valley is almost entirely made up of clastics. The only consistent line of demarcation falls between the nearshore vari-colored shales and fine grained sandstones and the underlying red beds section of red to maroon shales and reddish coarse grained sandstones. These two facies are hereafter referred to as the Dorcheat facies and the Schuler facies.

SCHULER FACIES

Figures 8 and 9 are isopachous and lithofacies interpretations for the Schuler facies of the Cotton Valley Group. Thickness variations within the Schuler facies develop unusual patterns. In Washington County, Alabama, it is abnormally thick. In Smith and Simpson Counties the facies thins downdip and it is theorized that the southwestern limits of the Schuler facies occur within the limits of this map.

The abnormally thick area in Washington County, Alabama (Cross section A′-A″), is interpreted to result from an influx of coarse clastics and conglomerates from a source area north of Clarke County, Mississippi. This influx is undoubtedly the result of a rejuvenation of the southern Appalachian extension. This is more graphically illustrated by the Sand-Shale Ratio contours on Figure 9.

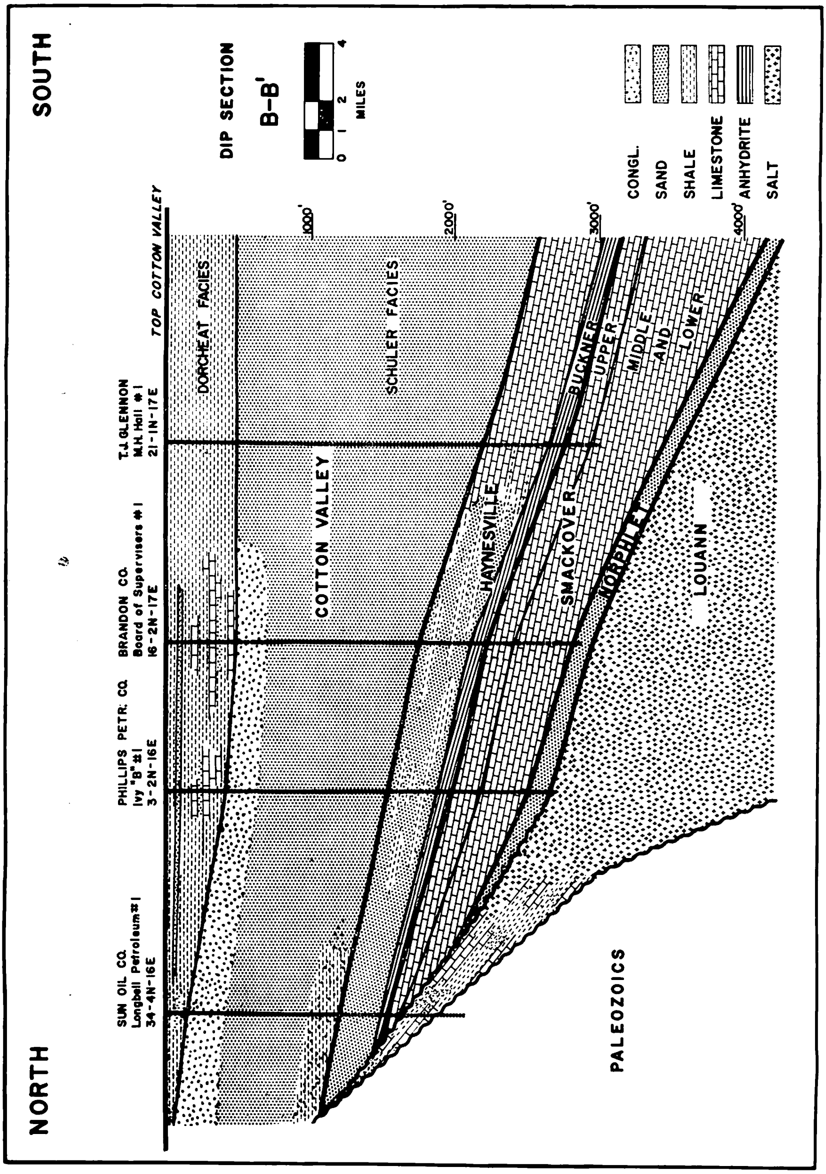

NORTH
SOUTH
DIP SECTION
B–B'
0 1 2 4
MILES
CONGL.
SAND
SHALE
LIMESTONE
ANHYDRITE
SALT
SUN OIL CO.
Longbell Petroleum #1
34-4N-16E
PHILLIPS PETR. CO.
Ivy "B" #1
3-2N-16E
BRANDON CO.
Board of Supervisors #1
16-2N-17E
T.J. GLENNON
M.H. Hall #1
21-1N-17E
TOP COTTON VALLEY
1000'
2000'
3000'
4000'
DORCHEAT FACIES
SCHULER FACIES
COTTON VALLEY
HAYNESVILLE
BUCKNER
UPPER
MIDDLE
AND
LOWER
SMACKOVER
NORPHLET
LOUANN
PALEOZOICS

Figure 14.

Isopachous contouring on Figure 8 also indicates certain structurally influenced abnormalities in Jasper and Wayne Counties. These are again the result of influences from the Paleozoic Fold Belt and platform area of Wayne County.

The lithofacies triangle is dominated by sand sized clastics. Carbonates are almost non-existent in this interval and seldom does shale exceed 30% of the total thickness. Conglomerates increase noticeably shoreward and to the east. The shales are red, and dark red to maroon while the sands are white to red, medium grained to conglomeritic and angular. The red coloration probably indicates an arid climate.

Also shown on the lithofacies interpretation is a stippled pattern indicating the presently mapped updip limits of the Bay Springs sand. This sand is light colored, medium grained, and porous, with many of the individual grains having a frosted appearance. It is capped by a light grey, pseudo-oolitic limestone which has a maximum thickness of 30 feet. The Bay Springs sand itself, attains a thickness of some 600 feet.

