MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph.D.

Director

BULLETIN 84

KEMPER COUNTY GEOLOGY

By

RICHARD JOHN HUGHES, JR., M.A.

UNIVERSITY, MISSISSIPPI

1958

VIEW OF WAHALAK CREEK VALLEY FROM NICHOLSONS HILL, WILCOX ESCARPMENT IN DISTANCE.

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MISSISSIPPI GEOLOGICAL SURVEY
COMMISSION

STAFF

LETTER OF TRANSMITTAL

Office of the Mississippi Geological Survey
University, Mississippi

April 10, 1958

To His Excellency,
Governor James Plemon Coleman, Chairman, and
Members of the Geological Commission

Herewith is the report on Kemper County Geology, the manuscript to be printed as Bulletin 84 of the Mississippi State Geological Survey. It is the work of Richard J. Hughes, Jr., M.A. It covers one of the most important areas in Mississippi for the reason that the county was the transition region where depositional environs changed from the adjoining states. In short it is the transition region with many of the important changes in such an area. The author has given it careful and extended study.

The connotation of the Names for the geologic time divisions and of the Names for the geologic rock divisions, adopted (1) by the International Geological Congress in 1907, and (2) by such outstanding geologic text-book authors as William B. Scott, Ph.D., LL.D. in his text, "An Introduction to Geology," Second Edition Revised 1908, The Macmillan Company; and (3) by Thomas Chrowder Chamberlin and Rollin D. Salisbury, 1908, Henry Holt and Company, was 25 years later, in violation of the law of priority changed by the Committee on Stratigraphic Nomenclature (1930).

Most unfortunate of all, is the fact that "Group," (and other names) cannot be used without first defining in each case what the author embraces by such terms. The term, "Group" in this report differs, for example, from the usage by the Mississippi State Geological Survey in previous reports.

No Natural Science, Botany, Zoology, Paleontology, or Geology, can survive without such a law. Accordingly, no man, no society of men, can change such a law without resulting chaos.

The author has spent correctly (1) most of his space on Surface Stratigraphy, and (2) on such mineral resources as Water, Iron Ore, Sand, Clay, Bauxite, Oil and Gas, Lignite, and finally Phosphate.

Sincerely,

William Clifford Morse
Director and State Geologist

PREFACE

The present work, Kemper County Geology, is an academic study, in which the author has endeavored to present a systematic, factual picture of the strata. The study of the geology of Mississippi is of considerable antiquity, and the wide roots and branches of the investigations have led to voluminous over-lapping literature. The author has sought to uncomplicate the geology of Kemper County by the use of detailed illustrations, and by a formal organization in the presentation of stratigraphy and taxonomy, best suited to this area.

Alabama nomenclature, in the main, is used in the report, following the rule of priority. The use of Era, System, Series, Group, Formation and Member in the report is in accord with such usage in "Classification and Nomenclature of Rock Units," by G. H. Ashley et al., which appeared in 1933 in the Geological Society of America Bulletin (Vol. 44, pp. 423-459), and which has subsequently appeared in several issues of the American Association of Petroleum Geologists Bulletins. This classic, the "Ashley Report," defends itself. Notes and Reports of the American Commission on Stratigraphic Nomenclature were also consulted.

An areal study of a whole county embraces all facets of the science, and the scope of no one work by a single author can be as completely comprehensive, even as he may wish. For example, only approximately one-third of the measured sections have been included in this publication. The emphasis on surface stratigraphy, and the relatively minor focus on subsurface study may be adversely noted. The author believes that carefully recorded detail of rocks that crop out in the county is primary sequentially. In spite of meticulous care, errors of omission, commission, and inconsistency are inevitable, and the author will be grateful for calling his attention to these. He wishes to acknowledge that he has sought advice from men in many geological fields, and has been accorded much generous and valuable assistance. Recognition of any merits in this work should include particular credit to the aid of the following: the Mississippi State Geological Survey for financing the report; Mr. F. Stearns MacNeil of the U. S. Geological Survey, who made available to the author his field notes and maps; Mr. Watson H. Monroe of the U. S. Geological Survey, who pointed out the Bluffport marl member of the Demopolis chalk; Dr. Ralph E. Grim of the Department of Geology, University of Illinois, for the X-Ray diffraction diagrams; Dr. Louis C. Conant of the U. S. Geological Survey, for information on the Naheola formation in the northern part of the county; Mr. Joe W. Lang of the U. S. Geological Survey, for water analyses which appear in Table 2; Mr. Bryan C. Parks of the U. S. Bureau of Mines, for information on lignites; Dr. William F. Tanner of the Department of Geology, Florida State University, for permission to use the Sediment Color Chart; Mr. James S. Attaya, Consulting Geologist, with whom the author conferred on the structure map; Mr. William S. Parks of the Mississippi State Geological Survey, with whom the author conferred on the stratigraphic and structure sections. The author will always be grateful to his former teacher, Dr. Warren R. Wagner, Consulting Geologist for the photomicrographs, and to his former students, Jerry Simmons, Barry Greer, Oscar Ponder, Horace Baker, James Vines, John Wiygul, and Ray Blasingame for their assistance in various phases of the report. Last but not least, gratitude is due Louise Womack Hughes, the author's wife, for the frontispiece, for typing and proofreading the manuscript.

RICHARD JOHN HUGHES, JR.

UNIVERSITY, MISSISSIPPI
AUGUST, 1958

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Oliver Wendell Holmes, 1875

KEMPER COUNTY GEOLOGY

RICHARD JOHN HUGHES, JR., M.A.

INTRODUCTION

LOCATION AND SIZE

Kemper County is one of the border counties of east-central Mississippi. Its geographic position is determined by the coordinates, latitudes 32° 34′ 40″ N. and 32° 55′ 35″ N., and longitudes 88° 20′ 55″ W., 88° 23′ 25″ W., and 88° 54′ 55″ W. All the county is included in Townships 9 to 12 North and Ranges 14 to 19 West. On the north, it is bounded by Winston and Noxubee Counties; by Sumter County, Alabama, on the east; by Lauderdale County on the south; and by Neshoba County on the west (Figure 1). Its area of 754 square miles is trapezoidal in shape, approximately 24 miles long in a north-south direction; 32½ miles wide at the north, and 30¼ miles wide at the south.

ACCESSIBILITY

The county is easily accessible from most directions by paved roads. U. S. Highway 45 trends north-south through Wahalak, Scooba, Electric Mills, Sucarnoochee, and Porterville. State Highway 16 is an east-west paved road through Giles, Scooba, DeKalb and Pea Ridge. State Highway 39 is paved from DeKalb to Meridian in Lauderdale County, on the south, but north to the Noxubee County line it is mostly graveled. State Highway 397, another paved road, trends northwest to Louisville in Winston County. Equally important locally is an excellent network of section-line and farm-to-market roads. State Highway 493 north and south is an excellent graveled farm-to-market road through Prismatic, Klondike, Liberty, Moscow, Bluff Springs and Linville. In addition to these are fire breaks and numerous timber roads, which give access by automobile to almost every section.

One railroad serves Kemper County. The Gulf, Mobile and Ohio Railroad passes through Tamola, Enondale, Porterville, Sucarnoochee, Electric Mills, Scooba and Wahalak.

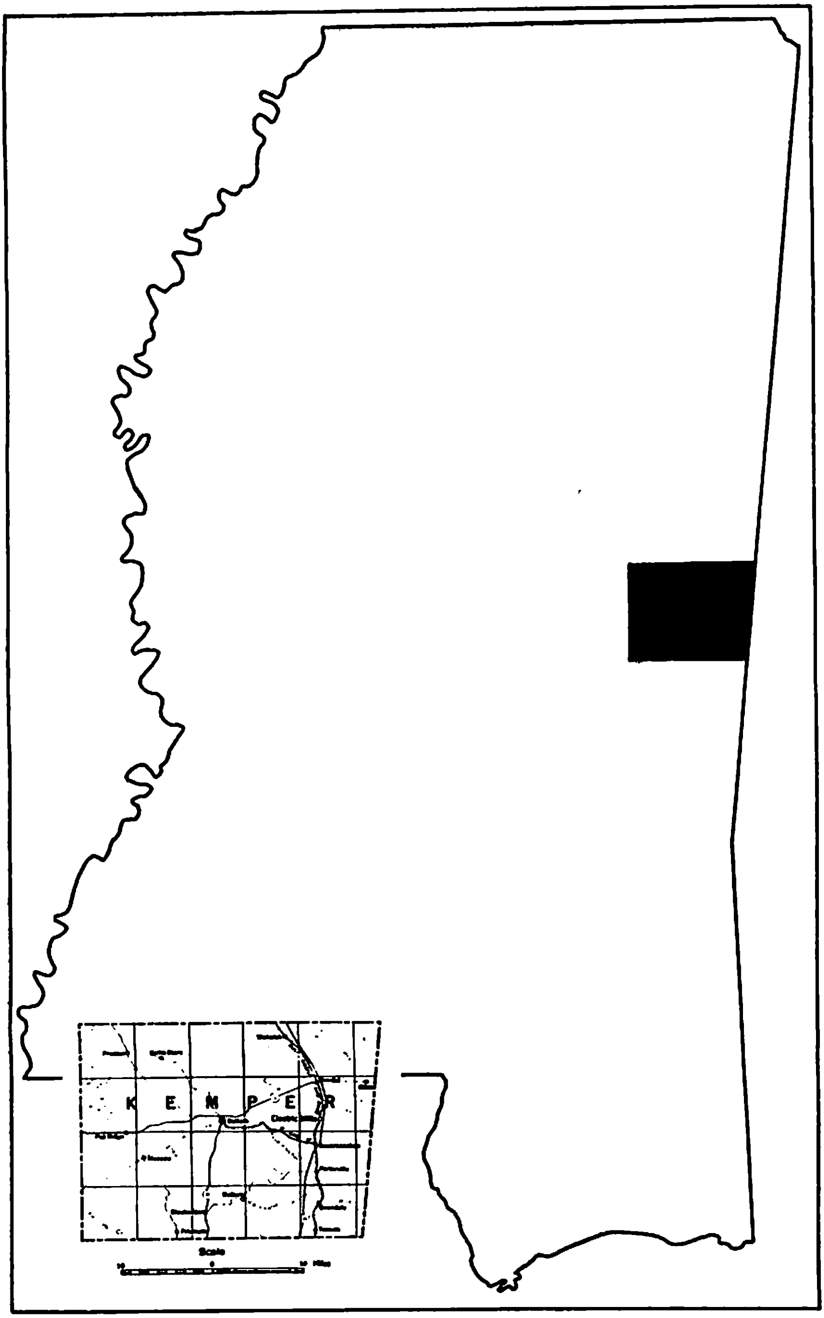


Figure 1.—Index map of Kemper County.

PURPOSE AND SCOPE OF THE REPORT

The primary purpose of the investigation was to study in detail the character, distribution and thickness of the formations exposed in Kemper County in order 1) to obtain such detailed information on the exposed rocks as would advance knowledge of the geology of Mississippi, and facilitate the more precise correlation of beds exposed in Kemper County with those exposed to the east in Alabama, and in other areas in Mississippi; and 2) locate deposits of mineral substances of economic value, and collect samples for analysis and experimentation.

