The Tula Prospect

Lafayette County, Mississippi

FREDERIC FRANCIS MELLEN

WILLIAM HALSELL MOORE

BULLETIN 96

MISSISSIPPI GEOLOGICAL ECONOMIC AND TOPOGRAPHICAL SURVEY

FREDERIC FRANCIS MELLEN
Director and State Geologist

JACKSON, MISSISSIPPI

1962

The Tula Prospect

Lafayette County, Mississippi

FREDERIC FRANCIS MELLEN

WILLIAM HALSELL MOORE

BULLETIN 96

MISSISSIPPI GEOLOGICAL ECONOMIC AND
TOPOGRAPHICAL SURVEY

FREDERIC FRANCIS MELLEN
DIRECTOR AND STATE GEOLOGIST

JACKSON, MISSISSIPPI

1962

LETTER OF TRANSMITTAL

Office of the Geological Economic & Topographical Survey

Jackson, Mississippi

August 25, 1962

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

Gentlemen:

Man is so completely controlled by the complex multitude of cyclical events affecting his life he frequently takes these events for granted, even though his mind is always active in processes of analysis and synthesis. He is controlled by the diurnal cycle, the seasonal cycle, the meteorological cycle, the hydrological cycle; he is servant of and heir to the depositional and erosional cycles in geology and to the limitless biological cycles of which we know; and he is at the mercy of economic and political cycles. These, and other natural cycles have effectively induced into Man's activities and behaviors many other secondary cyclic events.

Among these are the leasing of land for oil and gas and the drilling of wells in search of these fugacious mineral substances. The bilateral agreements ("custom") have set the usual term of leases at ten years. In 1952 Union Producing Company completed the very profitable discovery gas-condensate well of the Muldon Field, Monroe County. In the drilling that followed, Magnolia Petroleum Company in its No. 1-A Snow, also in Monroe County, found high-gravity oil in what appeared to be paying quantities. These, and other discoveries led to extensive leasing throughout the Mississippi portion of the Black Warrior Basin during the years 1952 and 1953.

Meanwhile, another cycle of discovery and development enticed the Petroleum Industry capital to south Mississippi and elsewhere. Now, late in 1962, many of the leases of north Mississippi have expired, are expiring or will soon terminate. Within the last several years, much leasing of open lands has taken place by companies participating in the 1952-53 play and by others who, for various reasons, did not make that play.

The purposes of this report are therefore:

1. to recognize and to anticipate the 10-year cycle of leasing and development in the "hard rock country" of north Mississippi.

2. to review generally some of the exploration techniques that may be employed in the search for Paleozoic or pre-Paleozoic oil and gas.

3. to review the available information on Cambrian production and possibilities.

4. to emphasize the great economic contribution of the Survey's Sample Library to the Petroleum Industry.

It is very probable that the coming 10-year cycle of leasing and developing in north Mississippi will witness the drilling of basement test wells. It is not improbable that this period will also witness the first Cambrian oil production in the southeastern United States—for Mississippi! This, again, emphasizes the fortunate position of our State in having such a great range and thickness of sedimentary section, and that no County in our great State has been "condemned" for oil or gas production.

It is recommended that this short report be published as Bulletin 96 of the Survey.

Respectfully submitted,

Frederic F. Mellen
Director and State Geologist

FFM: mw

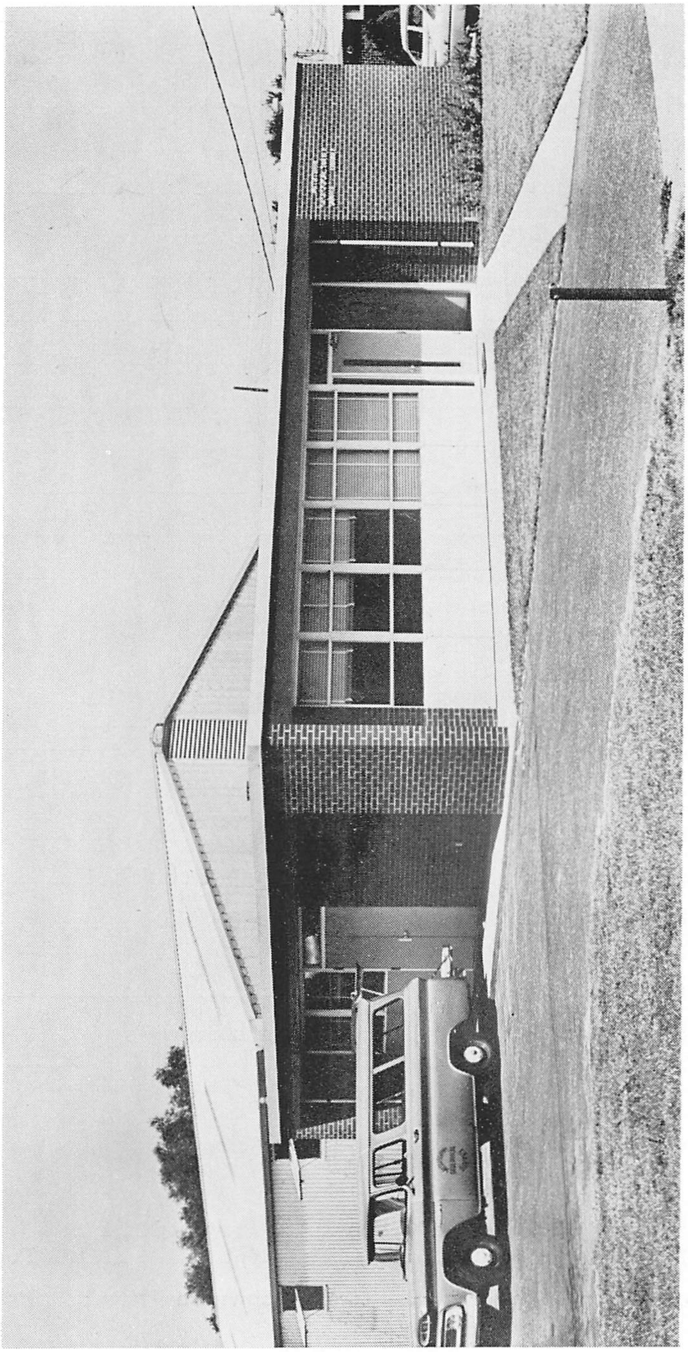
CONTENTS

ILLUSTRATIONS

FIGURES

FRONTISPIECE

PLATES



Frontispiece. Mississippi Geological Survey's Sample Library, 2525 North West Street, Jackson, Mississippi.

THE TULA PROSPECT, LAFAYETTE COUNTY, MISSISSIPPI

FREDERIC F. MELLEN
WILLIAM H. MOORE

ABSTRACT

Well cuttings and cores reposited in the Sample Library of the Mississippi Geological Economic & Topographical Survey are being used in stratigraphic, structure and other studies in the continuing search for oil, gas and other minerals. Cuttings and cores are particularly valuable when, for various reasons, electrical logs and other stratigraphic logging tools are not available. Recently found samples from the W. L. Stewart No. 1 Russell well, in the Tula area of Lafayette County, Mississippi, when studied in conjunction with the nearby Adams Oil & Gas Company No. 1 Lewellen and with more recently drilled wells in the Black Warrior Basin, make possible corrections of earlier concepts of deposition and stratigraphy. An analysis of the regional setting of Mississippi during early Cambrian times, and a review of North American Cambrian oil and gas exploration and development, indicates that the Black Warrior Basin is a favorable province for deeper exploration. The conclusions support, and are supported by, various geophysical surveys of the area.

INTRODUCTION

For many years, the area around Tula in southeastern Lafayette County has attracted the attention of oil prospectors (Figure 1). The lands have been leased for oil and gas by various companies, individuals, and groups a number of times over the past thirty years. However, to date only two test wells have been drilled. The repeated efforts to develop dependable geological information upon which to base the drilling of test wells has resulted in the accumulation of certain geological and geophysical data on the "Tula prospect." All of these data point to the vindication of the judgment of that passing parade of wildcatters that here is a structure of more than ordinary magnitude that deserves adequate testing for oil and gas.