Updip the limestone caprock disappears and the Bay Springs sand intercalates with the typical Schuler red beds facies. Downdip, in the Soso area, the Bay Springs interval becomes argillaceous and nonporous. The Bay Springs sand is believed to represent either an early strand line of the Schuler or a channel fill deposit of reworked sediments. From an economic standpoint, it is important to emphasize that a mappable trend does exist and that it does have downdip, as well as updip limits.

Paralic is a term first used by Schuchert in 1928 to describe an inorganic and organic depositional record formed by oscillations of land and shallow sea conditions. This avoids use of the word terrestrial, which implies deposition of sediments entirely on land. A paralic environment is interpreted for the Schuler facies. This would require a nearby source area together with a period of rejuvenation of the land surface. The sediments were laid down in an oxidizing environment as the seas continued their basinward regression.

DORCHEAT FACIES

Figures 10 and 11 are isopachous and lithofacies interpretations for the Dorcheat facies of the Cotton Valley. The Dorcheat

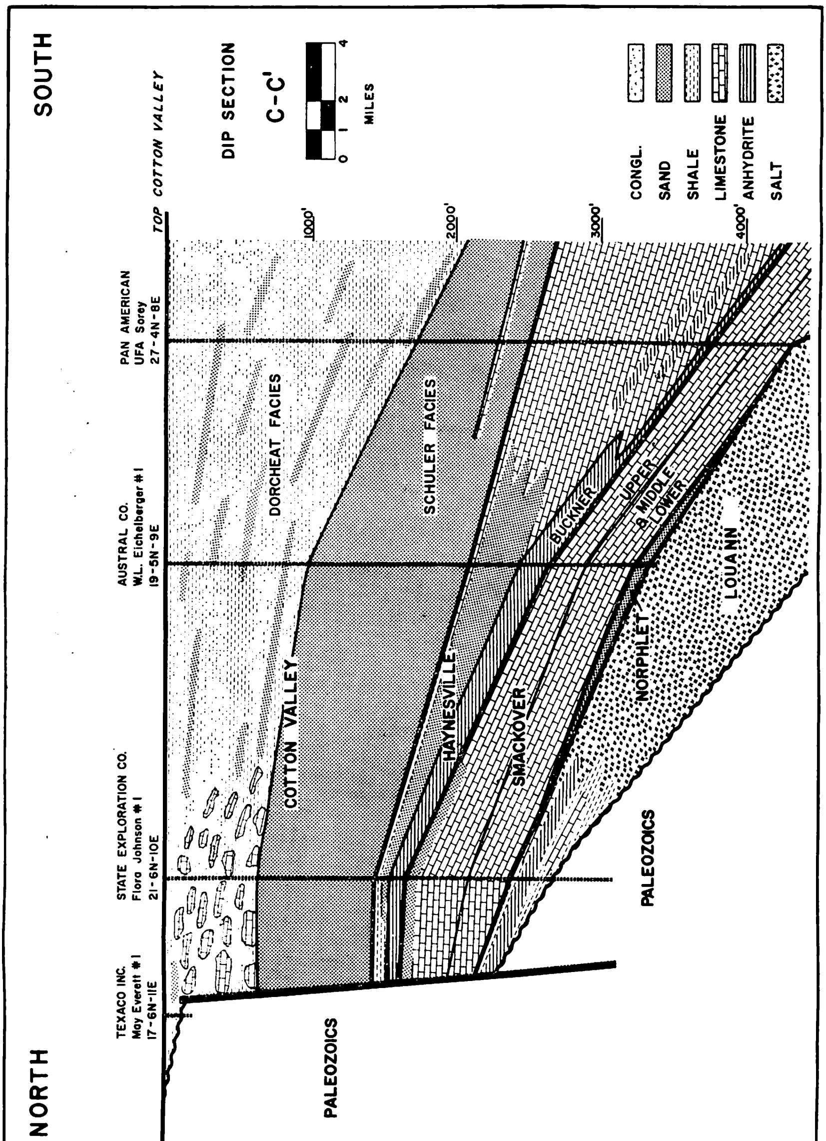

SOUTH
NORTH
DIP SECTION
C-C'
0 1 2 4
MILES
CONGL.
SAND
SHALE
LIMESTONE
ANHYDRITE
SALT
TOP COTTON VALLEY
1000'
2000'
3000'
4000'
PAN AMERICAN
UFA Sorey
27-4N-8E
AUSTRAL CO.
W.L. Eichelberger #1
19-5N-9E
STATE EXPLORATION CO.
Flora Johnson #1
21-6N-10E
TEXACO INC.
May Everett #1
17-6N-11E
DORCHEAT FACIES
SCHULER FACIES
COTTON VALLEY
HAYNESVILLE
SMACKOVER
BUCKNER
UPPER
& MIDDLE
LOWER
NORPHLET
LOUANN
PALEOZOICS
PALEOZOICS

Figure 15.

facies marks the final depositional record of Jurassic sediments. In a major portion of the area, the updip limits of the Dorcheat facies are also the updip limits of the Cotton Valley. It is known to overlap other Jurassic sediments and rest unconformably on the Paleozoic unconformity. However, to the east along the Mississippi - Alabama line the Dorcheat thins and gradually fingers out into red beds and conglomerate of the Schuler facies (Cross section A′-A″).

The Dorcheat of North Louisiana, as described by Swain in 1944, is a nearshore pastel, vari-colored shale and sandstone. This is typical of the Upper Cotton Valley section of Mississippi. The shales, which are predominant, consist of purple, green, ochre and light colors while the sands are also light colored and are usually fine grained. Porosity in the sandstones decreases noticeably downdip. Siderite concretions, commonly found at the top of the Dorcheat, are indicative of the unconformity between the Cotton Valley and Hosston.

In a restricted area through Jasper and Clarke Counties, the Dorcheat becomes quite calcareous and shale size particles are predominant. Although limestones found in this area are thin, they are correlatable for considerable distances and their presence indicates a departure from the typical environmental pattern of the Dorcheat. These fine grained clastics and carbonates are interpreted to represent a lagoonal, quiet water environment which occurred shoreward from the littoral environment of the Dorcheat facies.