Although the report is concerned primarily with Kemper County, it was necessary to study in detail the lithic units exposed in the surrounding counties, more especially in Alabama. In the Tertiary section the writer found a remarkable change in lithologies of the same age from western Alabama into Kemper County. Here, the classic marine section of Alabama passes westward into a nonmarine facies, making correlation and stratigraphic delineation exceedingly complex. For some formations, it proved desirable to visit critical localities considerable distances away, in order to determine the relations of the rocks of the mapped area to rocks previously described by other geologists. Stratigraphic sections of the formations were measured within the mapped area, and also at favorable localities in the surrounding region. A study of the fossils in various formations, and determination of ranges of species were essential.

PREVIOUS INVESTIGATIONS

The published contributions which bear either directly or indirectly on the geology of the area are, in the main, of four types: 1) Geological studies of near-by areas; 2) stratigraphic and paleontologic papers dealing with formations that are present in Kemper County, or with correlative formations; 3) papers discussing the structural problems of the Gulf Coast area, and particularly the Mississippi Embayment; and 4) reports dealing with minerals of economic import. The categories outlined above contain a large number of titles, many of which are listed in the bibliography of the present report. Only those that deserve special mention in connection with the present report are discussed here.

In 1854 appeared the first general account of the geology of Mississippi. Wailes (Wailes, 1854) devoted some ninety-two pages to geology and paleontology, and had several color diagrams illustrating aquifers, and structure, in addition to numerous plates of fossils. Mention was made of ferruginous deposits of Kemper County (p. 229). The remainder of the report was devoted to agriculture, and included sections on the fauna and flora of the state. Further information of a general nature about the county may be found in the work of Harper (Harper, 1857). Included in his report were a geologic map of Mississippi, a glossary, and several sections and maps of different counties, along with a table showing stratigraphic units. Mention was made (pp. 93-95) of the "Cretaceous Formation" in the eastern part of Kemper County, and "the argillaceous carbonate of lime, here called rotten limestone . ." and fossils collected near Wahalak, including vertebrae, teeth, and coprolites of the Mosasaurs. Other important fossils mentioned are the bones and skeletons of *Cheloniana,* or turtles. Invertebrates found and identified by Harper included *Ostraea carinata, plumosa, Gryphaea mutabilis, Exogyra costata,* and *Belemnites americanus.* He roughly divided the Cretaceous into two groups, "calcareous or lime group," and the "glauconitic group." Harper also mentioned a lignite bed in Kemper County, northwest of DeKalb, which he described as being 4 feet thick (p. 210).

Probably the most important of the earlier general works is that by Hilgard (Hilgard, 1860), who provided a more detailed geological map accompanying his text, than his predecessors, and also published in this work, two generalized cross-sections (Figures 1, 2). He divided the Cretaceous of Mississippi into the "Eutaw Group," the "Tombigbee Sand Group," the "Rotten Limestone Group," and the "Ripley Group." The Tertiary "Formations" he grouped into the "Northern Lignitic," the "Claiborne Group," the "Jackson Group," the "Vicksburg Group," and the "Grand Gulf Group." His Quaternary "Formations" included the "Orange Sand," the "Bluff Formation," the "Yellow Loam," the "Hommock or Second Bottom," and the "Alluvial." He considered the "Orange Sand" formation as characteristic of "the greater part of the surface of the State," (p. 5) and he stated, "The extensive and minute examination, which I have bestowed on the various stages and facies of the Orange Sand formation of Mississippi have failed to satisfy me that it contains any fossils whatsoever characteristic of itself." (P. 17.) Hilgard studied the fauna of the "Rotten limestone" and the lignites of the Tertiary in Kemper County.

Crider (Crider, 1906) discussed at some length the "Porters Creek Clays," and mentioned that the Flatwoods belt is about 10 miles wide at Scooba, in Kemper County (p. 55). An analysis of the clay from that vicinity appeared in his text. From a maximum width of outcrop of 14 miles, with a westward dip of 15 feet to the mile Crider figured the thickness of the Porters Creek to be 210 feet. Samples from the Selma of Kemper County were analyzed. In addition, in Crider's work were numerous lists of fossils which he collected.

Excellent descriptions of lithology, as well as a review of early Cretaceous classification schemes appeared in Stephenson's "Cretaceous Deposits of the Eastern Gulf Region and Species of *Exogyra* from the Eastern Gulf Region and the Carolinas" (Stephenson, 1914). The paper contained also numerous photographs of specimens, faunal lists indicating three collecting localities in Kemper County, and a correlation chart showing lithologic variations and age relations of the Cretaceous deposits from Maryland and Delaware through Mississippi thence to Tennessee and Illinois. In 1915, Stephenson (Stephenson, 1915) described several sections of the Cretaceous-Paleocene contact zone in Kemper County (pp. 164-166), mentioning some of the fauna contained therein.

In 1915, Lowe (Lowe, 1915) in "Mississippi, Its Geology, Geography, Soils and Mineral Resources," alluded to outcrop belts of the Cretaceous in Kemper County. A revision of this work, with additions, appeared as Bulletin 14 of the Mississippi State Geological Survey in 1919, and as Bulletin 20 in 1925. The marls and limestones of Mississippi were discussed by Logan (Logan, 1916) in "Marls and Limestones of Mississippi," on page 46 of which reference is made to the Selma chalk in the northeastern part of Kemper County. An analysis of the chalk appeared in Table 18.

Probably the first extensive exploration for bauxite in Mississippi was made in 1923 by Morse (Morse, P. F., 1923). A description and analysis of the bauxite deposits on the J. C. Flora property in Kemper County appear on page 174 of Morse's report. General information on bauxite, both domestic and foreign, and data on characteristics and chemical composition are contained in this bulletin.

Stephenson, Logan, and Waring's "The Ground-Water Resources of Mississippi with Discussion of the Chemical Character of the Waters by C. S. Howard," (Stephenson, Logan, and Waring, 1928) represents the first real contribution to subsurface water study in Mississippi. Sixty-three pages are devoted to the general geology of Mississippi, and opposite page 28 appears a generalized geologic section of Mississippi, along with information on water-bearing capacity and kind of water. Water resources are discussed by county, the text consisting of remarks on the general features, ground water conditions, and local supplies. Kemper County is given due space, tables of wells drilled and analyses of ground waters being presented (pp. 255-259). A reconnaissance geologic map, Plate 2; a map showing areas of artesian flow and location of typical wells, Plate 8; and a map showing ground-water conditions of the Cretaceous, including areas of artesian flow and location and depth of typical wells, Plate 9, are included in the report.

In 1933, Lowe in "Coastal Plain Stratigraphy of Mississippi, Part First, Midway and Wilcox Groups," (Lowe, 1933) mentioned high ridges north and south of DeKalb in Kemper County (p. 63) marking outcrops of oxidized and indurated minerals believed to be Naheola (Sec.27, T.11 N., R.16 E.): "This may be sandy indurated facies of Ackerman or southern representative of Tippah sandstone member of the Porters Creek, but probably is the Naheola." Other references are to lignites at the base of the Ackerman, and to a collecting locality at Wahalak, in the northern part of Kemper County. Reference is made on page 19 to a gray, calcareous clay, which on the basis of fossils he called either upper Clayton or basal Porters Creek. Lowe further stated that additional examination of the area might discover the Clayton under an altered physical aspect.

Grim (Grim, 1936) collected samples from four different localities in Kemper County (pp. 83-87 and pp. 91-92), and from his mechanical analysis and microscopic examinations determined the depositional conditions. All the Kemper County samples were collected from the Wilcox.

In 1940, Stephenson and Monroe published on the geology of the Cretaceous outcrop area in Mississippi (Stephenson and Monroe, 1940). The report added considerably to the knowledge of the area involved. Sections were described, and fossils collected from several localities in Kemper County. Numerous cross sections added to the value of the report. In the same year, several sections in the southern part of Kemper County were described by Foster (Foster, 1940).

Investigations of an economic nature have resulted in the publishing of several reports, with specific references to Kemper County. U. S. Bureau of Mines War Minerals Report 298, "Bauxite Exploration in Winston, Kemper, and Noxubee Counties, Mississippi," published in 1944, mentioned bauxite on the Flora property, and the amount shipped. F. Stearns MacNeil issued a report in 1946 (MacNeil, 1946) in which Midway-Wilcox geology was studied as a part of the extensive bauxite investigations which were carried on by the U. S. Geological Survey and the U. S. Bureau of Mines. A correlation chart accompanied MacNeil's report, and on it are descriptions of fourteen measured sections of Kemper County geology. This work represents probably the most detailed surface regional investigation of these deposits yet published.

In 1950, Mellen issued a report (Mellen, 1950) on the Fearn Springs formation in Mississippi. Mellen named the Fearn Springs formation in 1939 (Mellen, 1939), and the objectives of his 1950 report on the Fearn Springs were three-fold: "To correct any misconception of what is included in Fearn Springs formation;" "To illustrate the cyclical deposition that has been observed in the Southeastern States in beds ranging in age from Pennsylvanian or earlier to Miocene;" and finally, "To present a provincial argument that these depositional cycles, in being genetic units, individually represent a complete geologic process, the sediments of which, irrespective of their heterogeneity, comprise a fundamental rock unit, the formation." On pages 10 and 11 of Mellen's paper are photographs of the "Interbedded sand and shale in upper member of Fearn Springs formation," and "Fearn Springs-Ackerman unconformity," both in road cuts in Kemper County (from Foster, 1938, Figures 7, 8). In 1951, MacNeil (MacNeil, 1951) discussed the Fearn Springs as a member of the Wilcox formation, and its relation to the Ackerman formation, with notations regarding their distribution in Kemper County.

Information pertaining to subsurface stratigraphy of Kemper County is of a general nature. Nunnally and Fowler (Nunnally and Fowler, 1954) discussed the broad aspects of the Lower Cretaceous subsurface stratigraphy in Mississippi, and their isopach map of the Lower Cretaceous, Plate 3, shows its thickness in Kemper County to be between 1,000 and 2,000 feet.

Detailed structural mapping has been done by major oil companies in Kemper County in recent years, but this information is not available to the public.

In 1955, Priddy published a report on the fresh water aquifers of Mississippi (Priddy, 1955). From his studies he showed the water-bearing possibilities of the Wilcox in Kemper County to be excellent. In addition to tabulation of data from key wells of the counties in question, Priddy published a geologic map showing fresh water units and seven cross sections.

PRESENT INVESTIGATION

Preparation: Aerial photographs of Kemper County on a scale of 1:20,000 or 3.168 inches per mile, obtained by the Mississippi Geological Survey from the Agricultural Adjustment Administration, were indexed for ready reference in the field. The writer used as a base map a Mississippi State Highway Department county road map, on a scale of 1:63,360, or 1 inch per mile, made from aerial photographs in 1950, revised 1955. The accuracy of the roads and drainage on the base map was checked by 1955 aerial coverage, and by driving over the county, and the necessary corrections were made. For quick reference to the photographs, the position of each flight strip was plotted to scale at the top and bottom of the base map. A careful study of the photographs was made under the stereoscope, of the drainage, and topography, as well as the cultural detail, prior to field work.