The most significant of the data are contained in the stratigraphic and structural revelations of the few pounds of cuttings from the two wells drilled. The determinations are based upon careful microscopic examinations, not only of the cuttings from

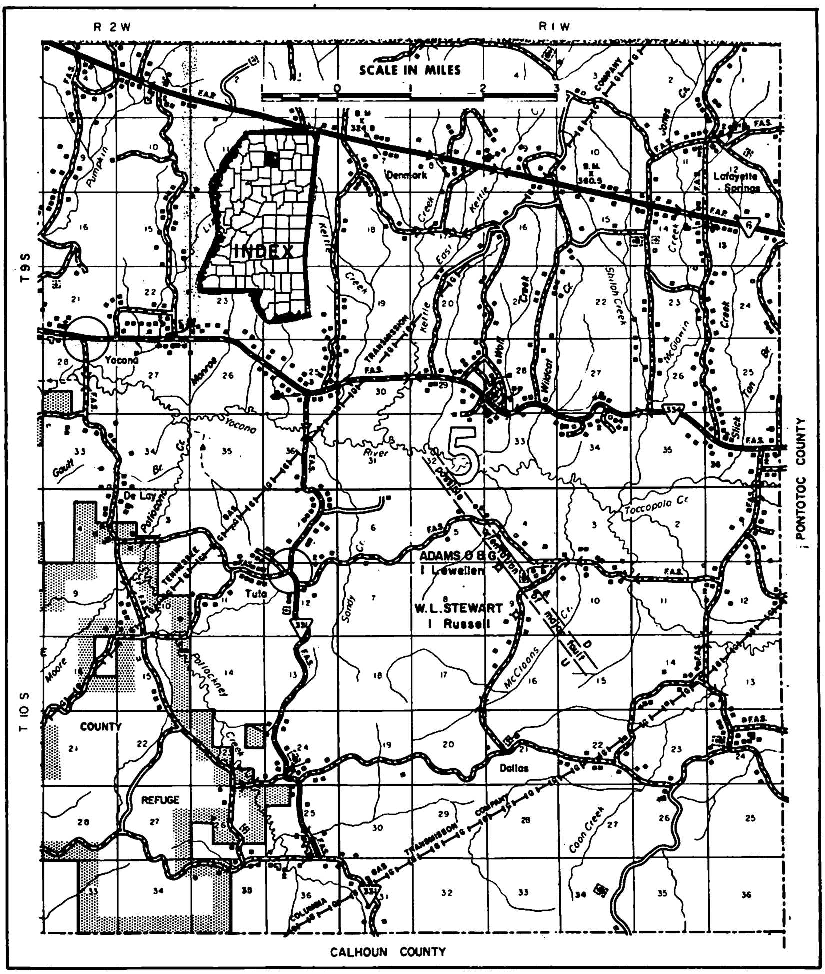


Figure 1.—Map of southeastern Lafayette County, Mississippi showing the locations of the Russell and Lewellen wells and the culture in the Tula area. Map furnished by courtesy Mississippi Highway Department.

the two Tula wells, but also of those wells drilled subsequently in adjoining Counties.

The only important drilling for oil or gas in Lafayette County to date are the two wells mentioned, both on the Tula prospect and in the same section of land. W. L. Stewart began drilling his No. 1 Dr. A. E. Russell on September 12, 1935, and abandoned it because of hard formations at the depth of 2,447 feet on February 1, 1937 (Figure 2). This well was reportedly in quartzitic Pennsylvanian rocks but, seemingly, there had been no examination of the cuttings from this well until they were found in the sample collections of the Survey and first examined by the senior writer in May, 1958. The next wildcat test well on the pospect

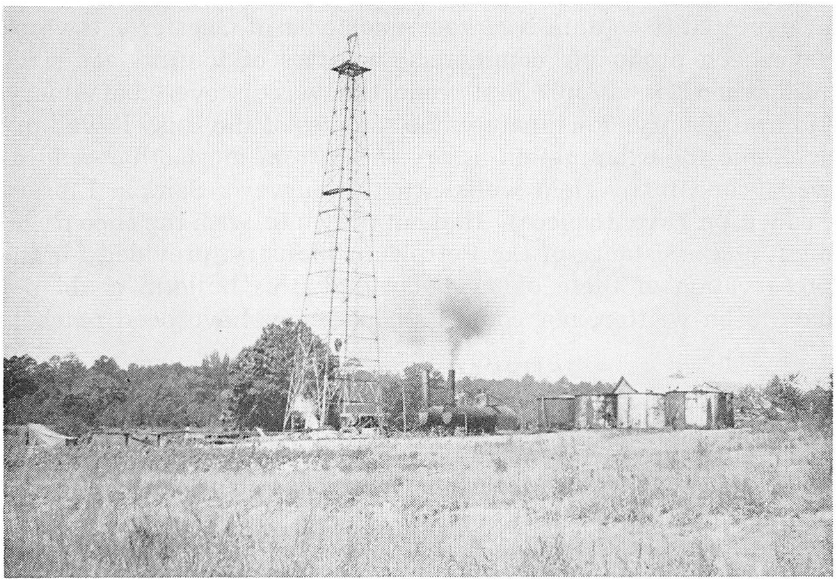


Figure 2.—The W. L. Stewart No. 1 Dr. A. E. Russell, Lafayette County, Mississippi, September 23, 1935. Photo by F. F. Mellen.

was drilled by Adams Oil & Gas Company, the No. 1 Zollie E. Lewellen. This test was spudded on June 6, 1939, and abandoned as dry on October 14, 1939, in the Knox dolomite at a depth of 4,185 feet. The total 424 bits used in drilling this well was considered to be the world's record at that time. Most of the bits were used in drilling the Mississippian-Devonian-Silurian chert. Recent advances in bit construction and design and in drilling techniques have been employed in this region, demonstrating that both drilling time and cost can be reduced greatly today. The Adams Oil & Gas Company had an experienced geologist "sitting on the well." Moreover, the Company distributed samples and electrical logs to other oil company geology departments and to the Mississippi Geological Survey; it filed all its information with the Mississippi Oil & Gas Board.

Based upon the recognition of conglomeratic Pennsylvanian sandstones resting upon a "short" Chester (Mississippian) section, many geologists concerned with regional problems had postulated a westerly thinning or a westerly truncation of Chester sediments in the subsurface of north-central Mississippi.[1] This would mean that the areas and Counties west of the Lewellen well would not be expected to contain reservoir sandstones of Chester age which have been producing commercial volumes of natural gas since 1926, when Mississippi's first production was discovered at Amory, Monroe County. Fortunately, the samples of the Russell well are available for examination as are those from most other wildcat wells (and many field wells), in the Survey's Sample Library in Jackson (Frontispiece). Had not the State, with the encouragement and assistance of the Petroleum Industry, provided for the preservation of these old well cuttings, this bulletin could not have been written, nor could its conclusions have been reached.

SURFACE GEOLOGY

Sands, silts, clays, and lignites of the lower part of the Wilcox group form the surface terrain over most of the Tula prospect. In the eastern part of the area, silty micaceous clays of the Naheola member of the Midway formation are exposed.

Priddy[2] in his Pontotoc County report pictured and described a fault exposure just east of the Lafayette County line. Later study of this fault by core drill and seismic prospecting indicates a strike approximately N.42°W. and that the surface displacement is down on the northeast about 8 or 10 feet. If this fault is related to the Tula structure, it most certainly is on the eastern edge, and this relationship is substantiated by gravity interpretation.