The Dorcheat thickens gradually to approximately 1000 feet, at which point the rate of thickening increases noticeably. This rate change coincides with a comparable thinning in the Schuler facies and could possibly continue until the entire Cotton Valley sequence is occupied by Dorcheat facies. Anomalous areas are again present in Jasper and Wayne Counties indicating continued structural influence exerted upon the depositional record in these two areas. However, by the end of Cotton Valley time, sediments had effectively covered all existing Jurassic structures and the surface was essentially monoclinal.

The Dorcheat environment of deposition was that of an open neritic shelf in a humid climate. Seas were transgressive and were not restricted. The supply of coarse clastics from the nearby source area has abated and the Dorcheat sands are for the most part fine grained.

The littoral environment, which is indicated by the dotted pattern, begins some 20 to 25 miles in front of the Phillips fault scarp. Sand percentages in this environment increase considerably and porosities also apparently improve. The Sand-Shale Ratio contours clearly indicate the presence of the littoral zone and it is believed that within this environment some of the better Cotton Valley production will be found. It should be emphasized, however, that sands of the entire Dorcheat interval provide excellent objectives and that the only presently recognized restriction is the apparent downdip loss of porosity.

Another unusual facet of the Dorcheat facies is the presence of a limestone conglomerate in random areas along the downthrown side of the Phillips Fault System (Cross section C-C′). This conglomerate consists of vari-colored limestone pebbles in a matrix of light colored, dense limestone and fine grained, nonporous sandstone. An example of this conglomerate is found in the Carter Oil Company No. 1 Denkman (well 7) in Leake County. Source of the limestone pebbles is believed to be Paleozoic strata on the upthrown side of the fault. Presence of this conglomerate indicates that the fault scarp was present and that it was positioned above wave base, if not above sea level, during Dorcheat deposition.

CROSS SECTIONS

The location of cross sections A-A′, A′-A″, B-B′ and C-C′ are shown on Figure 1. Cross sections A-A′ and A′-A″ are strike sections, while B-B′ and C-C′ are dip sections. Although these cross sections have been referred to many times in the text, their significance is not always obvious. For this reason the specific purposes for which each was built is described in the following paragraphs.

CROSS SECTION A-A′

Cross section A-A′ is the western half of a strike section which extends from the Continental No. 1 Nanny Berry in Yazoo County through cross section A′-A″ to the Danciger Oil No. 1 John F. York in Washington County, Alabama. It was designed to show:

1. A sand influx from the northwest in the Dorcheat facies, possibly indicative of an ancestral Mississippi River source area in that direction.
2. The limited areal extent of the Bay Springs zone.
3. The variable depositional record of the Haynesville, including the area of predominant shale deposition in Madison and Yazoo Counties.
4. Areas of unusually thick Buckner anhydrite as well as areas where little or no Buckner is present.
5. The sand facies of the Upper Smackover.
6. Local areas where a thin sand is present at the top of the Smackover.
7. Sand facies of the Middle and Lower Smackover.

CROSS SECTION A′-A″

Cross section A′-A″ is a continuation of the preceding A-A′ section. It was designed to show:

1. The limited areal extent of limestones in the Dorcheat facies.
2. The eastern limits of the Dorcheat facies.
3. The influx of conglomerates from the north and east in the Schuler facies.
4. The limited areal extent of the Bay Springs zone.
5. The variable depositional record of the Haynesville including predominance of evaporites and unusual occurrence of halite in the area of the Danciger Oil No. 1 York.
6. The sand facies of the Middle and Lower Smackover.
7. The eastern limits of the Middle and Lower Smackover.

CROSS SECTION B-B′

Cross sections B-B′ and C-C′ are both dip sections which illustrate the two principal methods by which Jurassic sediments reach their updip terminus. Cross section B-B′ shows the progressive overlap of the Louann by the Norphlet, Smackover, Haynesville, and Cotton Valley. The term overlap is used to avoid any specific reference to depositional cycles since insufficient data are available to determine true interrelationships of these sediments near the updip margin. It should be noted, that at some point the updip terminus of the Louann is also reached and at that point Jurassic sediments overlap Paleozoic rocks with ages from Pennsylvanian to Ordovician. Cross section B-B′ also shows:

1. The position and areal extent of limestones in the Dorcheat facies.
2. The influx of conglomerate from the north in the Schuler facies.
3. The gradational facies variation from limestone to sand in the Haynesville.
4. The overlap and truncation of Jurassic sediments onto the Paleozoic surface.

CROSS SECTION C-C′

Cross section C-C′ allustrates the abrupt termination of all Jurassic sediments except the Dorcheat facies of the Cotton Valley against downthrown side of the Phillips Fault System. It also shows:

1. The limestone and shale conglomerate of the Dorcheat facies which is a product of the previously mentioned fault scarp.
2. The seaward thickening of the Dorcheat facies at expense of the Schuler facies.
3. The limited areal extent of the Bay Springs zone.
4. The variable depositional record of the Haynesville.
5. Local areas where a thin sand is present at the top of the Smackover.

Sediments underlying the Smackover in the State Exploration No. 1 Flora Johnson on this cross section are unusual and especially interesting. If the anhydrite shown to underlie the Smackover were interpreted to represent the Werner formation then underlying shales and carbonates could be Eagle Mills. Assuming this, the concept of an updip or shoreward facies of Louann salt as shown on this cross section would need drastic revision.

GEOLOGIC HISTORY

Seismic data indicates the Paleozoic surface underlying the Mississippi Salt Basin to be essentially monoclinal. It dips southwesterly towards the center of the basin at approximately 150 feet per mile. This peneplaned surface is known to have been disrupted in the area of the Phillips Fault System and Paleozoic Fold Belt. Inasmuch as Triassic age Eagle Mills red-beds rest on truncated Pennsylvanian or older formations, it is assumed that this hiatus represents the time required for the Appalachian orogeny. Accepting the age relationships of Bishop (1967, p. 245), it is also assumed that a hiatus exists between the Eagle Mills and the Werner anhydrite.