Field work: The field investigation began in July of 1954, and was continuous to the end of August of 1956, a total of twenty-four months. The geology was mapped directly on alternate photographs with a grease pencil, which would not damage the emulsion of the pictures, and which could be easily removed with carbon tetrachloride or similar solution. Reductions were then made photographically to the scale of the map, and the data were then transferred. Several weeks were spent driving through the county, taking notes on the general geology. Detailed systematic studies were then begun. Mapping was started in the northeast part of the county, where the oldest formations are exposed. Prior to each day's field mapping, a complete stereoscopic study was made of the photos of the area to be covered. Formations were traced along the outcrop where possible, and contacts and outcrops were located by making a small hole in the photograph with a needle, and marking on the reverse side of the print, the formation name. Important outcrops in inaccessible areas were reached by use of the Survey's Kaman helicopter. Nine stratigraphic tests were made with the Survey's George E. Failing 750 Core Drill, and for each hole an electric log was made with the Survey's Widco Logger, thus greatly simplfying the study of the geology in areas of poor exposure. No U. S. Geological Survey topographic quadrangle maps were available for Kemper County. U. S. Coast and Geodetic Survey bench mark data, as of 1946, were added to the base map, and were used in conjunction with an American Paulin altimeter for carrying elevations. In July of 1955, the Army Map Service made available a compilation of the Meridian Sheet, a topographic map on a scale of 1:250,000, which included Kemper and surrounding counties.

Collections of megascopic fossils and foraminiferal samples were carefully taken at intervals throughout the section, and along the strike of the beds in the same horizons. Collections of mineral substances of possible economic value were made, as well as lithologic samples, and the localities from which they were obtained carefully noted. Stratigraphic sections were measured with hand level and with a steel tape graduated to hundredths of a foot, photographed and sketched in the field. For accuracy and consistency in descriptions, grain size determinations were made first by visual comparison with the U. S. Geological Survey Grain Size Card, and later by a sand tube made by the Hydrologic Laboratory of the same organization, both devices following the Wentworth scheme of classification (Figure 2). A Brunton compass of the quadrant type was used for bearings and dip determinations. Profile sheets (scale: horizontal, 1 in.=100 ft.; vertical, 1 in. =10 ft.) were obtained from the State Highway Department. Detailed sections were measured at close intervals, and the geologic data obtained thus were placed directly on the profile by means of graphic conventions. By this means, the variation of the lithic units in several directions could be studied.

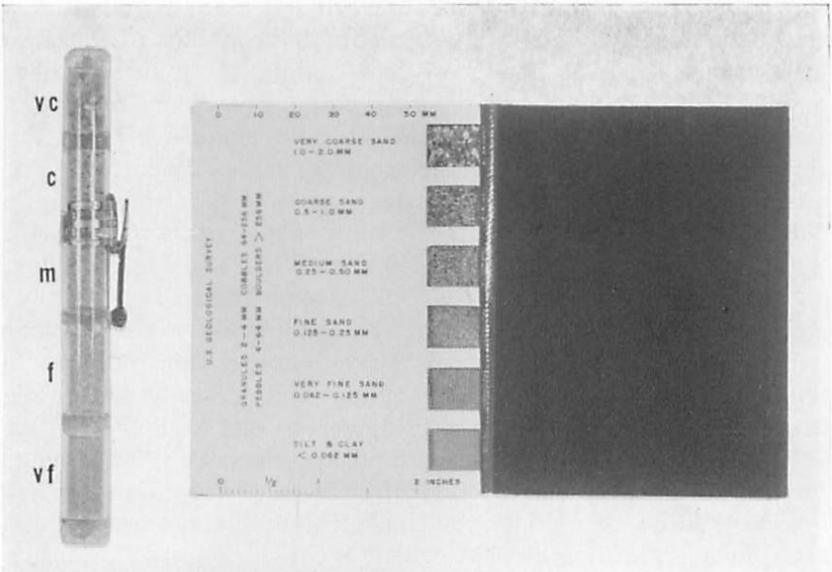


Figure 2.—Sand tube and grain size card.

Laboratory procedure: Fossil collections were cleaned, sorted, and identified. Foraminiferal samples were washed and studied. Thin sections were made of representative lithologies of formations within the county and photographed. For making subsurface correlations and isopach maps, electric logs were obtained for all wells in the county and in adjacent counties that had a direct bearing on the problem.

GENERAL RELATIONS

Physiography and Geomorphology: The physiographic provinces of Kemper County and their relationship to Mississippi can be seen by examining Figure 3. All of Mississippi lies within the Gulf Coastal Plain physiographic province. Kemper County is made up of "belted" topographic divisions of three major types—the Black Prairies, a broad, low-lying belt of land of slight to moderate relief and gently rolling hills; the Flatwoods Belt, a broad lowland having a relatively smooth, gently undulating surface; and the North Central Hills, a highland area, a maturely dissected plateau sloping gently to the southwest. The major part of the county lies within the Flatwoods and North Central Hills divisions; only a relatively small area in the extreme northeastern part is in the Black Prairie Belt.

The Black Prairie Belt borders the Tombigbee and Tennessee River Hills (Fall Line Hills of some geologists) on the west and extends as a great crescent-shaped belt across Mississippi from Tennessee on the north to Alabama on the east and thence across Alabama in a direction slightly south of east. Its boundaries are practically coincident with those of the outcrop units of the Selma group the nature of which is the major factor influencing the development of its physiography and soils.

The Black Prairie has its greatest width and most typical development in the southern half of its extent, where it is 25 miles or more in width. Inasmuch as the chalk is more readily eroded than the sands which compose the hills on either side, its surface elevation is lower than that of adjacent areas. Elevations of 100 feet are normal for the extreme southeast part of the belt in Kemper County and 250 feet and more to the north and west near Wahalak Creek.

The surface is gently rolling; valleys are generally broad and shallow, and the gentle rises which form the divides are almost imperceptible except for an occasional low, rounded knoll. However, the crests of the ridges may be distinguished at some distance by the blackjack and postoak which crown them, or by "bald knobs" formed by the outcropping chalk of those areas from which the mantle has been removed.

The cuesta form, which is typical of the Pontotoc Hills to the north, continues southeast through Kemper County, but is more subdued. The change in topography and the narrowing of the Pontotoc Hills in their southern extremity merely reflect a change in the character of the underlying material. The Ripley sand, which is the parent material of the Pontotoc Hills, and the Selma group, which is the parent material of the Black Prairie, grade laterally into each other. Here to the south the Ripley is a sandy chalk facies of the Ripley sand of the Pontotoc Hills.

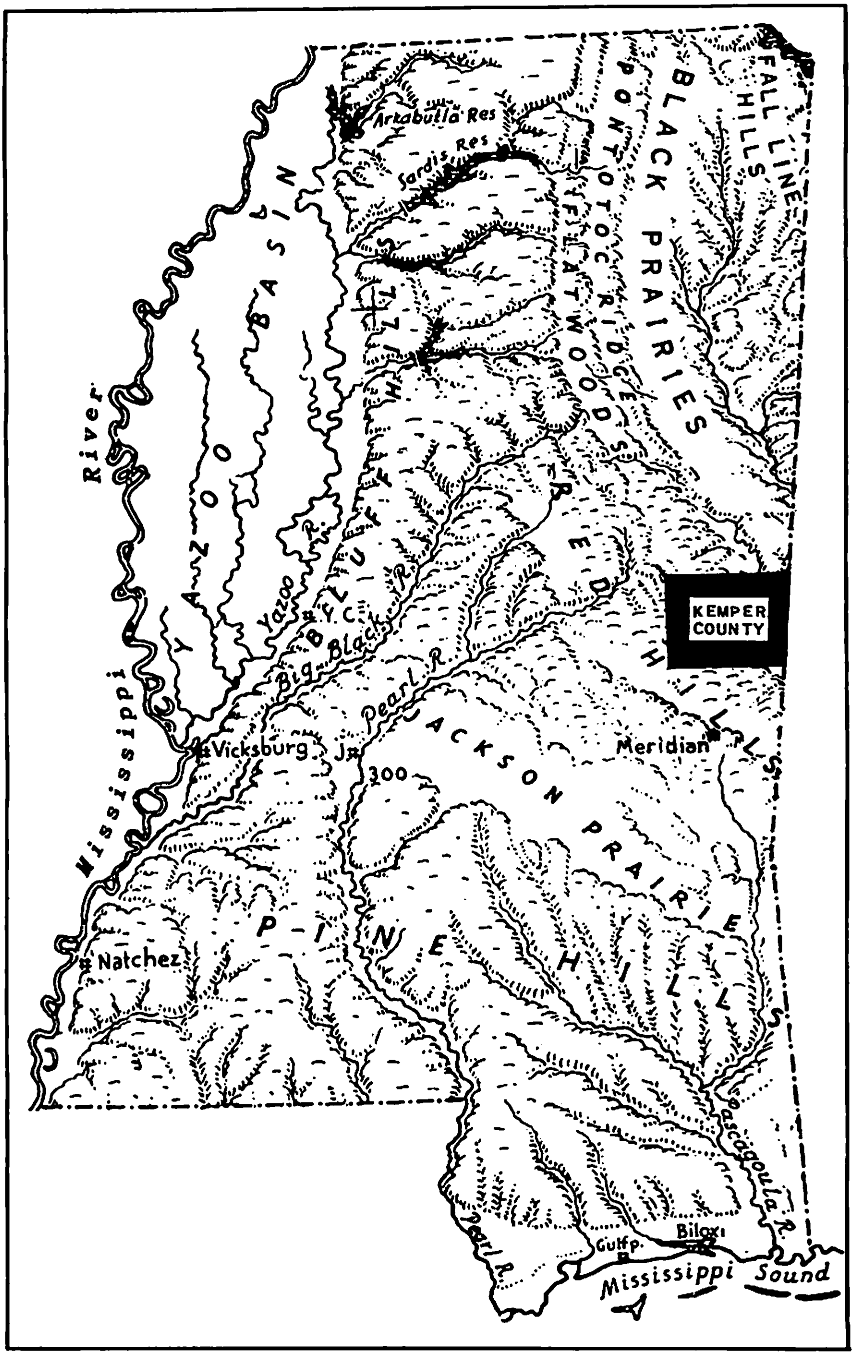


Figure 3.—Physiographic provinces of Mississippi and Kemper County. (After Raisz)

The lime and clay content increases, the underlying material becomes marly and grades into the sandy chalk facies of the Ripley sands, producing a more subdued topography.