Attaya[3] discussed the surface structure as follows:

> Another area of structural disturbance in Lafayette County which is seemingly separate from the one just mentioned is in the vicinity

of Tula. On Sandy Creek (NW.¼, Sec.6, T.10 S., R.1 W.) beds of Ackerman, units 3 and 4, are dipping at an angle of 20 to 30 degrees slightly south of west. This accelerated dip is not caused by surface sliding as is common in the clayey Ackerman beds, because the dip is clearly continuous from the east valley wall to the west valley wall of the Creek over a horizontal distance of about one-quarter mile.

The writers believe that even though surface evidences of structure are present on the prospect, the possibilities of making a satisfactory surface or shallow subsurface structural map to be used for oil and gas exploration are nil.

POST-PALEOZOIC SUBSURFACE GEOLOGY

The strata overlying the Paleozoic formations are separate from them by an unconformity representing many millions of years. Elsewhere the many thousands of feet of Permian, Triassic, Jurassic, Comanchean and earlier Cretaceous sediments were laid down during those times and preserved unto the present. During

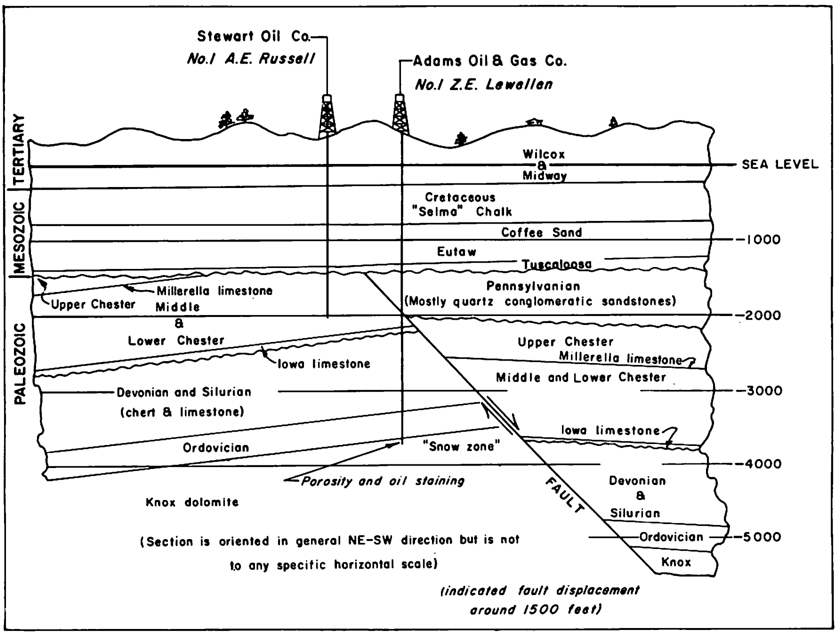


Figure 3.—Reconstructed section showing the structural interpretation used in this report and the relation of the overlying Mesozoic rocks to the underlying truncated Paleozoic rocks in the Tula area.

the period of this vast hiatus the Appalachian Revolution and other large crustal disturbances took place so that the magnitude of structure within the old Paleozoic rocks of the Tula area is far greater than in the younger blanketing sediments (Figure 3).

In the Lewellen well the following stratigraphic points above the Paleozoic are picked:

	Well depth (feet)	Subsea depth (feet)
Elevation	436	
Fearn Springs	195	(+241)
Betheden residuum	295	(+141)
Midway shale (Naheola)	305	(+131)
Clayton marl	555	(—119)
Prairie Bluff (Cretaceous)	700	(—264)
Chiwapa sandstone	810	(—374)
Base Chiwapa	910	(—474)
Demopolis (Saratoga) chalk	980	(—544)
Annona chalk	1110	(—674)
Coonewah bed	1125	(—689)
Coffee sand	1230	(—794)
Arcola (?)	1370	(—934)
Eutaw	1515	(—1079)
Tuscaloosa	1745	(—1309)
Paleozoic (Pennsylvanian)	1845	(—1409)

PALEOZOIC SUBSURFACE GEOLOGY

When there were few data upon which to construct a pre-Cretaceous "sub-crop" map showing the distribution of Paleozoic formations in northern Mississippi, relatively simple distribution patterns were obtained.[4,5] However, within the past ten years the drilling of deep core holes and deep test wells has yielded stratigraphic and structural data which render much more complex patterns. Unfortunately, much of these data have not been released for publication.* The great intensity of structural defor-

*The data afforded by the present studies are qualified by the unavailability of logs and samples from a number of important exploratory wells some of which are 1962 completions and others completed a number of years ago. For example, one well is reported to have encountered acidic igneous rock interpreted to be either abyssal or plutonic rock of pre-Cambrian age or hypabyssal rock intruded into younger Paleozoic sediments. If this rock is "basement" it is probably the first basement mation is not alone due to anticlinal folding, but, as this paper will show, is caused in large part by the faulting of these consolidated sediments. There are other faults known in the Black Warrior Basin of magnitudes smaller, equal to, and even much greater than the one herein described in association with the Tula structure.

It is not the purpose of this report to present subsurface structural contour maps of this or any other part of the Black Warrior Basin. The degree of structural control is yet insufficient to render subsurface methods of exploration of much value in the search for oil or gas when used alone. However, when critical subsurface data are used in conjunction with accepted geophysical techniques the province may be explored with greater confidence. For one thing, no one structural datum within the Paleozoic may be used throughout the Basin, rather, it is necessary to map on a number of horizons, viz: the "Millerella" limestone, the Iowa limestone, the top of the Devonian, the top of the Ordovician, and the top of the Knox dolomite. As will be discussed later, no well in Mississippi has ever reached basement rock,† so it is not possible to prepare anything other than a purely conjectural configuration of the basement.

---

rock encountered in the State. The number of these "tight holes," regrettably, is increasing. A review of these wells shows a current distribution in the Paleozoic region of Mississippi to be approximately as follows:

Newton County	1 well
Panola County	7 wells
Tate County	4 wells
Tunica County	1 well
Yalobusha County	1 well
Total	14 wells

Fortunately, these wells do not alter any of the conclusions relating to the Tula area or its immediate environs.

---

†See preceeding footnote.

The following Paleozoic tops were picked in the Lewellen well by the senior writer:

	Well depth (feet)	Subsea depth (feet)
Elevation	436	
Pennsylvanian (truncated)	1845	(—1409)
Mississippian (Evans zone) FAULTED	2415	(—1979)
Iowa limestone FAULTED?	2610	(—2174)
Maury sandstone	2648	(—2212)
Devonian chert	2650	(—2214)
Dutch Creek sandstone zone	2680	(—2244)
Clear Creek (Camden) chert	2800	(—2364)
Silurian ?	3395	(—2959)
Wayne	3695	(—3259)
"Patterson" sandstone-Richmond (?) (Ordovician)	3700	(—3264)
Black River-Stones River limestones	3767	(—3331)
Base "Wilson" dolomite zone, circa	3900	(—3464)
Murfreesboro limestone	3900	(—3464) or
	3945	(—3509)
Knox dolomite	4040	(—3604)

Essentially the same correlations were used by Adams Oil & Gas Company's geologists in 1939 with the notable exceptions of their placing the Devonian and Silurian cherts in Lower Mississippian and the "Patterson" sandstone as a basal Silurian sandstone. The evidences for stratigraphic division of the cherts are clear. However, there is as yet no positive proof of either the Silurian or the Ordovician age of the "Patterson" sandstone, and our assignment to the Ordovician is one of academic preference.‡

‡The "Patterson" sandstone, named for the sandstone developed at the Silurian-Ordovician contact in the interval 5270-5320 in the L. E. Salmon No. 1 Rex Patterson, Sec.21, T.11 S., R.1 E., Pontotoc County, Mississippi, possibly is equivalent in age to the Thebes sandstone of the Illinois-Missouri region, as the Thebes is defined in the Wilmarth (1958) Lexicon of Geologic Names of the United States. As further defined by J. Marvin Weller (1940) in Illinois Geological Survey Report of Investigations No. 70:

> Commonly the Thebes sandstone directly overlies the Fernvale limestone or locally the Kimmswick limestone . . . These facts suggest that the Thebes sandstone is a local lenticular member in the lower part of a succession of shaly beds that to the north are referred to the Maquoketa formation. The lower Maquoketa age of the Thebes sandstone is substantiated by the occurrence of fossils in both Alexander County, Illinois, and Ste. Genevieve County, Missouri, similar

The "short" Chester section (2,415-2,610 feet) of only 195 feet between the hard conglomeratic Pennsylvanian sandstones and the Iowa cherty limestone is identified by lithology and interval correlation as the Evans limestone and sandstone with its thick underlying shale. This means, of course, that all of the middle and upper Chester and possibly some of the Pennsylvanian is absent. Also, the basal Chester Lewis zone and some of the Iowa (here only 40 feet thick, 2,610-2,650 feet) are absent. Based upon the correlations hereinbelow discussed the section missing at 2,415 feet is estimated to be in the order of 1,000 feet to 1,500 feet, and the section missing at 2,610 feet is estimated to be in the order of 100 feet.