As the Early Jurassic seas overlapped the Eagle Mills a barrier formed somewhere south of the study areas, preventing normal circulation of the seas. The resulting evaporitic conditions caused the precipitation of the Werner anhydrite and then great thicknesses of Louann salt.

Beginning with the Norphlet, the Jurassic depositional record witnessed the change of the Mississippi Salt Basin from a flat, formless topography to a rugged seascape with fault scarps, individual domes and extensive anticlinal ridges. Structural activity, which was relatively minor during early stages of deposition, rose steadily until the end of the Jurassic period. This resulted in an ever increasing supply of clastics.

The first depositional record of Upper Jurassic seas is the Norphlet sandstone. Dissolution of salt by these waters almost predetermines the reddish coloration and absence of fossils in the Norphlet. Lower Smackover seas were also highly saline and darker sedimentary colorations favor a more humid climate. The increase in the quantity of fossils found in Middle Smackover sediments indicates a decreasing salinity of the water.

Middle and Lower Smackover isopachs indicate a time of rapid basin subsidence. As Smackover seas overlapped the Louann salt they encountered the more rugged topography of the Paleozoic Fold Belt and Phillips Fault System. Here the depositional record became complicated as Paleozoic topography was gradually obliterated.

Smackover seas were warm, and for the most part, shallow. Adjoining land areas apparently had little structural relief. Towards the end of Upper Smackover sedimentation the seas began a regression which continued, with minor interuptions, through the end of Jurassic deposition. During Upper Smackover time, the first evidence of widespread structural influence is noted. The platform area of Wayne County as well as many local areas presently defined as salt structures must have received uplift during this period. This uplift was primarily the result of structural movement in Paleozoic sediments beneath the salt.

Although the Smackover is primarily a carbonate, there are significant amounts of clastic material throughout the section. These clastics had only local distribution and were characterized by poorly sorted, angular sandstones with associated heavy minerals. It is believed that these distributary sediments found their origin in the erosion of Triassic age igneous material from the north and northwest of the study area.

As the seas continued their regression the climate also became more arid and the resulting evaporitic conditions resulted in deposition of the Buckner anhydrite. The areal extent of the Buckner is restricted and only in local areas does the Haynesville become highly evaporitic. Nevertheless, the Haynesville seas, like those of the Smackover, were restricted and evaporitic relationships are strongly evidenced in the entire section.

Structural uplift, which began during Smackover deposition, continued and became intense throughout the Haynesville. Local structures were unusually active and the possibility of actual salt movement, as a positive force, beneath these structures becomes more comprehensible.

The continued regression of seas during deposition of the Cotton Valley was abetted by the apparently abrupt rejuvenation and uplift of land areas adjoining the basin. Evidence for this is found in the sudden influx of coarse clastics from the land area. The coarse grained clastics of the nearshore Schuler facies grading seaward into the fine grained clastics of the Dorcheat facies correlates clearly with the relationships found in North

Louisiana. The interface of the two facies progressed landward as the supply of clastics diminished.

By the close of Cotton Valley deposition, the rate of sedimentation had overcome nearly all local structures and seafloor topography was relatively flat. Cotton Valley sediments had even buried the Phillips Fault System and overlapped most of the Paleozoic Fold Belt.

FINIS

A section of summaries and conclusion would be inappropriate for this paper because much of this presentation consisted of conclusions drawn from this study and there is no desire to be repetitious. Furthermore, it is acknowledged that the hours of work and effort expended on this project are themselves only a prelude or summary of what will be required to digest and interpret the bulk of information which will be available in the coming years.

Instead, one final scrap of information will be submitted and its significance questioned. Well 19 on Figure 1A is the Pan American Petroleum Corporation No. 1 James B. Hill in Sumpter County, Alabama. At a depth of 2436 to 2531 feet the following sample log description is given: limestone; white, chalky and sandy, grading downwards into a white and light tan, dense limestone with scattered solution cavities. The overlying sediments have been identified as Lower Tuscaloosa sands and shales. The underlying formation is Pennsylvanian shale.

Between the Lower Tuscaloosa and the Pennsylvanian, only the Jurassic could have a limestone facies this far updip; yet the Jurassic pinchout supposedly occurs many miles to the south. Could this be Smackover? Did the Jurassic seas actually reach this far north? Was there a separate Jurassic embayment on the north side of the Middle Mississippi Ridge?

These and a myriad of other unanswered questions await the geologist. For Mississippi, the end has come to an era when a geologist could rely wholly on the structural contour. The role of stratigraphic interpretation will become increasingly important in the search for Jurassic production.