The Flatwoods Belt in Kemper County is a strip approximately 12 miles wide underlain by the stiff, blocky, massive gray clays of the Porters Creek clay. Its elevations vary from 200 feet in the eastern part to approximately 300 feet in the western part. The Flatwoods presents the aspect of a flat, almost featureless or gently undulating plain, slightly modified by broad, shallow valleys, an aspect similar to that exhibited by morainic topography. A close stereoscopic examination of aerial photographs indicates that the appearance of flatness is probably accentuated by the heavy stand of oak and loblolly pine which prevents the slight relief and gentle slopes from coming into view. The exact boundary between the Flatwoods and the Black Prairie is distinguished in much of Kemper County mainly by change in soils, vegetation and drainage.

In the north and west part of the Flatwoods area the topographic features are more pronounced, an undulating, rolling and hilly topography having been developed—a topography which is particularly noticeable along the western edge where the Flatwoods grades into the rugged sand hills of the north central upland. This is the topographic expression of the underlying geologic conditions, for in the west the upper Porters Creek clay is sandy. Examples may be found in Sec.6, T.11 N., R.17 E.; Sec.23, T.12 N., R.16 E., and Sec.11, T.12 N., R.16 E.

Bordering the Flatwoods on the west and extending to the Loess Bluffs bordering the Mississippi Alluvial Plain and to the Central or Jackson Prairie region on the south are the sand and clay hills of the North Central Hills division, the equivalent of the Southern Red Hills of Alabama and west Georgia. Various names have been given to this province such as Red Hills, North Central Plateau, North Central Highlands, Shortleaf Pine Region, and Yellow Loam Region, by different authors. All these terms are descriptive of one or more of the characteristics of the area as developed in Mississippi, and are local in character, whereas the physiographic unit which they are used to define extends north into Tennessee and Kentucky and east into Alabama and Georgia.

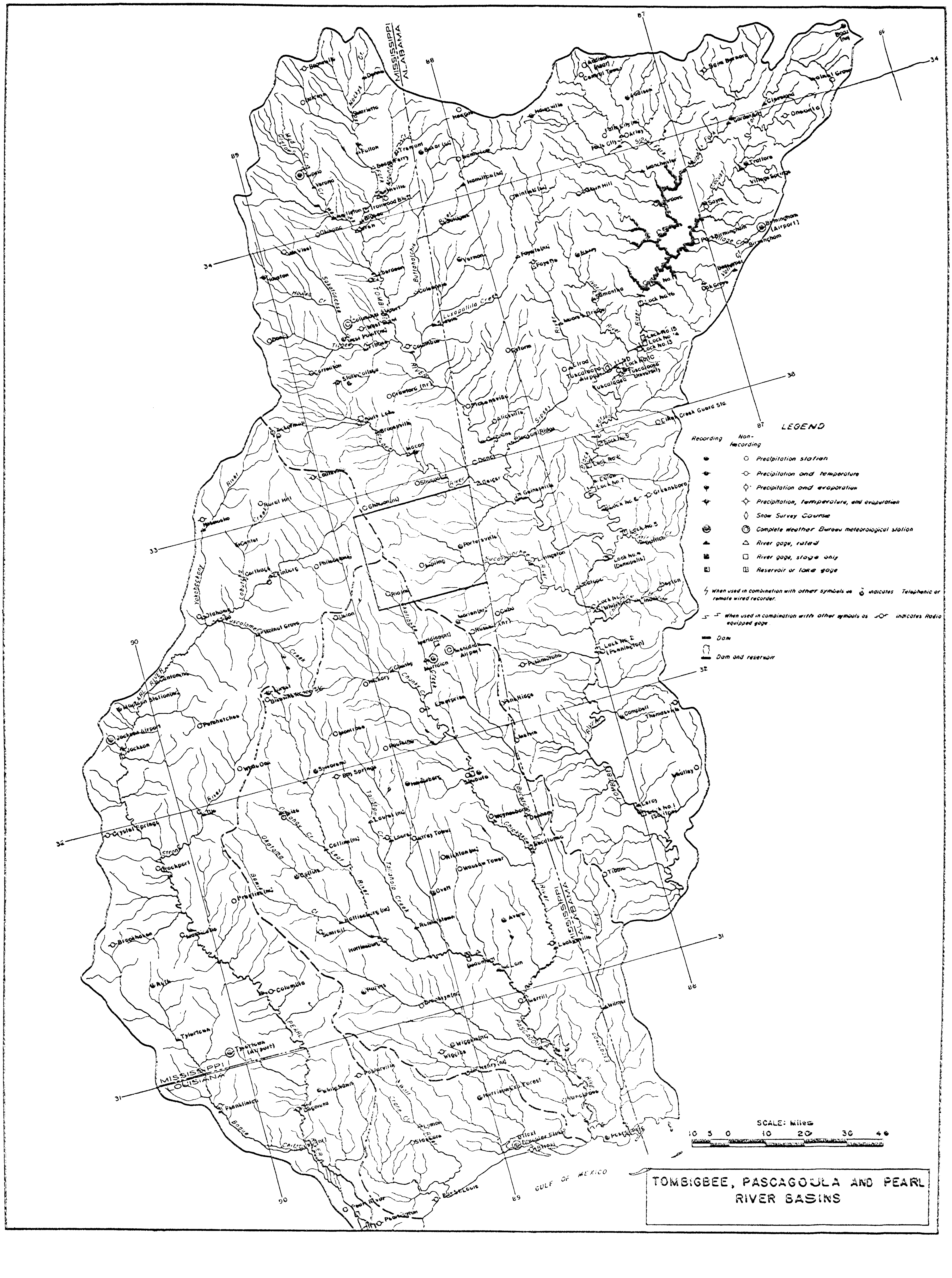
As the name North Central Hills implies, this is a highland area, a maturely dissected plateau, whose slope, agreeing with the dip of the underlying beds toward the south and west, is too faint to be perceived. The extent of the North Central Hills corresponds closely to the surface distribution of the sands and sandy clays of the Wilcox and Claiborne groups. The sands and sandy clays are unconsolidated and hence wash badly on the hillsides. Gullying is characteristic of the area. Into these sediments numerous streams have cut valleys to depths of as much as 200 feet below the tops of the ridges, and throughout most of the area the topography is rough or rugged, except for the broad flats of the major streams and the relatively rolling terrain of major inter-stream areas.

DRAINAGE

Kemper County is thoroughly dissected by numerous rivers, creeks, intermittent streams, and rills, which have gullied much of the unconsolidated land into a maze of deep erosional channels. The major streams flow northeast, east, southeast, south, and northwest, and the relatively rugged terrain of western Kemper County divides the drainage areas of the Tombigbee, Pascagoula and Pearl River Basins (Plate 2).

The eastern two-thirds of the County is drained by the Tombigbee River System, mainly through the southeasterly-flowing Sucarnoochee Creek and its tributaries, including Pawticfaw and Blackwater Creeks and a small part of Ponta Creek; also through Wahalak, Bodka and Scooba Creeks, which flow easterly, northeasterly, and southeasterly through the northeastern corner of Kemper County to join the Noxubee River System. Both Sucarnoochee Creek and Noxubee River join the Tombigbee River in Alabama, which empties in distributaries north of Mobile Bay, a part of the Gulf of Mexico. The Tombigbee River System in northeast Mississippi drains about 6,000 square miles. The Tombigbee River is formed by the confluence of East and West Forks 20 miles north of Aberdeen. Its principal tributaries are Bull Mountain Creek, Luxapalila Creek, and Buttahatchie River on the east; and Tibbee and Noxubee Rivers on the west (Anderson, 1950).

Wahalak Creek heads in north central Kemper County (T.12 N., R.16 E.) and flows in a broad arc through the northeastern



TOMBIGBEE, PASCAGOULA AND PEARL RIVER BASINS part of the county. It flows for a considerable distance southeast, as do many of its tributaries, then, turns rather abruptly east, then northeast, to join Noxubee River in Noxubee County near the Noxubee-Kemper County line. Wahalak drainage originates in the Porters Creek formation in the Flatwoods physiographic province, and in its northeasterly course, crosses the Black Belt of Cretaceous outcrops. It has a flood plain averaging some three-quarters of a mile in width, and has an average gradient of 13.1 feet per mile.

Bodka Creek flows generally southeast and east, through the northeastern part of Kemper County (Ts. 11N., 12N., Rs. 18E., 19E.) to Noxubee River, which it joins near the junction of Noxubee and Tombigbee Rivers in Alabama. It drains the easily eroded Cretaceous formations, the Ripley, the Bluffport marl, and Demopolis chalk, where the bedrock is compact, and the rain water runs off rapidly. Chalk, composed largely of calcium carbonate, is easily eroded because rain water charged with carbon dioxide forms a weak solution of carbonic acid, increasing the solubility of calcium carbonate to over 800 parts per million. The chemical reactions and explanation are as follows:

$$(H_2O+CO_2 \longrightarrow H_2CO_3;\ H_2CO_3+CaCO_3 \longrightarrow (Ca(HCO_3)_2)$$

$$\begin{array}{lccccr}
 & & & CO_2 \text{ (in air)} & & \\
 & & & \downarrow\uparrow & & \\
 & & & H_2O+CO_2 \text{ (in water)} & & \\
 & & & \downarrow\uparrow & & \\
Ca(HCO_3)_2 & CaCO_3 & + & H_2CO_3 & & (1) \\
 & \text{(Solid)} & & \downarrow\uparrow & & \\
 & \downarrow\uparrow & & & & \\
 & CaCO_3 & & H^+ + HCO_3^- & & (2) \\
 & \text{(in solution)} & & \downarrow\uparrow & & \\
 & \downarrow\uparrow & & & & \\
 & Ca^{++} + CO_3^{--} & & H^+ + CO_3^{--} & & (3)
\end{array}$$

With the removal of CO_2 from the solution, some of the H_2CO_3 would necessarily break up into H_2O and CO_2 to supply the deficiency of CO_2 thus created. In turn, some of the ions of stage (2) would unite to form molecular H_2CO_3. To supply the HCO_3^- ions taken from stage (2), the ions of stage (3) would unite, thus removing CO_3^{--} ions from the solution. Inasmuch as these CO_3^{--} ions are attracted as much by the Ca^{++} ions as by the H^+ ions, some of the ionized $CaCO_3$ will revert to the molecular condition and hence into the solid state as a precipitate.

As a result of these chemical reactions, the surface of the drainage basin underlain by these chalky formations is characterized by low relief and a topography ranging from nearly level plains to rounded hills flanked by long, smoothly covered slopes. In areas bordering the larger streams, the prevailing rolling topography is modified by terrace deposits to nearly flat plains. Because the belt lies lower than the hilly district to the east, the static level of the water is close to the surface, and artesian wells are obtainable in many valleys. The flood plain of Bodka averages half a mile in width, and the average gradient of the creek is 9.76 feet per mile.

Scooba Creek flows generally southeast and east through Kemper County to join Bodka Creek in Sumter County, Alabama. Scooba Creek heads in Kemper County (Ts. 11N., 12N., R.17 E.) and is formed by the confluence of three main tributaries which flow southeast, east, and northeast. The erratically dendritic drainage pattern of the creek lies on a belt of low relief, most of which is underlain by the compact, impervious Porters Creek clay. The topography is gently undulating to more or less flat plain characteristic of the Flatwoods physiographic province. The headwaters and most of the length of the tributaries are intermittent streams; flowing springs to feed the creeks are rare. The flood plain averages half to three quarters of a mile in width, and the gradient of the stream averages 7.69 feet per mile.