Until the 1958 examination of the Russell well cuttings, the "short" Chester section in the Lewellen well appeared to fit into a pattern supporting the idea of westerly truncation of the Chester. The Justiss-Mears No. 1-A Clark in northwest Chickasaw County and the L. E. Salmon No. 1 Patterson in southwest Pontotoc County have abbreviated Chester sections overlain by Pennsylvanian conglomeratic sandstones. In the Patterson well the abbreviation was 912 feet above the Iowa, in the Sanders sandstone zone; and in the Clark well the abbreviation was about 1,000 feet above the Iowa, in the "Millerella" limestone zone. Both of these wells suggest a northwesterly truncation of the Mississippian rocks by the Pennsylvanian in the direction of the Lewellen well.

Although no electrical log was available for the No. 1 Russell, the examinations of the cuttings clearly indicate that this well had not encountered Pennsylvanian rocks below the Cretaceous, but, instead, it had penetrated 618 feet of Chester sediments, entering the Paleozoic in the Sanders sandstone zone and bottoming in the shale interval between the Evans and Lewis zones.

---

to those occurring near the base of the more typical Maquoketa farther north where the Thebes member is not developed (p.8).

The subsurface distribution pattern of the Patterson sandstone suggests that it was never coextensive with the Thebes; rather, the Patterson has an indicated southwesterly source. Both sandstones occupy essentially the same stratigraphic position though possibly of different sources. Of course, if the "Patterson" sandstone were Silurian in age it could be correlated with the Clinton sandstone of the Ohio region, which has a much more petroliferous connotation than the name "Thebes."

Thus, the Russell well at its total depth of 2,448 feet—estimated to be still some 270 feet above the Iowa—was found to have penetrated 423 feet of Chester more than was present in the Lewellen well only 3,600 feet away. This, plus the 270 feet, means that the Lewellen well has some 693 feet less of Chester section than the Russell well would have penetrated had it drilled deeper to the Iowa. Furthermore, the upper Chester sands, the Carter, the "Millerella" and the Parkwood-Pennington sections evidently had been displaced by the down-faulted Pennsylvanian block penetrated by the Lewellen well. The estimated displacement of the major fault is some 1,000 feet to 1,500 feet (Figure 3, Plate 1).

The lithological comparisons of No. 1 Lewellen and No. 1 Russell are made with the Salmon No. 1 Patterson and Salmon No. 1 Naugher, both in Pontotoc County (Plates 1 & 2). Approximately 7½ miles west of the Russell well (SE.¼, SE.¼, Sec.7, T.10 S., R.2 W.) Seaboard Oil Company drilled its No. 1 Fair Lumber Company in December, 1947, to a depth of 2,225 feet. At 2,140 feet (—1544) quartzitic sandstones and hard dark-gray silty shales of Pennsylvanian lithology and log characteristics suggested confirmation of the reported Pennsylvanian in the Russell well. This core hole does, however, substantiate the identifications of Pennsylvanian in the Lewellen well, and is fully congruous with the present interpretations.

OIL AND GAS RESERVOIRS

Sample examination of No. 1 Lewellen shows porosity at intervals throughout the 145 feet of Knox dolomite penetrated (4,040-4,185 feet). These chips of rock showing porosity also show light oil staining and some fluorescence, particularly in CCl_4. The writers believe that there is sufficient porosity in the Knox penetrated to yield formation fluids on testing and that there is a good possibility that these fluids will be oil and (or) gas (Figure 4).

The writers have been unable to find any evidence of coring or drill stem testing of the Lewellen well, and they regard such coring or testing to be essential to the evaluation of the potential of the Knox "Snow" zone.

The Magnolia Petroleum Company's No. 1-A J. B. Snow, discovery well of the New Hope Oil Field (now abandoned) in Monroe County, produced a sustained volume of fluid from the

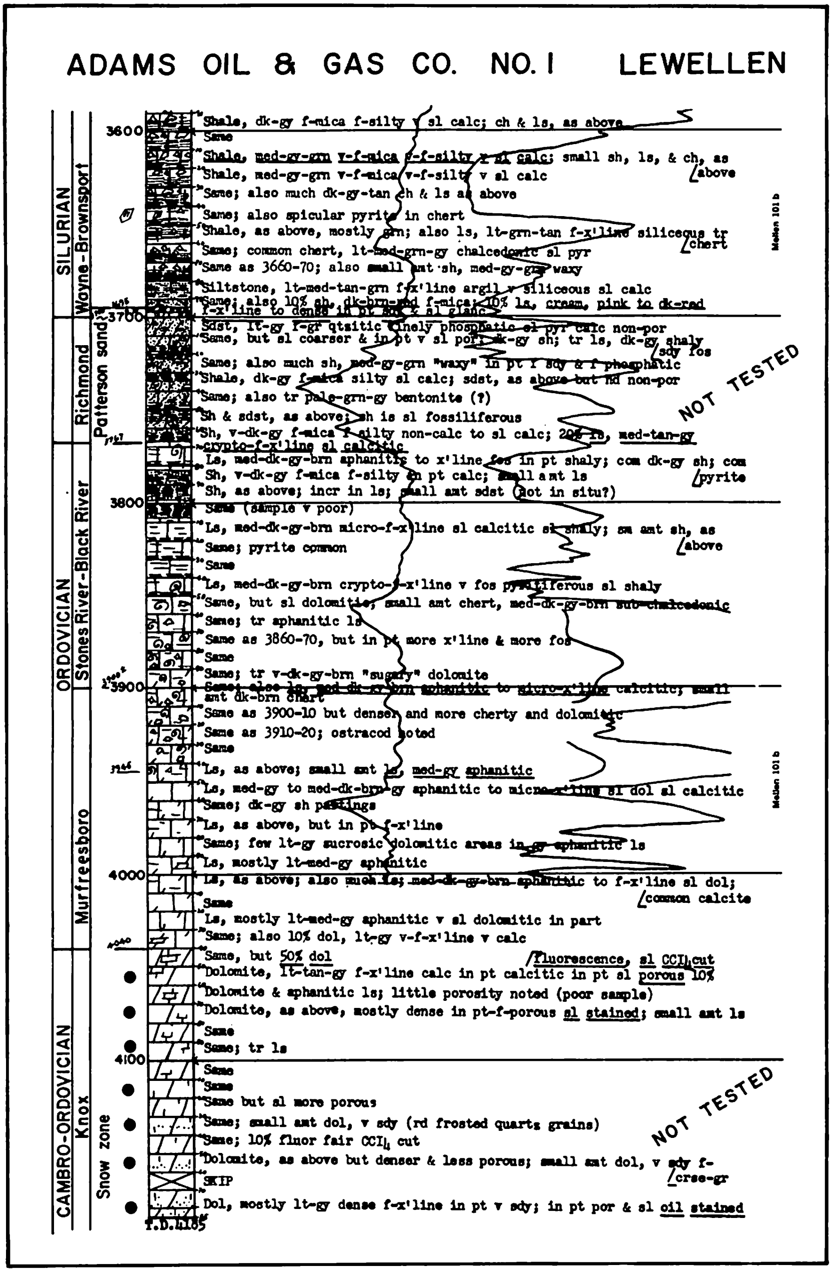


Figure 4.—Correlated bottom part of sample log, electrical log superimposed, of Adams Oil & Gas Co. No. 1 Z. E. Lewellen, showing the principal untested strata in this wildcat oil test well. This well was drilled during the summer and early fall of 1939 at the same time Union Producing Company was drilling and completing its No. 1 Green C. Woodruff at Tinsley, Yazoo County, Mississippi's first commercial oil discovery.

upper 200 feet of Knox. Although the well soon went to water, it was apparent that the reservoir had appreciable size and that profitable oil fields might be found in the Knox in this area. Deeper within the Knox, the "Pierce" zone has yielded salt water in tests at rates in excess of 700 barrels per day.