System	Series	Group	FORMATION	LITHOLOGY
Jurassic	Upper	Cotton Valley	Schuler	Dorcheat member - Vari-colored mudstones, some with inclusions of siderite concretions. Light-red to dark-red, maroon and purple shales. Red and white predominantly very fine- and fine-grained sandstones with a few zones of "coarser" conglomeritic sandstones. Vari-colored thin-bedded limestones and nodular limestones in restricted areas. Shongaloo member - Sequence of white, red and pink fine- to coarse-grained rarely lignitic occasionally calcareous commonly conglomeritic sandstones, some dark-red, maroon and purple silty micaceous occasionally sandy shales, minor amounts of vari-colored mudstone and a few thin streaks of lignite. Pink Sandstone facies - A distinctive pink sandstone facies characterized by a pink and red fine-to coarse grained commonly conglomeritic sandstones and generally subordinate amounts of white sandstone and minor amounts of shale and mudstone.
		Louark	Haynesville-Buckner	Buckner facies - An upper sequence of dark-red and maroon silty finely micaceous often anhydritic shales with subordinate amounts of red and white very fine- and fine-grained often anhydritic sandstones and siltstones. A lower or basal sequence of anhydrite with subordinate amounts of white very fine- and fine-grained anhydritic sandstones, siltstones, black shales, limestones and dolomitic carbonates. Haynesville facies - A variable lithologic sequence of pale-gray to gray and tan dense to chalky sandy pseudo-oolitic and oolitic limestones, dolomitic carbonates, red and black shales, red and white very fine- to medium-grained sandstones and varying amounts of disseminated and interbedded anhydrite which grade basinward into dark dense sublithographic to lithographic carbonates with minor amounts of disseminated and interbedded anhydrite.
			Smackover	Upper Smackover - White fine- to coarse-grained sandstones and dolomitic and calcareous sandstones. Rare oolitic sandstones and traces of secondary anhydrite. Pale-gray, light-gray, dark grayish-brown, dark-gray, white and tan dense to very finely crystalline and chalky limestones. Sandy oolitic fossiliferous pisolitic porous to non-porous limestones. Porous to non-porous lime-cemented oolites. Pale-gray to brown very fine to finely crystalline porous to non-porous dolomites and dolomitic carbonates, generally with minor amounts of secondary anhydrite. Lower Smackover (Brown Dense Limestone Unit) - Upper sequence of light-brown, brown and dark-brown and dark-gray dense sublithographic and lithographic limestones with minor amounts of black silty micaceous shale. Local development of dolomitic carbonates with secondary anhydrite and sandy zones. Lower sequence of very fine- to coarse-grained sandstones with occasional inclusions of "coarser" sand grains or small quartz pebbles.
			Norphlet	Bright to dark-red silty, finely micaceous commonly sandy shales. Red and pink very fine-to medium-grained sandstones and siltstones with scattered inclusions of "coarser" grains and small quartz pebbles. Subordinate amounts of white very fine- to medium-grained sandstones and siltstones. Minor amounts of finely disseminated anhydrite and detrital anhydrite. Conglomeritic with local "rubble zones" in updip areas.
	Middle	Louann	Louann	White massive crystalline halite with minor amounts of disseminated anhydrite.
	Lower		Werner	An upper sequence of anhydrite with minor amounts of intercalated black shale and fine-grained anhydritic sandstone. A lower conglomeritic sequence generally consisting of vari-colored chert chips and red clastics.
Triassic	Upper?		Eagle Mills	Varying red and purple shades of shale. Red, purple, green and pale-gray mudstones, some with inclusions of small siderite concretions. Red, pink and white very fine and very fine- to fine-grained sandstone. Minor amounts of light-gray siltstone. Zones of coarse clastics. Red and pink argillaceous limestones in restricted areas.

Stratigraphic column applicable to this study area.

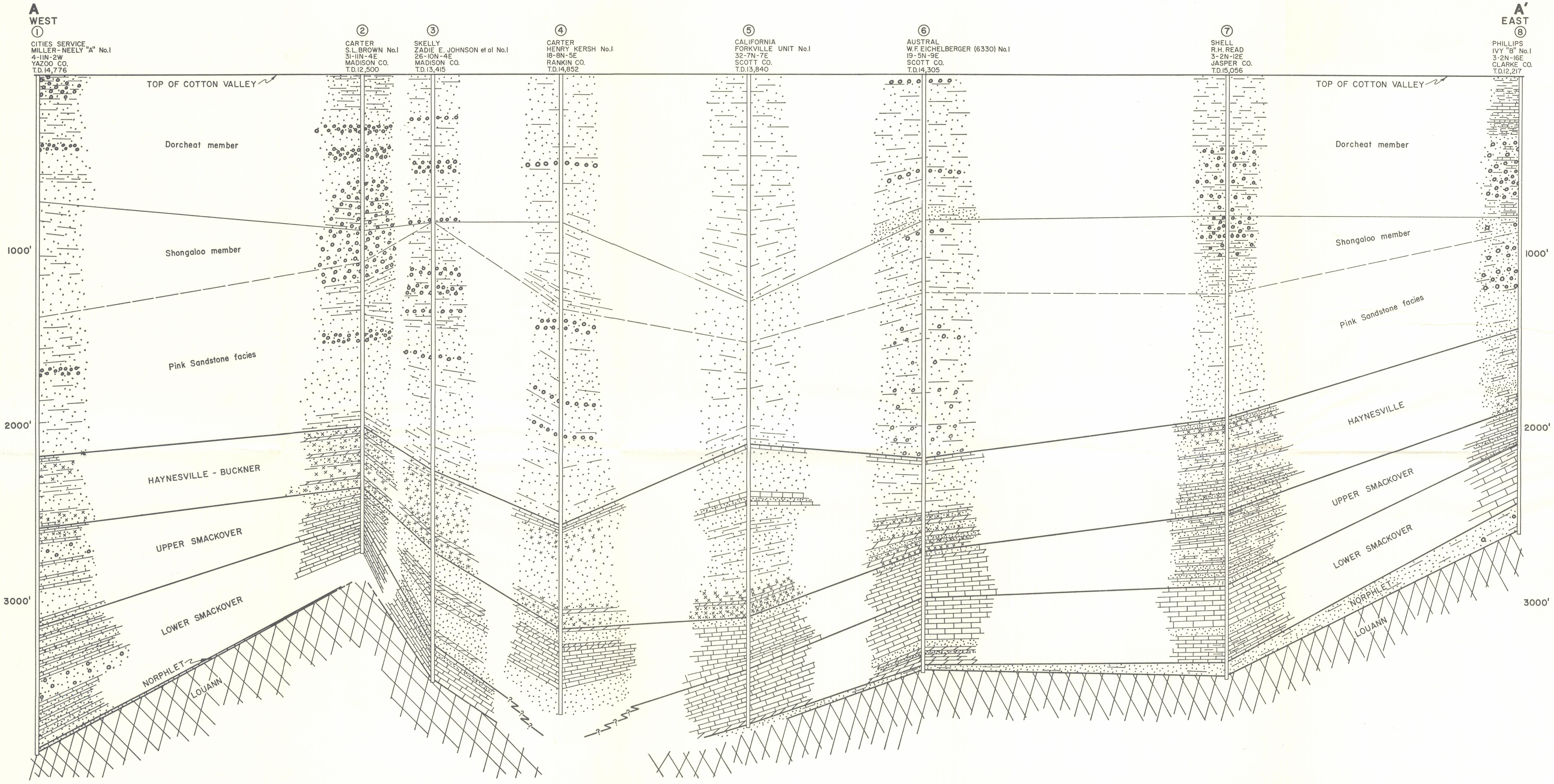
MISSISSIPI GEOLOGICAL, ECONOMIC & TOPOGRAPHICAL SURVEY
WILLIAM HALSELL MOORE, DIRECTOR