Sucarnoochee Creek System in Kemper County is formed by two main streams: 1) Sucarnoochee Creek; 2) Pawticfaw and Blackwater Creeks, which together form a major tributary of Sucarnoochee Creek (Plate 2). In Alabama, Sucarnoochee Creek is called Sucarnoochee River, and flows east and southeast to join the Tombigbee River near Moscow. Sucarnoochee Creek and its large tributaries, Pawticfaw and Blackwater, draining an area of some 325 square miles, more or less, extending northwest-southeast almost through the center of Kemper County, form the largest drainage system of the county, approximately half of the total area. All the waters of this large, intricate drainage system head in the northern and western parts of Kemper County (Ts. 12 N., 11 N., 10 N., 9 N., Rs. 15 E., 16 E.). Most of the Sucarnoochee Creek System in Kemper County flows on the sandy, easily eroded Eocene formations, and the main course of the creek, diagonally through the east central part of the county, hugs the foot of the steep, northeast face of the Wilcox escarpment. The stream has cut deeply into the sandy hills, and throughout most of its course has exposed the underlying Porters Creek clay, which forms the stream bed at present. Intermittent tributaries are numerous, forming a modified dendritic pattern, having many trellis-like, fault-controlled features. The flood plain of Sucarnoochee Creek averages a mile in width; Pawticfaw's flood plain is one half to three quarters of a mile in width; while the flood plain of Blackwater Creek averages one half mile in width. The gradient of the upper part of Sucarnoochee Creek averages 9.75 feet per mile; and that of the lower part averages 6.06 feet per mile. The gradient of Pawticfaw averages 13.79 feet per mile, and the gradient of Blackwater Creek averages only 3.33 feet per mile.

The southwestern part of Kemper County (Ts. 9 N., 10 N.) is drained by the Pascagoula River System, through south and southeast flowing tributaries of Okatibbee and Penders Creeks. The Pascagoula River, draining 8,900 square miles in southeast Mississippi, is formed by the confluence of the Chickasawhay and Leaf Rivers north of Merrill in George County. Principal tributaries include Bowie and Tallahala Creeks (tributary to the Leaf), and Chunky, Okatibbee and Bucatunna Creeks (tributary to the Chickasawhay). Escatawpa River whose drainage area lies largely in Alabama, is the principal tributary of the Pascagoula (Anderson, 1950).

Okatibbee and Penders Creeks independently drain the southwestern part of Kemper County, join in Clarke County, and flow south to join Chunky Creek, which becomes a part of Chickasawhay River north of Enterprise, Mississippi. Thence the run-off flows to the Pascagoula River, and empties into the Gulf of Mexico at Pascagoula, 40 to 50 miles west of Mobile Bay. As evidenced by the rugged, dissected topography of southwestern Kemper County (Plate 2), the streams traverse heterogeneous formations of sand and clay. The flood plain of Okatibbee Creek in Kemper County averages half a mile in width; and the flood plain of Penders Creek averages half a mile in width in the same general area. The gradient of Okatibbee Creek is 13 feet per mile; and the gradient of Penders Creek is 12.5 feet per mile.

In the northwestern part of Kemper County (Ts. 11 N., 12 N.) the drainage is north and northwest via Bogue Chitto and its tributaries, which are a part of the Pearl River System. Pearl River flows into the Gulf of Mexico about 70 miles west of the mouth of the Pascagoula River. Pearl River, rising in central Mississippi and flowing through the middle of the southern part of the state, drains about 7,600 square miles. Its tributaries are small, the more important being Yockanookany and Strong Rivers, and Bogue Chitto (Anderson, 1950). Through most of its course in Kemper County, Bogue Chitto flows in a swampy terrain, due perhaps to a perched water table. The average gradient of Bogue Chitto in Kemper County is 9.8 feet per mile.

VEGETATION

The usefulness of vegetation as a guide to mapping geologic formations was early shown by Cuyler in "Vegetation as an Indicator of Geologic Formations." (Cuyler, 1930.) Vegetation of different types appears on aerial photographs in different tones. The usefulness of plant changes as an indicator of changes in geologic formations is dependent to a large extent on the variation in types of lithology in which the plants grow. And in some instances the exception prevails, rather than the rule . . "on the Gulf Coastal Plain in Texas it is ordinarily difficult to map structures, particularly faults in Tertiary formations where sandy material prevails. The writer has been able to map several faults by finding a single plant species, namely *Daubentonia longifolia* DC. (rattle bush), which grows only in very moist conditions. This plant may be noticed in a sandy field where the actual formation is hidden by many feet of alluvial material. Although there is no surface indication of the fault, enough water may be forced up the fault plane to cause this bush to thrive. There may not be any other specimens within several miles."

In Kemper County there is a wide variation in lithologies and the importance of vegetation changes at geologic contacts is evident. The formations composing the Selma group are practically devoid of tree growth, except for scattered clumps of crab-apple (*Pyrus augustifolia*), honey locust (*Gleditschia triacanthos*) and wild plum (*Prunus chicasa*) dotting the surface where the soil is not reduced to cultivation. Along the bluffs of streams where the chalk is exposed or lies near the surface, is a more varied growth, such as hackberry (*Celtis mississippiensis*); very commonly redbud (*Cercis canadensis*); rock maple (*Acer sacharinum*); chestnut (*Castanea vesca*); and red cedar (*Juniperus virginiana*) (Lowe, 1919).

The Porters Creek clay belt is characterized by a heavy growth of trees. On the higher land are post oak (*Quercus stellata* Wagenheim); black jack (*Quercus marilandica* Muenchhausen); spanish oak (*Quercus falcata* A. Mechaux); short leaf pine (*Pinus mitis*); loblolly pine (*Pinus taeda*); black gum (*Nyssa sylvatica* Marshall), and hickory (*Carya*). On the bottoms are spanish oak (*Quercus falcata*), larger and taller; some post oak; abundant hickory of several kinds, the shell bark (*Carya ovata* (Miller) K. Kock) being plentiful; yellow poplar (*Liriodendron tulipifera* Linnaeus); sweet gum (*Liquidamber styraciflue* Linnaeus), and water oak (*Quercus nigra* L.). On the uplands the post oak and pine form the bulk of the timber (Lowe, 1919).

The North Central Hills region in Kemper County is underlain by the Naheola formation of the Midway group, and the Wilcox group. All the units contain a large amount of sand and differentiation by vegetation is impossible. Common to all are shortleafed yellow pine (*Pinus mitis*) and loblolly pine (*P. taeda*). On the bottom lands may be found black gum (*Nyssa sylvatica* Marshall); old gum (*Liquidamber styraciflua* Linnaeus); beech (*Fagus*); poplar (*Populus*); ash (*Fraxinus*); white oak (*Q. alba* L.); water oak (*Q. nigra* L.); willow oak (*Quercus phellas* Linnaeus); maple (*Acer rubrum, A. dasycarpum,* and *A. saccharinum*); black willow (*Salix nigra* Marsh); red bud (*Cercis canadensis*); black walnut (*Juglans nigra* L.), and red birch (*Bitula nigra*) which are the prevailing species of trees (Lowe, 1919).

CLIMATE

Climatic data for Kemper County for a 12-year period are shown in Table 1. More detailed information, compiled up to 1954, is available for Meridian, Lauderdale County, and the statistics presented here are for that area.

TABLE 1

MONTHLY, ANNUAL AND AVERAGE PRECIPITATION
(IN INCHES AND HUNDREDTHS)

PORTERVILLE, KEMPER COUNTY — ELEVATION, 200 FEET.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1905	....	....	2.93	5.40	5.08	5.58	4.24	8.07	1.45	3.46	3.28	5.10	....
1906	3.97	1.72	8.99	1.19	5.42	5.96	4.88	3.55	8.24	3.95	2.34	4.63	54.84
1907	2.79	6.33	1.64	7.25	9.33	2.69	4.86	1.48	2.14	2.34	5.13	4.66	50.65
1908	4.67	7.73	3.77	4.17	8.15	6.06	4.74	4.97	.77	1.01	.63	4.38	51.05
1909	1.62	6.95	8.77	10.64	12.16	7.25	2.64	....	....	1.41	1.07	3.17	....
1910	3.51	6.72	1.15	2.81	1.85	9.98	3.05	1.31	4.36	2.47	2.30	4.48	43.90
1911	....	3.42	1.37	6.69	2.39	4.49	3.19	5.63	1.59	2.80	6.75	8.39	....
1912	4.59	4.00	14.22	10.02	2.71	9.51	5.62	....	....	....	....	8.93	....
1913	7.23	5.26	8.97	2.43	6.13	1.68	8.01	.98	7.17	1.16	3.30	3.64	55.96
1914	1.52	3.88	6.18	3.97	1.19	2.40	4.13	7.22	6.84	1.50	3.23	6.34	48.40
1915	7.15	5.54	2.97	.50	8.89	7.76	2.33	3.94	3.21	2.23	4.24	7.20	55.36
1916	6.65	2.43	2.90	2.84	9.63	2.77	11.18	3.52	.64	1.00	....	....	....
Average	4.37	4.91	5.32	4.83	6.08	5.50	4.91	4.07	3.64	2.12	3.23	5.50	54.56

The climate of Kemper County is typical of the climate of regions of like latitude and distance from large bodies of water. Winter temperature is modified by southerly winds from the Gulf of Mexico, the average temperature for December, January, and February being 48.8° F. Variations from zero to 80° F. have been recorded, but are unusual. Frosts are frequent during the winter, and occasionally a thin skim of ice or light flurry of snow is recorded. Freezing cold seldom persists for more than two or three days, at the end of which time the weather moderates.

Temperatures range from 40° to 50° during the day, followed by crisp nights. Periods of frost may be followed by rain, colder weather, and brisk winds from the north.

Extreme variations of temperature are unusual and of short duration, although there may be considerable variation from the figures given as average. In the winter months the soil sometimes freezes to a depth of 1 to 2 inches, but rarely remains frozen for more than a day or two at a time. The winter rainfall averages 15.76 inches, coming usually as steady general rains from the southwest and frequently flooding the bottom lands.

The change of seasons is not marked by abrupt weather variations. The spring months, March, April, and May, having an average temperature of 64.3° F. and rainfall of 15.14 inches, are seasons of pleasant weather, favorable to plowing and seeding. Hailstorms are almost unknown, but thunderstorms, during which the rain falls rapidly, in marked contrast to the slow general rains of winter, are frequent, usually occurring during every month of the year. A pronounced maximum of activity occurs during the summer months, July having an average of 12 thunderstorms a month, and June and August 10 each. Average annual precipitation is 55.07 inches.