Where less developed the "Patterson" sandstone at 3,700 feet to 3,767 feet has had shows of oil and gas in a number of wells in Pontotoc County. Like the Knox, this zone was neither cored nor tested and cannot be considered to have been evaluated adequately on the Tula structure.

Many wells throughout the United States have been plugged and abandoned because they were believed to be incapable of commercial oil or gas production, in most cases because they were inadequately studied and tested before abandonment. The number of wells in this category is increasing, even in Mississippi. The outstanding example in Mississippi is Muldon Field which was originally drilled through the Carter (Mississippi's first productive gas reservoir) and Sanders sandstones without either coring or drill stem testing and abandoned as dry.[5]

GRAVITY

On the regional (or "raw") gravity map, the Lewellen well lies west of the axis of a strong maximum nose. This feature is thought to indicate an anticlinal fold of the basement and Paleozoic rocks, along which the denser rocks are nearer the surface (Figure 5). Such folding would have produced tensional faults such as that interpreted from sample work in No. 1 Lewellen. On the east side, a change in gravity gradient coincides with the Toccopola surface fault thereby substantiating the probability of Paleozoic faulting. Drilling in northeast Mississippi has proven repeatedly that gravity maxima do represent positive structural features.

SEISMOGRAPH

A seismograph map dated 1938 does not show the mapping datum. Inasmuch as there was no stratigraphic or structural control at the time the map was made, the seismologists did not know the reflecting horizon, nor did they have knowledge of faulting in the area. The map is computed to a sub-sea datum in feet which, in part, closely coincides with the Paleozoic sur-

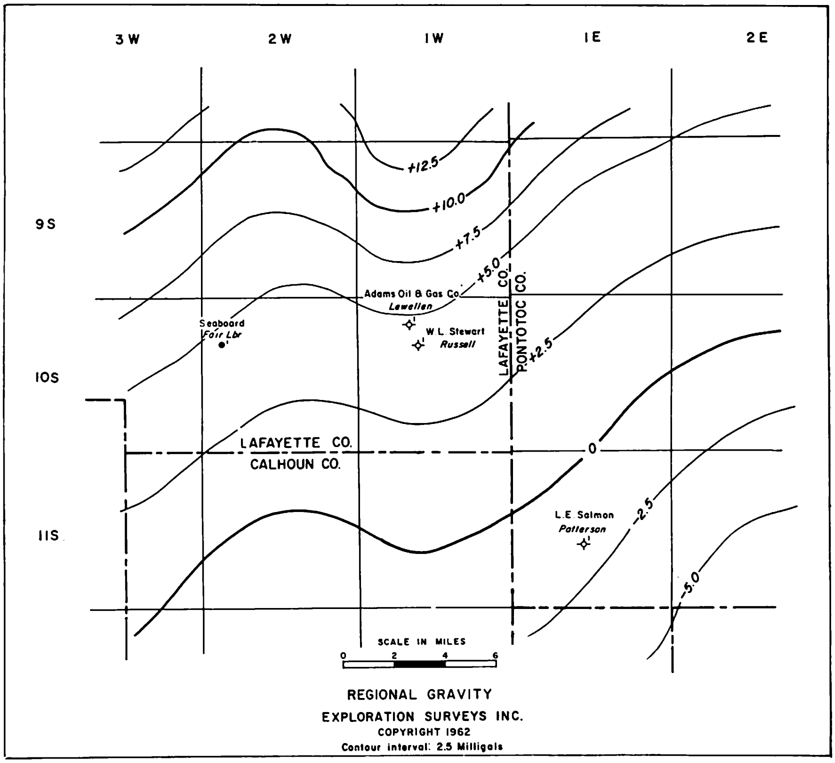


Figure 5.—A regional gravity map showing the strong gravity maximum anomaly on which the Tula wells, Russell and Lewellen, are located. Map furnished by courtesy of Exploration Surveys Inc., Dallas, Texas.

face. However, the magnitude of structural relief is far greater than any known irregularities on the Paleozoic floor. For this reason the writers believe that the reflections mapped are, for the most part, within the Paleozoic; they also believe that the computers may have used too low a velocity. That there is substantial validity to the work is attested by the recent sample correlation showing the Lewellen well to be approximately 120 feet higher than the Russell well; the seismic map indicated that the Lewellen well would be roughly 200 feet higher than the Russell well. The seismic map does not show faulting, but faulting can be inferred from the steeper dips east and northeast of the Lewellen well, and from the very low structural areas centering about 3 miles east and 3 miles southeast of No. 1 Lewellen. Undoubtedly, there has been some "jumping" of reflecting horizons on the map, but if the map has largely isolated the "high" areas from the "low" areas, and if it located the No. 1 Lewellen on one of these "highs," then it has successfully achieved its purpose and proved its value.

WHAT'S BELOW THE KNOX?

The idea of drilling a test well to basement rocks has intrigued geologists in Mississippi since the beginning of exploratory drilling, but to date no such well has been drilled. The thick sequence of sedimentary rocks in eastern Alabama has never been penetrated in its entirety nor has such a deep stratigraphic test been drilled in Arkansas. The deepest stratigraphic penetration in the area was obtained in the California Company's No. 1 Beeler in Giles County, Tennessee. This well penetrated 5,090 feet below the top of the Knox group of Cambrian and Ordovician age and encountered granitic rock at or near the bottom. With so large an area yet unexplored as to the nature of its oldest rocks, the need for basement tests is obvious.

In southern Mississippi a great thickness of Mesozoic and Cenozoic rocks would have to be penetrated before reaching rocks of Paleozoic age or older. This fact makes the northern portion of the State the most favorable area for drilling a basement test. In the northern third of the State, Paleozoic rocks are overlain by a cover of Cretaceous and Tertiary rocks thin enough to allow the Paleozoic rocks to be reached at relatively shallow depths. This still leaves problems that have, until recently, discouraged drilling of a basement test. These problems are: a thick section of hard, abrasive rocks; no completely reliable estimate as to depth to basement rocks; and lack of well control necessary for more accurate selection of a suitable drill site. The hard rocks defeated many early attempts to drill deep tests. The rate of penetration was slow, meaning more cost in rig time and the hard abrasive rocks wore out expensive bits rapidly. In addition, the possible objective horizons were not clearly defined and possibilities of "pay out" against high cost seemed remote. Improved rigs, bits and other drilling equipment, along with significant advances in drilling techniques, have cut drilling costs by increasing penetration rates. Close study of seismic, magnetic and gravity data, electrical logs, and cuttings and core samples makes the selection of a favorable drill site less of a problem.

The remaining question of depth to the basement can be answered only by drilling.

The values to Geology and Industry of basement tests are: the determination of actual depths to basement, nature of the basement rocks and data on formations that are penetrated. Knowledge of the basement and Cambrian rocks would be of great value in the interpretation of seismic, magnetic and gravimetric data.

A seismological observatory has been awarded for construction in Lafayette County for the University of Mississippi by the U. S. Coast and Geodetic Survey. Knowledge of basement position, composition and configuration would be valuable background knowledge for use in the interpretation of seismic energy recorded by the planned observatory.