STRATIGRAPHIC CROSS SECTION A - A′

YAZOO COUNTY To CLARKE COUNTY MISSISSIPPI

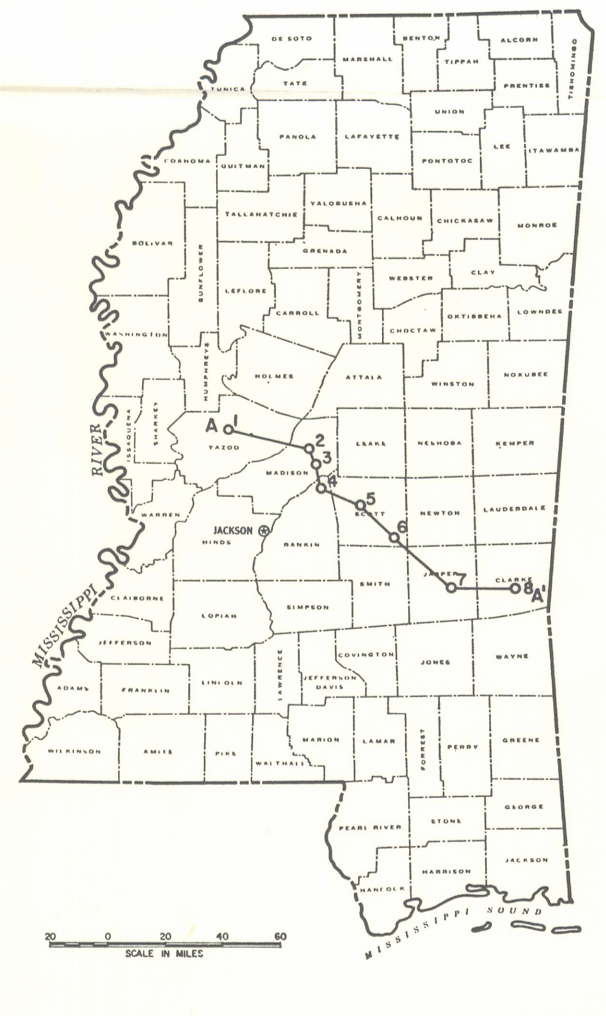
SCALE 0 1 2 3 4 5 10 15 Miles

1968