Summers are warm months of steady but not extreme heat. Maximum temperatures in the nineties occur on at least half of the days, but temperatures above 100° are rare. On only four occasions during a 65-year period has the temperature exceeded 100° F. The average temperature for June, July and August is 79.8°; for July, normally the hottest month, 80.9°, and for January, usually the coldest, 47.5°. The highest recorded temperature in Meridian was 105°, on two dates, June 13, 1930 and August 27, 1943; the lowest recorded was -7° F. on January 27, 1940. Minimum temperatures of freezing or below are recorded on an average of 25 to 35 percent of the days during the three winter months, but freezing weather has never occurred during the months of May to September inclusive. This remarkable uniformity of climate is the more apparent when it is considered that the difference between the average temperatures for June, July, and August, and December, January, and February is but 31.0° F. The average temperature for the year is 64.5° F.

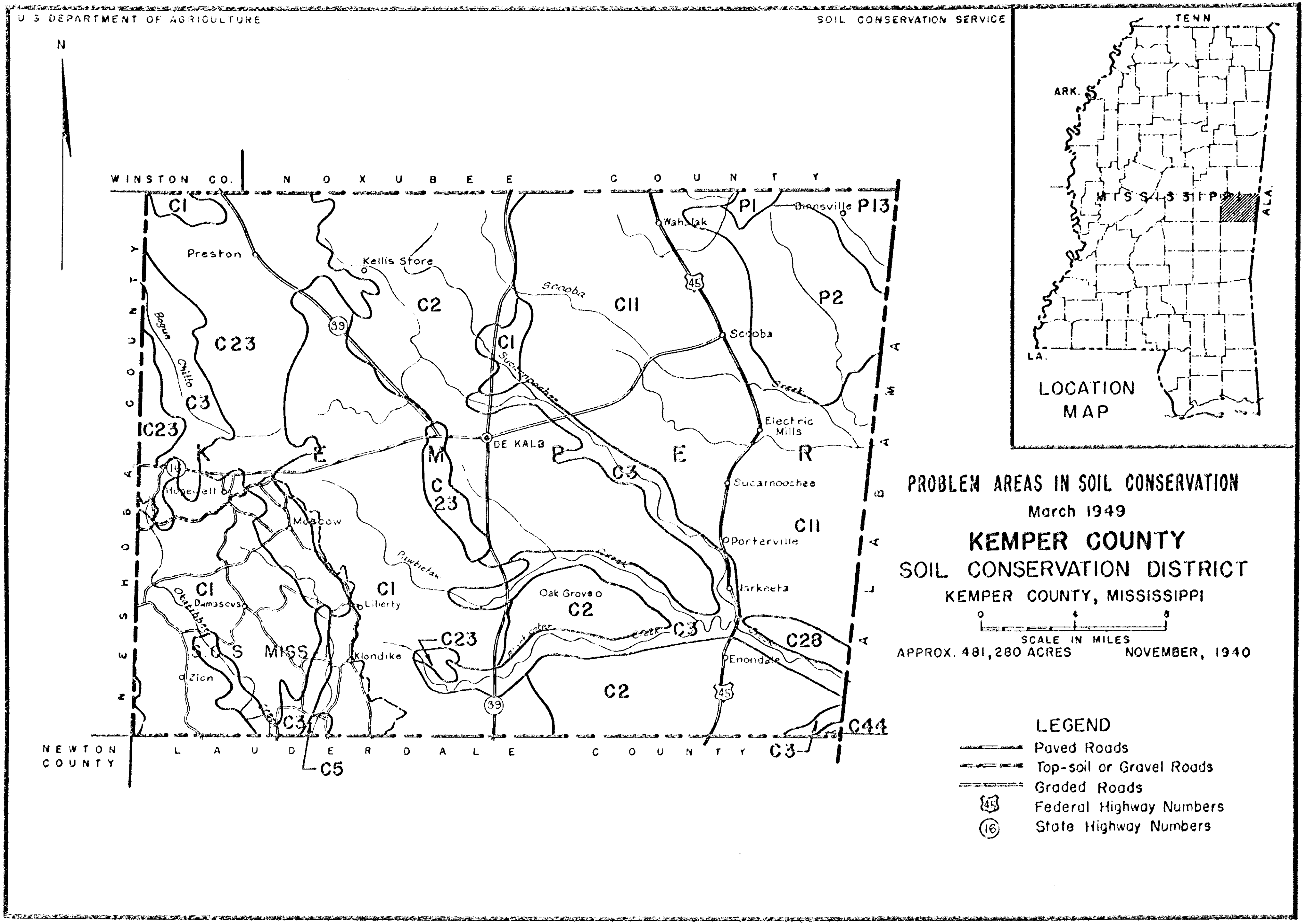
The extreme dates of the first frost in the fall and the last in spring are October 13 and April 25, respectively. The average date of the first and last frost occurence, based on 65-year records is November 7 and March 19, though in 1910 a killing freeze occurred as late as April 25. The growing season for tender vegetation is 235 days, or nearly 8 months. This gives ample time to ripen all ordinary farm crops.

There are few damp, foggy days, and the percentage of sunshine, particularly in winter, is very high. The average number of clear days on an annual basis is 135; partly cloudy 120; and cloudy 110. The relative humidity is often high. Night-time humidities have a yearly average of 83 to 85 percent; the midday yearly average is much lower, 54 percent. The lowest humidities are during the winter months when cold continental air is flowing over the district, while high humidities are the rule when maritime tropical air is present. In winter the prevailing winds are from the north, in the spring, from the south, in the summer from the southwest, and in the autumn from the northeast. March is the windiest month of the year, the March wind having an average velocity of 7.1 miles per hour.

Meridian's average annual precipitation of 55.07 inches is fairly evenly distributed by months, except for a relative dryness during the autumn. March is normally the wettest month, having a mean rainfall of 6.58 inches; October is usually the driest, the rainfall being only 2.38 inches. An adequate supply of rain is usually available for the growing season, and the relative dryness of September, October, and November is particularly favorable for the harvesting of crops.

SOILS

The two major groups of soils in Kemper County belong to the Red and Yellow Podzolic soils which cover most of the county, and are found characteristically throughout an extensive


U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
N
WINSTON CO.
NOXUBEE COUNTY
NESHOBA COUNTY
ALABAMA
NEWTON COUNTY
LAUDERDALE COUNTY
KEMPER
Preston
Kellis Store
Wahalak
Binnsville
Scooba
Electric Mills
DE KALB
Sucarnoochee
Porterville
Narkeeta
Oak Grove
Hopewell
Moscow
Damascus
Liberty
Klondike
Zion
Enondale
S C S MISS
C1
C2
C3
C5
C11
C23
C28
C44
P1
P2
P13
TENN
ARK.
LA.
ALA.
MISSISSIPPI
LOCATION MAP
PROBLEM AREAS IN SOIL CONSERVATION
March 1949
KEMPER COUNTY
SOIL CONSERVATION DISTRICT
KEMPER COUNTY, MISSISSIPPI
0 4 8
SCALE IN MILES
APPROX. 481,280 ACRES
NOVEMBER, 1940
LEGEND
Paved Roads
Top-soil or Gravel Roads
Graded Roads
Federal Highway Numbers
State Highway Numbers

region in the southeastern part of the United States, including most of the Coastal Plain, much of the Piedmont, the Ozark plateaus, and the southern ends of the Appalachian Plateau and limestone valleys. These soils are typically acid, strongly leached and are low in organic matter and plant nutrients. In the extreme northeastern part of the county the soils belong to the Intrazonal soils known as the Rendzina soils. The Rendzina soils in the more recent classification of soils are referred to as the Grumosols.

The Red and Yellow Podzolic soils are locally known as sandy clay hills soils and may be subdivided into several groups (C1, C2, C3, C5, C23, C28, and C44). These soils overlie the North Central Hills or the Naheola, Nanafalia, Tuscahoma, and Hatchetigbee formations. The soils of the C11 group cover the Flatwoods Belt or the Porters Creek formation.

The Intrazonal or Rendzina soils are dark colored, heavy-textured soils usually underlain by calcareous sediments. These soils develop from chalk, soft limestone, or marl and may be regarded as immature. Locally they are referred to as the Black Belt or Black Prairie soils and are subdivided by soil scientists into the following groups, P1, P2, and P13. These soils overlie the Demopolis, Ripley, Prairie Bluff and Clayton formations in Kemper County (Plate 3). The descriptions of the soil groups of Kemper County appear below (Covell, R. R., State Soil Scientist, and Havens, Y. H., Assistant State Soil Scientist; personal communication, 1956).

"C1 Rough hill areas. The soils are usually thin and have limited profile development. They have sandy surfaces over friable sandy materials. Gravel occurs through these soils in local areas. Some of the soils are heavy, tough acid clays. Slopes are steep or very steep. Erosion is slight over much of the area, becoming moderate locally. Ridge tops are usually narrow, but some do widen out sufficiently for occasional fields. Small valleys are narrow or medium width and of limited value for cropping because of inadequate drainage. Much of this area is still in forest cover. RUSTON, EUSTIS, CUTHBERT, SHUBUTA, MANTACHIE and BIBB SOILS.

"C2 Rough hill areas. The soils are usually thin and have limited profile development. They have sandy surfaces over friable sandy materials. Gravel occurs through these soils in local areas. Some of the soils are heavy, tough acid clays. Slopes are steep or very steep. Erosion is slight over much of the area, becoming moderate locally. Ridge tops are usually narrow, but some do widen out sufficiently for occasional fields. Small valleys are narrow or medium width and of limited value for cropping because of inadequate drainage. Much of this area is still in forest cover. EUSTIS, RUSTON and CUTHBERT SOILS.

"C3 Valley land along larger streams. The overflow land in this unit generally is imperfectly or poorly drained. Some of it is well drained. Textures are sandy or silty. Frequent overflow is a serious hazard to row crops. Drainage is needed for the best use of the land as well as protection from overflow, but drainage is often impractical. The land ranges from poor to good in quality. Adjoining the overflow land in this unit are varying amounts of terrace or bench lands made up of shallow to moderately deep, sandy soils on nearly level and gentle slopes with little erosion hazard. The majority of the land in this unit is still in forest. IUKA, MANTACHIE, BIBB, PRENTISS and STOUGH SOILS.

"C5 Moderately deep, sandy loam table lands on gentle slopes with moderate erosion. Drainageways have short, strongly sloping to steep side slopes. Small bottoms are usually medium width, or narrow with imperfectly or moderately well drained sandy bottom soils. Much of this unit is open land which is being or has been cropped. SAVANNAH, SHUBUTA, PRENTISS, MANTACHIE, and IUKA SOILS.

"C11 Interior flatwoods. Dominantly shallow silty or sandy soils over heavy, dense, gray, acid clays on gentle slopes with slight erosion. Occasional short steep slopes occur adjacent to stream valleys. Bottoms are moderately wide with gray, poorly drained, slightly heavy overflow soils. The soils in this unit have low inherent fertility. Much of the unit is still in forest. Good grazing lands can be developed in this unit. WILCOX, MAYHEW, IUKA and MANTACHIE SOILS.