A well located with a favorable structural position could test the known producing horizons in North Mississippi and would have additional production possibilities in rocks of Cambrian age and in possible porous zones developed as weathering and erosional surfaces on the basement rocks.

CAMBRIAN SANDSTONE OIL PRODUCTION

In many parts of the United States and Canada, Cambrian sandstones underlie the great Cambrian-Ordovician limestone-dolomite section. These sandstones are capable of producing important volumes of oil and gas. McCaslin[6] states that North America is the only continent having undoubted Cambrian production. New York, Ohio, Texas, Kansas, Nebraska, Wyoming, and the province of Ontario in Canada have fields producing Cambrian oil and gas.

Shows were reported in the Cambrian of Ohio for many years, but it was not until 1959 that the first commercial well was completed. This well is located in Medina County and produces gas from the Trempealeau formation at 7,040 feet. This was the deepest producer in the State and set off a flurry of deep drilling. Several wildcats have had good shows in the Trempealeau since the Medina County discovery. The search for Cambrian production spread into the adjoining states, and in 1960 a wildcat in

New York flowed gas from the Gatesburg formation. This caused geologists to take a closer look at this widespread Appalachian formation.

The first Cambrian production in Texas came in 1952 with the discovery of the White Flat Field. The production in this field is from the Wilberns formation of the Upper Cambrian. Since the discovery at White Flat, six other field discoveries have been made from the Wilberns. This formation is well known in the area of the Llano Uplift and consists of four members: the Wedge sandstone, the Morgan Creek glauconitic limestone, the Point Peak shale and the San Saba limestone.

Kansas is the oldest and most prolific producer of Cambrian oil in the United States. It has 21 fields producing from the Reagan sandstone. The first of these fields was discovered in 1926. Since that time, the Reagan has produced more than 50 million barrels of oil. The central Kansas Uplift restricts the Reagan to western Kansas. McCaslin[6] believes that the Kansas production is from stratigraphic traps on the western side of this uplift. The Reagan sandstone is widespread in the Mid-Continent region, extending from Nebraska to Oklahoma. Most geologists in this area believe that the Sleepy Hollow Field in Nebraska, discovered in 1960, produces from the Reagan.

Cambrian production in Wyoming is from the Lost Soldier Field, discovered in 1958. This field has produced 6 million barrels of oil from the Deadwood formation of the Upper Cambrian.

The discovery of Princeton Field in 1960 opened the province of Ontario to Cambrian production. This field produces both oil and gas from the Cambrian basal quartz (conglomerate?) at a depth of 2,900 feet. This discovery has started an active campaign of drilling into these geologically ancient rocks.

The above statements show that the Cambrian is an important exploratory objective. Discoveries since 1953 have initiated Cambrian production in several new areas, and due to the widespread distribution of Cambrian rocks, more discoveries can be expected. There are several reasons why North Mississippi might be one of the more favorable areas for Cambrian exploration.

King[7] refers to the continental nucleus as it exists today:

> This is the Central Stable Region of North America, the nucleus of the continent, which has been only mildly deformed since the beginning of Paleozoic time. Within it, Pre-Cambrian basement rocks stand relatively high, forming a wide platform which to the south and west is more or less mantled by Paleozoic and Mesozoic sediments, but to the north and east emerges to form the Laurentian Shield.

Mississippi is distant from the exposed center of this continental nucleus and was in a better position to receive sediments in earlier Cambrian time than were the areas nearer the center of the Stable Region. As Cambrian seas transgressed the Stable Region, younger sediments were deposited toward the interior of the Continent. In discussing the early Cambrian paleogeography, Dunbar[8] states that the great land mass of Appalachia stood high, along the eastern edge of the continental mass and contributed sediments to the low-lying areas to the west. These statements show that Mississippi was located favorably in relationship to the dominant land masses to have a more complete section of Cambrian rocks deposited than some of the areas now producing oil and gas.

Clastic rocks of Cambrian age have not been penetrated in Mississippi. The closest area of exposed Cambrian is in eastern Alabama, approximately 100 miles east of the Mississippi line. This section consists of four formations: the Weisner, the Shady, the Rome, and the Conasauga. The Weisner formation is described by Smith[9] as 2,000 to 4,000 feet of massive conglomeratic sandstone and sandy shale. Butts[10] describes the Shady as 1,200 feet of thick-bedded gray limestone; the Rome as 1,000 feet of red and green shale, red sandstone, and gray siliceous limestone; and the Conasauga as 1,900 feet of interbedded limestone, shale, and dolomite.

While this is not an attempt to correlate the two, the Cambrian lithology in eastern Alabama is very similar to the lithologic sequence of the Wilberns formation, which produces in seven fields in west Texas.

If Cambrian rocks, similar to the exposed section in eastern Alabama, are present beneath the flat lying Paleozoic rocks to the west (there is no reason to believe they are not present), then objective horizons are present, and, in addition, there may be other structural features which are not reflected in these overlying Paleozoic rocks. In discussing the future oil possibilities in this country, Levorsen[11] states:

> All folding that folds the younger rocks also folds the Cambrian, and in addition there are folds and faults that do not reach the younger sediments. There are consequently many traps in Cambrian rocks, both structural and stratigraphic, that have not been tested.

POSSIBLE BASEMENT OBJECTIVES

In addition to Cambrian objectives, the possibility of production from the basement rocks themselves cannot be precluded. Basement rocks have produced over 100 million barrels of oil, mainly from fields in California, Kansas, Venezuela, and Morocco. Altogether there are 25 fields producing from basement rocks. These fields produce from many types of basement rocks such as granite, gneiss, schist, and quartzite. As it is believed that oil is not indigenous to basement type rocks, especially those of igneous origin, there must be other sources for the hydrocarbons. Landes[12] suggests three possible sources for basement rock accumulations.

> These are: (1) overlying organic rock, from which oil was expelled downward during compaction, (2) lateral, off-the-basement but topographically lower, organic rock from which oil was squeezed into an underlying carrier bed through which it migrated updip into the basement rock, and (3) lower lateral reservoirs from which earlier trapped oil was spilled due to tilting or over filling.

Landes[12] further states that all known basement rock accumulations are found where the basement rock is at a higher elevation than the surrounding flanking sediments. Exploratory wells should be located deliberately in order to probe upward bulges of the basement rock as well as their sedimentary cover. Magnetic and gravity work suggest that this condition is a distinct possibility in northern Mississippi. As stated previously, magnetometer and gravitimeter surveys have located many large anticlinal structures in northern Mississippi, which appear to be basement in origin. One such structure is the Tula prospect.

As stated before, no completely reliable estimates can be made as to the depth to basement, or as to the depth to pre-Knox Cambrian, inasmuch as no wells have penetrated this section.

Many wells in northern Mississippi have penetrated the Cambro-Ordovician Knox, a number of them going more than 2,500 feet into the Knox. Wells with deepest penetration below the top of the Knox are listed below.

Well Name	Depth of Penetration Below Top of Knox (Feet)
Salmon-No. 1 Andrews Pontotoc Co., Miss.	2893
Honolulu-No. 2 Davis Calhoun Co., Miss.	2981
Gulf-No. 1 Basden Union Co., Miss.	3150
Magnolia-No. 1 Pierce Monroe Co., Miss.	3413
Magnolia-No. 1 Warren Pontotoc Co., Miss.	3491
Union-No. 2 Sanders Monroe Co., Miss.	3582
Stephens-No. 1 Petrie McNairy Co., Tenn.	4080
California-No. 1 Beeler Giles Co., Tenn.	4920 in Knox 170′ in material below Knox

The recently abandoned Gulf Oil Corporation No. 1 Wiley 34-10 in Tuscaloosa County, Alabama, penetrated 5,355 feet below the top of the Knox to make it the deepest penetration to date in the Southeastern States. This test, on the Wiley Dome, encountered the Knox at 5,705 feet and bottomed in Cambrian carbonate rock at 11,060 feet without reaching the Weisner formation.