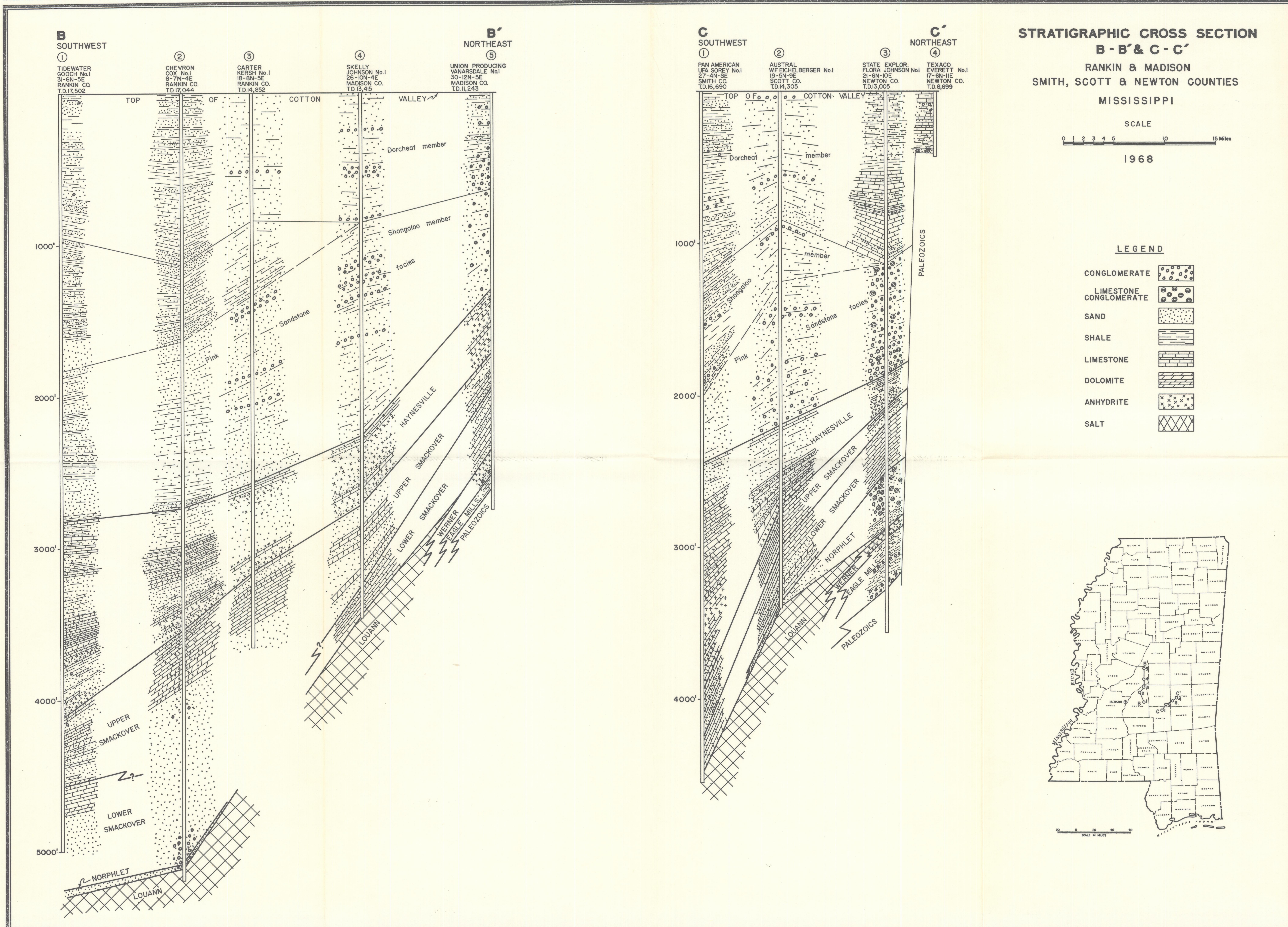


LEGEND

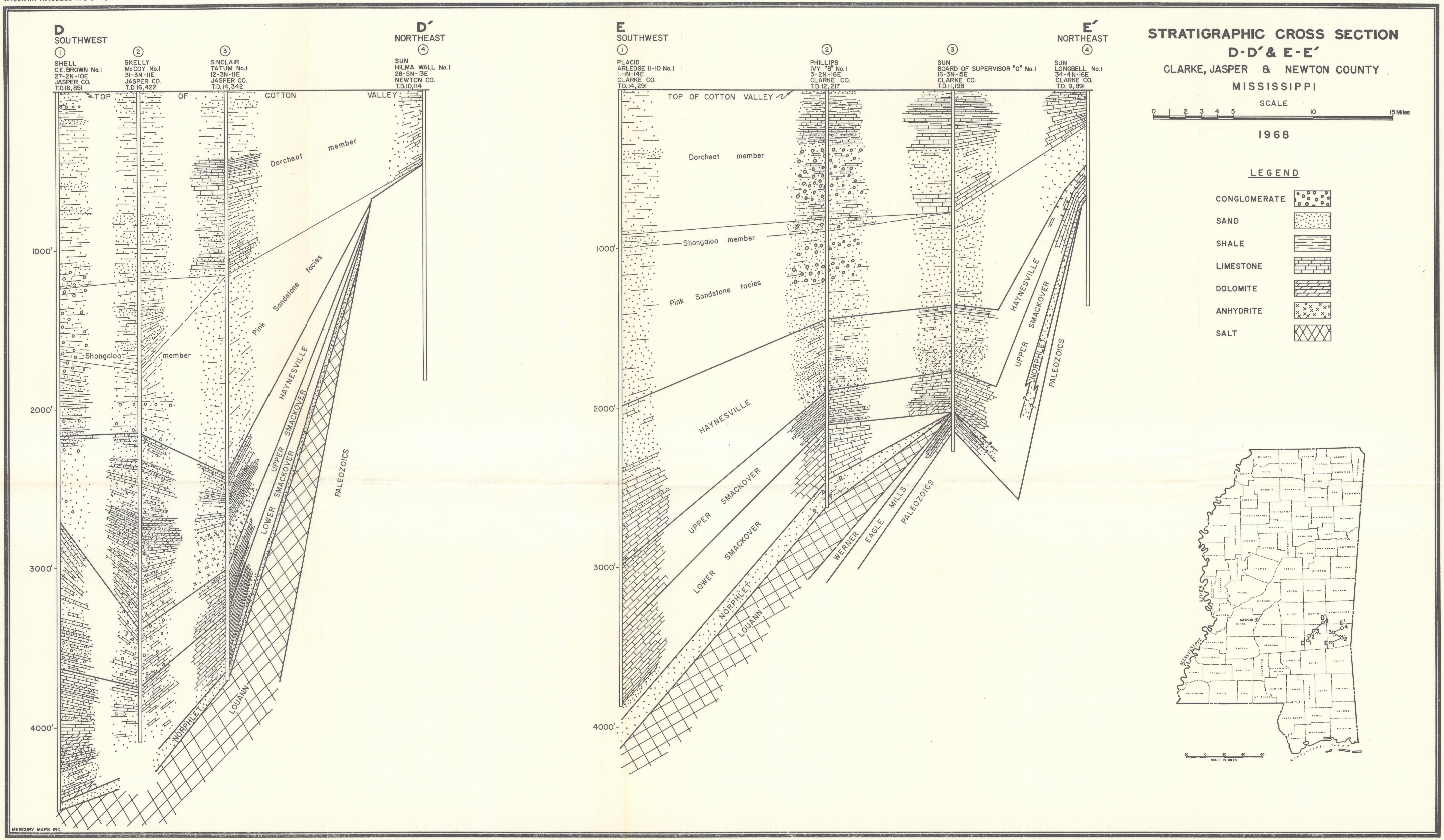
- CONGLOMERATE
- SAND
- SHALE
- LIMESTONE
- DOLOMITE
- ANHYDRITE
- SALT



MERCURY MAPS INC.