"C23 Broad ridge top areas of moderately deep, silty or sandy loam soils with hardpans on moderate slopes, and side slopes ranging from rolling to steep, of sandy to very heavy soils with erosion moderate over the whole area. Valleys are narrow or medium width with productive, sandy alluvial soils when drained. Most of the better sloping and part of the steeper sloping land in this unit has been cleared and cropped. SHUBUTA, ORA, SAVANNAH, RUSTON and CUTHBERT SOILS—Valleys IUKA, MANTACHIE and BIBB SOILS.

"C28 Deep, friable well drained sandy loam soils on gentle and steep slopes with moderate erosion. Valleys tend to be narrow and bottom soils are imperfectly drained and sandy. With drainage they are fairly productive. This is a good agricultural unit, with soils quite fertile inherently. RUSTON, RED BAY and FACEVILLE SOILS.

"C44 Shallow soils with sandy loam surfaces and heavy acid clay subsoils on moderate and steep slopes with moderate erosion. This unit also includes some minor areas of deep, well drained sandy loam and loamy sand soils. Bottoms are narrow, poorly drained alluvial soils. Much of this area is cutover timber land and is used for open range. CUTHBERT and RUSTON SOILS.

"P1 Mixed prairie and coastal plain bottoms. Mixed heavy textured, near neutral and sandy, acid bottom lands, needing drainage for row crop production. Adjoining the overflow lands are varying amounts of mixed prairie and sandy bench lands on nearly level slopes and only slightly eroded. These bench lands range from poorly drained to moderately well drained. The majority of this unit is open crop or grass land. CATALPA, KAUFMAN and TRINITY SOILS.

"P2 Heavy, shallow to moderately deep, acid clay soils on nearly level to strong slopes, generally with moderate erosion. Bottoms in this area tend to be broad and are composed of dark, heavy clays. Drainage is needed in the bottoms. Much of the hill land is in poor quality hardwood forest. It is, however, good grass land. Post Oak Prairie. OKTIBBEHA, VAIDEN, EUTAW, CATALPA and KAUFMAN SOILS.

"P13 Shallow to medium depth, dark, heavy alkaline clays over soft, chalky limestone, on moderate slopes and severely eroded. Open land. Bottoms are broad, with dark, alkaline, heavy clay soils which are very productive but need drainage. Very well suited to grass and forage crops. HOUSTON, BINNSVILLE and SUMTER SOILS."

POPULATION AND ECONOMIC DEVELOPMENT

The 17th census of the United States, for the year 1950, shows that the population of Kemper County consisted of 6,460 white people and 9,433 colored people, a total of 15,893 or 21 people per square mile, a decrease of 5,974, or 27.3 percent, below the census of 1940. All the population is rural—3,102 rural non-farm population, and 12,791 rural farm. According to the Bureau of the Census, to be classed as urban, people must be residents of a town having 2,500 inhabitants or more.

There are no towns of any considerable size within the county. DeKalb, the county seat, one of the old towns of the state, is located near the center of the county, and has the largest population, 943. Scooba, north by east of DeKalb, is second, with a population of 734. DeKalb shows a gain of 87 inhabitants over the 1940 census, whereas Scooba shows a gain of 128. Numerous villages are scattered over the county, among which are Wahalak, Enondale, Porterville, Sucarnoochee, Damascus, and Liberty.

The chief industries of the county are almost exclusively agricultural; farming and lumbering. Much of the county is timbered with long-leaf and short-leaf pine, oak, walnut, chestnut and gum. The rich farm lands of the east Mississippi prairie belt, lying east of Scooba, are one of the most productive sections of the state. They are adapted to growing alfalfa, melilotus and other clover, and grasses. In the middle and western parts of the county the soil is a sandy clay loam, easily worked and productive. Good crops of cotton, corn, oats, wheat, sugar cane, water melons, sorghum, field peas, potatoes, fruits and vegetables are raised. Pasturage of native grasses, switch cane, and Japan Clover is excellent, and considerable attention is paid to stock raising and dairying. The Gulf, Mobile and Ohio Railroad aids materially in the transportation of raw materials to the various markets. The principal market is Meridian, some 30 miles to the south. Another method of transportation is trucking. Water melons of Kemper County commonly are shipped by this method.

In 1950, the U. S. Department of Agriculture statistics showed that there were in the county, 2,808 farms, comprising 292,000 acres, and having an average value per farm of $2,848.00. The total value of farm products sold in 1949 was $1,621,000.00.

Timber is one of the county's greatest resources. The owners of large private forests in the South are experiencing an upsurge in market value, and are placing their holdings under good forest management. Logging is relatively easy, and tree growth is rapid. The gum naval stores, one of the nation's oldest industries, is still in active production; and since 1947 other sources of turpentine and rosin have been developed through destructive distillation of long-leaf pine stumps and the recovery from pulpmill waste. The pulp industry is one of the newest of the large forest industries. Half the pulp, and one-third of the paper of the United States is produced in the South. The pulp industry here began concentrating on kraft paper, but is being diversified by the developing manufacture of paper for newsprint and other light colored papers. Trees are the paying crop for a large percentage of the land. (Trees, Yearbook of Agriculture, U. S. Dept. of Agriculture, 1949, pp. 279-281). In Kemper County are some of the large private forest holdings of the South. The Flintkote Lumber Company of Chicago, Illinois, has holdings in Kemper County that include practically all of the Flatwoods Belt. These large forests formerly belonged to the Sumter Lumber Company. The total value of forest products produced in Kemper County in 1949 amounted to $176,936.00 and in 1953, $97,993.00. (County Table 8, Nursery, Greenhouse and Forest Products, Censuses of 1954 and 1950, pp. 119-125, in U. S. Dept. Commerce, Bureau of the Census, Washington, D. C., 1956, Mississippi—Counties and State Economic Areas, 1954, Census of Agriculture, Vol. 1, pt. 22).

HISTORY

Kemper County was established December 23, 1833, and received its name from Reuben Kemper, an American soldier in the Florida and Mexican wars. Reuben Kemper was born in Virginia. With his brothers, Nathan and Samuel, he led unsuccessful expeditions against the Spanish in Baton Rouge, Mobile and Pensacola. The "Kemper affair" was the beginning of the disorder that finally furnished the United States some actual warrant for taking possession of Baton Rouge, as well as the coast region near Mobile. The activities of Reuben Kemper were intimately connected with the disturbance and mystery which involved the Mississippi Territory during the years 1805-07 (Rowland, 1925).

Kemper was one of the sixteen counties formed in 1833 from the territory acquired from the Choctaws, by the treaty of Dancing Rabbit, and the congressional description defined its boundaries as follows: "The territory within townships nine, ten, eleven, and twelve North, of ranges fourteen, fifteen, sixteen, seventeen, eighteen, and fractional range nineteen East." The eastern boundary of Kemper County is diagonal because in the border settlement between Mississippi and Alabama, the boundary surveyed in 1820, was accepted as a line running from the mouth of Bear Creek to "what was formerly the north-west corner of the county of Washington, Alabama." This was the territorial county of Washington, and where the trading road from the Choctaw nation to Mobile crossed the line of the first Choctaw cession was the north-west corner indicated. (Rowland, 1925.)

DeKalb, the county seat, chartered December 23, 1833, named for the German soldier, Johann Kalb, known as Baron deKalb, who came to America in 1776 to assist in the fight for independence, is on the site of the old Choctaw village "Holihtasha" (Indian for "The fort is there"), and was ruled by Hopiah Iskitina (Little Leader). DeKalb is responsible for the sobriquet "Bloody Kemper." After the war between the states, this formerly quiescent southern town became the scene of one of the bloodiest of the Reconstruction massacres. Over a period of years, from 1868 to 1876, certain elements of the county, under the "carpetbag" judge, William Chisolm, and the Ku Klux Klan, waged a bitter contest for supremacy. Shooting from ambush resulted in the deaths of members of both factions and made travel through the county unsafe.

In 1876, John Gully, a member of the Klan, was shot and killed as he rode horseback across the county one night. Judge Chisolm was accused of the murder and was held in the DeKalb jail, his wife, daughter, and two sons insisting on being locked in with him. In late December, 1876, the Chisolm massacre took place. A mob, with the cry, "Fire the jail," entered to take Chisolm. The judge seized a gun and prepared to escape with his daughter and son. The three were shot and killed as they appeared before the crowd at the top of the steps. An account of the violence in that period, 1868-1876, is recorded vividly in the "Chisolm Massacre," by James M. Wells, who wrote, "On Sunday, the twenty-ninth of April, 1877, a body of three hundred men, styling themselves, 'the best citizens' of Kemper County, in the State of Mississippi, conspiring together and cooperating with the sheriff and other officers of the county, cooly and premeditatedly murdered three men and two children; one of the latter a young and beautiful girl, and the other a dedicated boy aged thirteen years." (Wells, 1877.) Wells states further, "In Kemper County the spirit of blood-thirsty intolerance toward the negro and his 'white allies' as all white Republicans were called became so great, and murders and whippings by the Ku Klux so alarmingly frequent, that troops were finally called in and a military camp was established at Lauderdale Springs." The "Chisolm Massacre" obviously was written from the Republican point of view. A counter punch to this book was one written apparently from the Democratic point of view. It is "Kemper County Vindicated, and A Peep at Radical Rule in Mississippi, by James D. Lynch, and appeared in 1879 (Lynch, 1879). A third, date unknown, but notarized as being authentic October 18, 1917, is "Captain Guy Jack's Iconoclast." The book was written in Scooba, Kemper County, and concerns the same period of history as the books by Wells and Lynch. It is written "from the standpoint of justice and truth knowing no religious creed or political party; portraying fearlessly FACTS, hewing to the line, letting the chips fall where they may, on white or black, Republican or Democrat, saint or sinner, Jew or Gentile, be he dead or alive!" according to the author. In the preface, he writes, "It is like dipping my pen in my own hearts blood for me to write what I do herein about men who were my neighbors . . With malice towards none, with charity for all, Guy Jack." (Captain Guy Jack's Iconoclast, Publisher unknown, notarized by W. L. Robinson, Memphis, Shelby County, Tennessee, October 18, 1917.)

After the turmoil of Reconstruction days, Kemper County has become a peaceful, pleasant place. DeKalb is the home of Senator John C. Stennis, who was born in Kemper County, and has served in the United States Senate since 1947. (Who's Who in America, 1957.)

REGIONAL GEOLOGY OF THE CENTRAL GULF COASTAL PLAIN

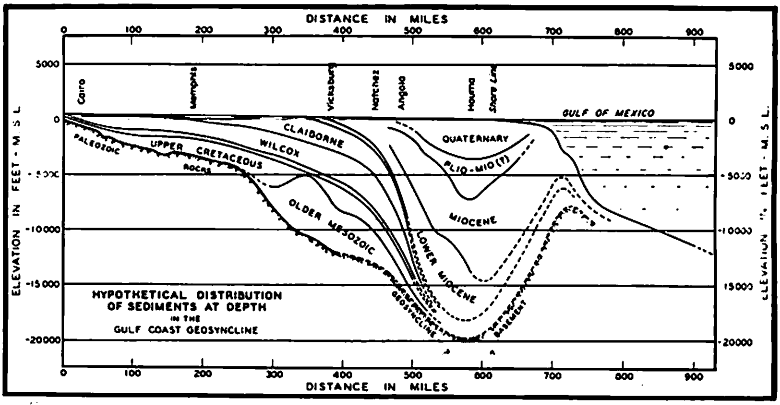
In order to facilitate a better understanding of the geological conditions within Kemper County, the geology of the Central Gulf Coastal Plain is here reviewed, presenting the broader aspects of the stratigraphic units and character of the rocks, a knowledge of which is essential to an understanding of the depositional and structural history of the region.