Although these wells do not reveal the complete thickness of the Knox in Mississippi, comparisons can be made with the Knox of the outcrop area, the thickness penetrated in the California No. 1 Beeler, and correlative horizons determined in some wells. This information suggests that a well located on one of the large structures in northern Mississippi, such as the Tula area, should be able to test the Cambrian and penetrate solid basement rock at a feasible depth. This would fulfill the need for scientific information on all possible producing horizons and on the nature of the basement rock. This test would also help to evaluate the one million acres of land, or more, under lease in this area.

CONCLUSIONS

The present investigations suggest that a sizeable portion of Lafayette County, west of Tula and south of Oxford, is underlain by a "normal" thickness of Chester rocks at an optimum depth to permit commercial accumulations of oil or gas if porosity is developed and traps are present. This is contrary to an earlier theory that the Chester was truncated westerly by the pre-Pennsylvanian erosion and early Pottsville deposition.

Samples from the W. L. Stewart No. 1 Russell when correlated with more recently drilled wells and with the Adams Oil & Gas Company No. 1 Lewellen show that the "short" Chester in the Lewellen well is abbreviated by faulting rather than by regional truncation.

Gravity and seismic work have confirmed surface suggestions of the Tula Structure, but the final confirmation has been the result of well sample lithologic studies. It appears that magnetometer and gravitimeter surveys are useable reconnaissance methods for locating many of the large anticlinal structures of northern Mississippi which appear to be basement in origin. Core drilling and seismic exploration may be locally useful.

There have been far too many wells in Mississippi which were abandoned as dry without adequate testing. Some of these have later been brought in as commercially producing wells. Muldon gas-condensate field in Monroe County is the outstanding example. For this reason, the examination of cuttings, cores, logs and other data of abandoned wildcat wells can be a profitable investigation. Specifically, the Lewellen well appears neither to have been cored nor drill stem tested in the "Patterson" sandstone, nor in the Knox dolomite "Snow" zone, testing which the work herein reported indicates should have been done.

Besides the known objectives of the Black Warrior Basin, the writers feel that prospectors for oil and gas in this region should begin to plan for the drilling of basement tests to determine the "ultimate" objective depths of the province. The increasing importance of basal Cambrian sands as oil reserves in the United States, the presence of these sands on the outcrop in eastern Alabama, and the necessity for evaluation of the many hundreds of thousands of acres of leased lands in northern Mississippi add up to good economic reasons for the exercise of our geological imagination and our curiosity to know "What's down there."

ACKNOWLEDGMENTS

Mr. William S. Parks ably assisted in the editorial work on this report.

Mrs. Mary Alice Russell Webb typed the manuscript in its several stages and aided in the selection of words, word forms and style.

Through the courtesies of Mr. Shelby Pitts and Dr. Maynard Jones, the Exploration Surveys Inc. of Dallas, Texas, provided the gravitimeter map reproduced in this report. Dr. Jones and several oil company geophysicists have graciously discussed the general geophysical background of the northern part of Mississippi with the writers of this report. Similarly, this report has been aided immeasurably by last minute conferences with principal geologists of oil companies on general basic data from wells most recently drilled or bearing directly on the problems this report summarizes.

The writers acknowledge appreciation to the Survey Board, which initiated the establishment of the Sample Library, to the Building Commission, to the many companies who contributed funds to the construction of the Sample Library, as attested by the metal plaque on the building (Figure 6), and to the wholehearted cooperation of nearly all companies and countless geologists and other individuals who are continuing to furnish samples and cores to the Survey's repository.

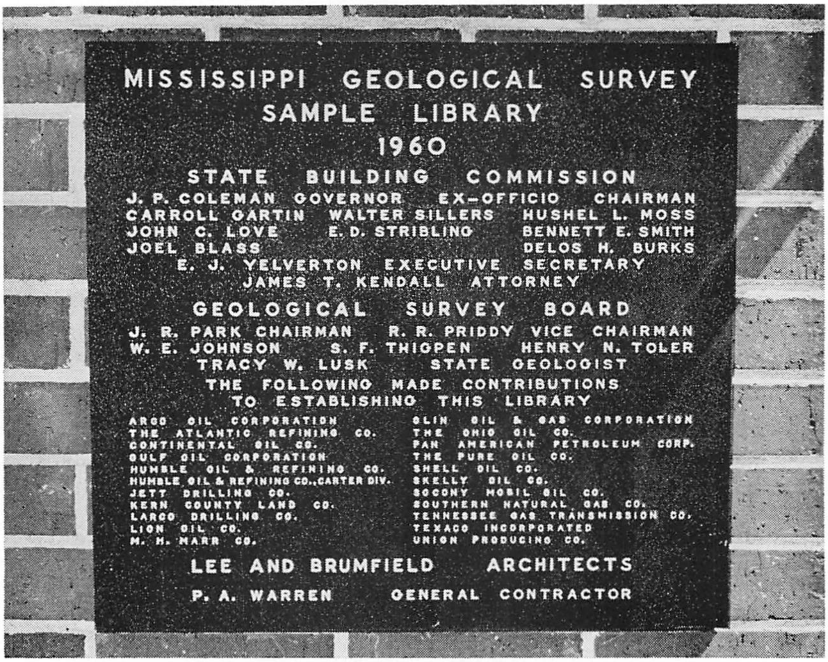


Figure 6.—Plaque commemorating the dedication of the Survey's Sample Library, 2525 N. State Street, Jackson, Mississippi.

REFERENCES

1. Mellen, Frederic F., Paleozoic possibilities of northern Mississippi and Alabama, The Oil Weekly, Vol. 102, No. 10, pp. 28-40, Aug. 11, 1941, (see fig. 5).

2. Priddy, Richard R., Pontotoc County mineral resources-geology, Miss. Geol. Survey Bull. 54, 1943 (see fig. 8, p. 35).

3. Attaya, James S., Lafayette County geology, Miss. Geol. Survey Bull. 71, 1951, p. 45.

4. Mellen, Frederic F., Black Warrior Basin, Alabama and Mississippi, Bull. Am. Assoc. Petr. Geol. Vol. 31, No. 10 (Oct., 1947), fig. 1.