STRATIGRAPHIC CROSS SECTION
B - B' & C - C'
RANKIN & MADISON
SMITH, SCOTT & NEWTON COUNTIES
MISSISSIPPI
SCALE
0 1 2 3 4 5 10 15 Miles
1968
LEGEND
CONGLOMERATE
LIMESTONE CONGLOMERATE
SAND
SHALE
LIMESTONE
DOLOMITE
ANHYDRITE
SALT
B
SOUTHWEST
B'
NORTHEAST
1
TIDEWATER
GOOCH No.1
31-6N-5E
RANKIN CO.
T.D.17,502
2
CHEVRON
COX No.1
8-7N-4E
RANKIN CO.
T.D.17,044
3
CARTER
KERSH No.1
18-8N-5E
RANKIN CO.
T.D.14,852
4
SKELLY
JOHNSON No.1
26-10N-4E
MADISON CO.
T.D.13,415
5
UNION PRODUCING
VANARSDALE No.1
30-12N-5E
MADISON CO.
T.D.11,243
TOP OF COTTON VALLEY
Dorcheat member
Shongaloo member
facies
Sandstone
Pink
HAYNESVILLE
UPPER SMACKOVER
LOWER SMACKOVER
WERNER
EAGLE MILLS
PALEOZOICS
LOUANN
NORPHLET
1000'
2000'
3000'
4000'
5000'
C
SOUTHWEST
C'
NORTHEAST
1
PAN AMERICAN
UFA SOREY No.1
27-4N-8E
SMITH CO.
T.D.16,690
2
AUSTRAL
W.F. EICHELBERGER No.1
19-5N-9E
SCOTT CO.
T.D.14,305
3
STATE EXPLOR.
FLORA JOHNSON No.1
21-6N-10E
NEWTON CO.
T.D.13,005
4
TEXACO
EVERETT No.1
17-6N-11E
NEWTON CO.
T.D.8,699
TOP OF COTTON VALLEY
Dorcheat member
Shongaloo member
Sandstone facies
Pink
HAYNESVILLE
UPPER SMACKOVER
LOWER SMACKOVER
NORPHLET
WERNER
EAGLE MILLS
LOUANN
PALEOZOICS
1000'
2000'
3000'
4000'
JACKSON
MISSISSIPPI RIVER
SCALE IN MILES
MERCURY MAPS INC.

MISSISSIPI GEOLOGICAL, ECONOMIC & TOPOGRAPHICAL SURVEY
WILLIAM HALSELL MOORE, DIRECTOR



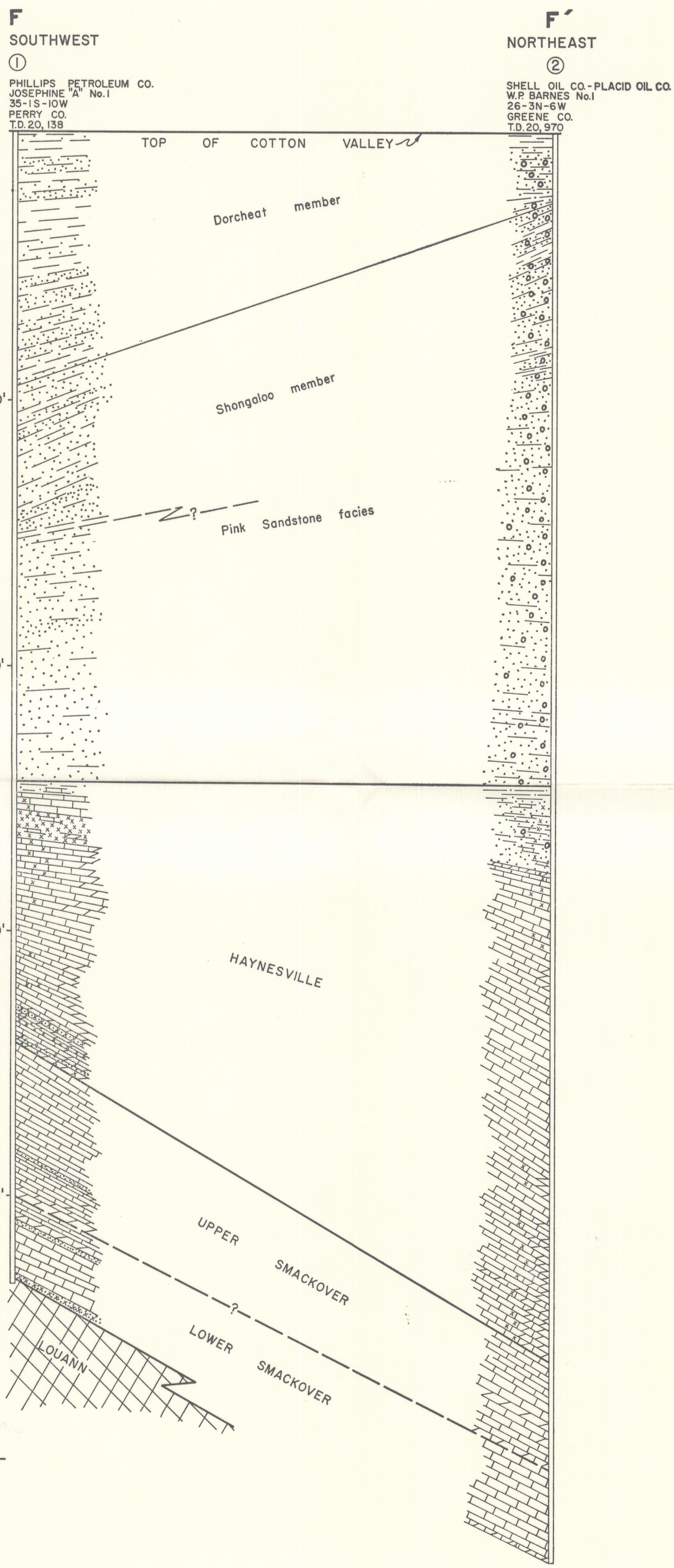
STRATIGRAPHIC CROSS SECTION F - F′

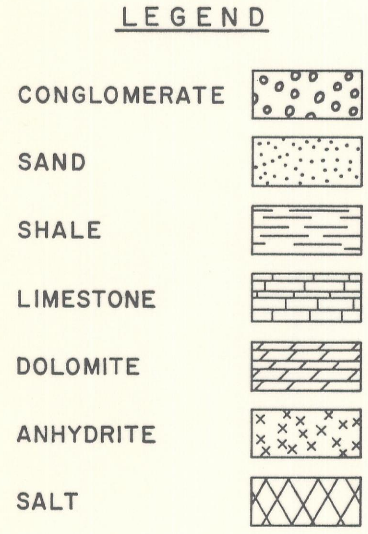
PERRY COUNTY To GREENE COUNTY MISSISSIPPI

SCALE

0 1 2 3 4 5 10 15Miles

1968





MERCURY MAPS INC.