5. Mellen, Frederic F., Mississippi's Black Warrior Basin yields gas-condensate, World Oil, July, 1953, fig. 8.

6. McCaslin, John C., Cambrian rocks may hold big reserves, The Oil and Gas Journal, pp. 208-210, April 24, 1961.

7. King, Phillip B., The tectonics of middle North America, 203 pp., 1951.

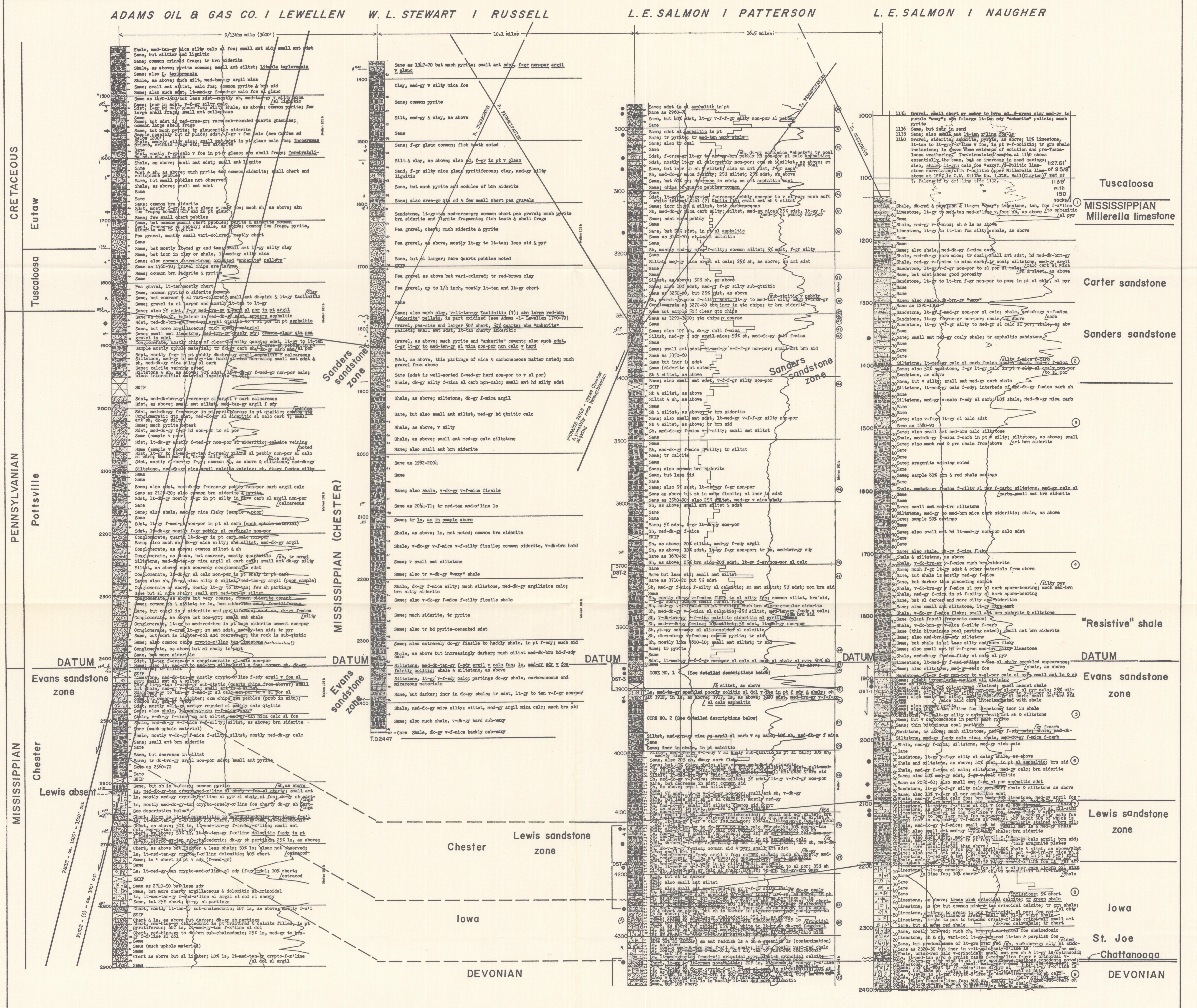
8. Dunbar, Carl O., Historical geology, second edition, 500 pp., 1960.

9. Smith, Eugene A., Alabama Geological Survey, geological map of Alabama with explanatory text, 1894.

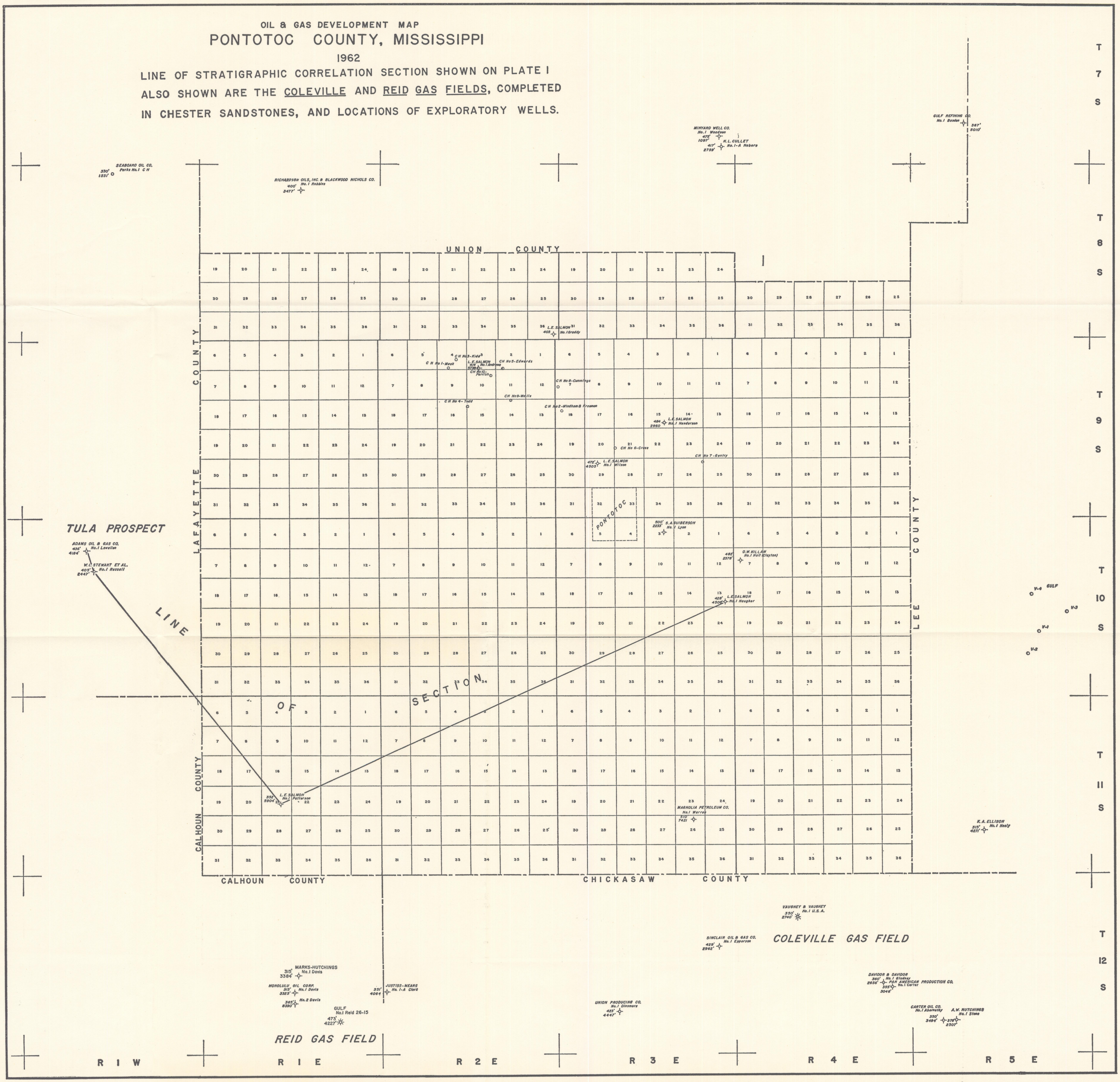
10. Butts, Charles, Paleozoic rocks, Geological Survey of Alabama, Special Report No. 14, p. 65, 1926.

11. Levorsen, A. I., Where will tomorrow's oil be found?, World Oil, p. 76, April, 1955.

12. Landes, Kenneth K., Basement rocks have oil potential, Petroleum Week, pp. 24-29, Nov. 4, 1960.



CORRELATION OF THE PALEOZOIC SECTION IN THE STEWART NO. I RUSSELL WELL IN LAFAYETTE COUNTY, MISSISSIPPI


OIL & GAS DEVELOPMENT MAP
PONTOTOC COUNTY, MISSISSIPPI
1962
LINE OF STRATIGRAPHIC CORRELATION SECTION SHOWN ON PLATE I
ALSO SHOWN ARE THE COLEVILLE AND REID GAS FIELDS, COMPLETED
IN CHESTER SANDSTONES, AND LOCATIONS OF EXPLORATORY WELLS.
UNION COUNTY
LAFAYETTE COUNTY
CALHOUN COUNTY
LEE COUNTY
CALHOUN COUNTY
CHICKASAW COUNTY
PONTOTOC
TULA PROSPECT
LINE OF SECTION
COLEVILLE GAS FIELD
REID GAS FIELD
T 7 S
T 8 S
T 9 S
T 10 S
T 11 S
T 12 S
R 1 W
R 1 E
R 2 E
R 3 E
R 4 E
R 5 E