Location: The Central Gulf Coastal Plain is coextensive with the Atlantic Coastal Plain on the east, and is that coastal area bordering the Gulf of Mexico; including all or parts of Texas, Louisiana, Arkansas, Tennessee, Mississippi, and Alabama. Its geographic limits are 85° to 94° West Longitude, and 29° to 35° North Latitude. East to west, it extends from the border of Georgia and Alabama to the mouth of the Rio Grande River south of Texas, and it extends as far north as the latitude of Memphis, Tennesee. Inland, from the Gulf of Mexico, the Central Gulf Coastal Plain averages more than 200 miles north-south, except where the Mississippi River crosses the Plain. There, an extension, the Mississippi Embayment, increases the north-south extent of the Plain to some 500 miles inland from the present Gulf coast line. The east-west width of the Embayment, 225 miles on the south, decreases to less than 125 miles in the latitude of Cairo, Illinois. The emerged portion of the Central Gulf Coastal Plain has an area of approximately 145,000 square miles; the submerged portion, to a depth of 10,000 feet, about 140,000 square miles (Murray, 1952).

Character and Form of the Sediments: The Central Gulf Coastal Plain is underlain by sedimentary formations composed of sand, clay, marl, reef limestone, limestone and chalk, and subordinate amounts of gravel, diatomaceous earth, water-laid volcanic material, and salt plugs or so-called salt domes. They range in geologic age from Jurassic to Recent.

Igneous intrusives of possible late Mesozoic age are present near the inner margin of the plain in parts of Arkansas, and intrusives believed to be of Tertiary age in Texas south of the Balcones Fault Zone. In the southern part thick accumulations of chalk and limestone are resting on a basement of consolidated rock ranging in age from pre-Cambrian to Triassic (?). The sediments throughout the length of the Coastal Plain are lacking in uniformity, and were deposited in basins, each basin characterized by its own particular sediments, as sedimentation shifted from time to time. Thus, the extreme variation and discontinuity of sediments representing practically every type of depositional environment make correlation difficult.

The Gulf Coastal Plain has been the site for the accumulation of wedge-shaped deposits, primarily deltaic (but including



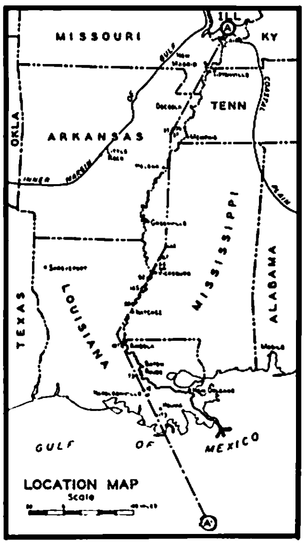


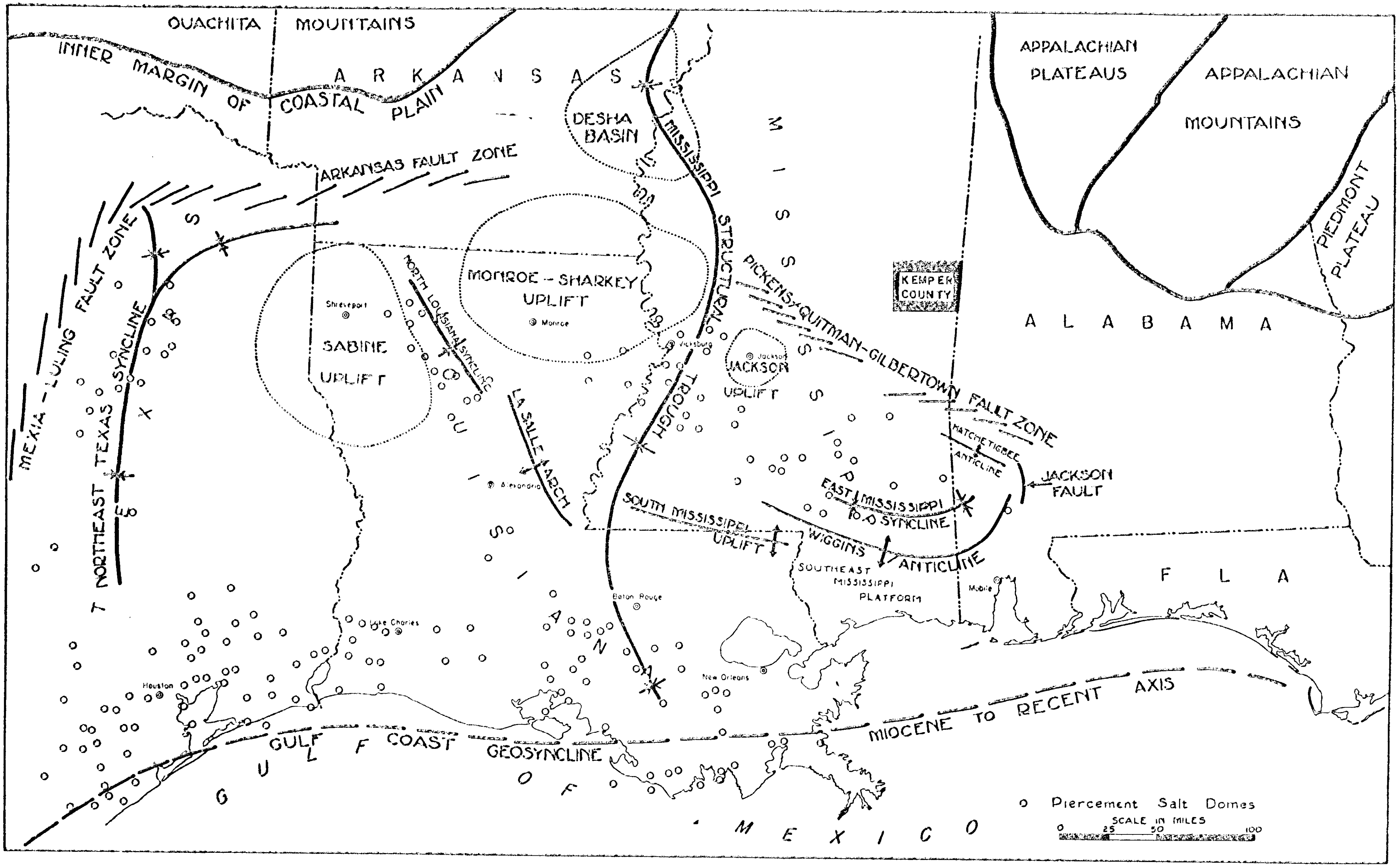
Figure 4.—North-south cross section and location map of line of section of Mississippi Structural Trough showing thickening of sediments in Gulf Coast Geosyncline. (After H. N. Fisk, 1944).

intercalcated marine strata) which thicken seaward, (Figure 4), the feather edge being along the inner margin of the Plain. The stratigraphic sequence which has been determined from detailed study of the Gulf Coastal Plain rocks is simple in its broad aspects, because it is controlled by a repetitious pattern of deltaic sedimentation, but it is extremely complex in details of arrangement of beds within each deltaic mass. Terminology used to designate minor lithologic units varies widely in different sections of the Coastal Plain.

Near the present shoreline of the Gulf of Mexico from Mississippi to Texas is the Gulf Coast Geosyncline. Within the geosyncline, or "bowl of the ladle" as it is often called, the sediments lose their wedge-like characteristics, and greatly thicken as deltaic masses. These masses are of two general types: 1) Those which tend to be elongate-lenticular, represented by major Jurassic and Lower Cretaceous (Coahuilan and Comachean) deposits; 2) ladle-shaped sediments of Upper Cretaceous (Gulfian) and Cenozoic age. These Mesozoic and Cenozoic sedimentary complexes may reach a thickness of as much as 40,000 feet.

Origin of the Sediments: A large part of the sediments of the Coastal Plain was brought into the sea by streams from adjacent highland areas. The major source of sediments during Jurassic and Cretaceous times was the Eastern United States. In Cenozoic time appreciable quantities of material came from the Western United States. Lesser quantities were derived from precipitation of calcium carbonate from the sea water; from accumulation of siliceous and calcareous shells and skeletons of marine organisms, large and small; from the formation of glauconite, and from water-laid volcanic material. Subordinate amounts of the sediments were deposited on river flood plains adjacent to the sea.

General Attitude of the Sediments: Sediments of the Central Gulf Coastal Plain have a gentle monoclinal dip seaward. The Gulfward monoclinal dip is influenced by two major downwarps: the Gulf Coast Geosynclinal Trough, and the Mississippi Structural Trough; and by four major upwarps: the Sabine Uplift, the Monroe-Sharkey Uplift, the Jackson Uplift, and the Wiggins Anticline (Plate 4). Numerous smaller positive and negative structural anomalies also contribute to the formation of a complex structural pattern. Deposits east of the Mississippi



STRUCTURE MAP OF CENTRAL GULF COASTAL PLAIN (AFTER MURRAY)

Embayment dip to the southwest and south; those west of the Embayment dip to the southeast and south. Their attitude is due primarily to the slightly inclined position in which they were deposited, and partly to subsequent slight seaward tilting. The dips are low, rarely amounting to one degree, generally less than half, and locally less than a quarter of a degree, except in local structures.

SURFACE STRATIGRAPHY

GENERAL STATEMENT

The rock deposits of Kemper County are of sedimentary origin, in part marine. Those exposed at the surface have been divided into 9, possibly 10, formations, several of which have been divided into members. These formations range in age from Upper Cretaceous to Recent. At many places the bedrock is covered by surficial deposits of probable Quaternary age (Plate 1).

The Upper Cretaceous sediments consist almost entirely of hard, glaring, bluish-white to gray, massive to bedded, argillaceous, sandy chalk, containing an abundant micro and macro fauna. The Tertiary deposits of Kemper County consist of calcareous sandstone and buff chalks of the Clayton formation; massive gray joint clays of the Porters Creek formation; fine, yellow, micaceous sands of the Naheola formation; and sands and interbedded clays, lignite and fine sands of the various units of the Wilcox group.

The oldest deposits exposed are the massive chalks of the Demopolis formation, which crop out in the northeast corner of the county. Due to the northwest strike of the overlying formations and their gentle southwest dip, younger formations are successively exposed downdip and exhibit rough, cuesta-like topography. The youngest sediments exposed are the fossiliferous, glauconitic sands of the Bashi marl member of the Hatchetigbee formation, which crop out in the extreme southwest part of the county.

The stratigraphic thickness of the surface rocks of Kemper County is approximately 1,625 feet. Deposits represented at the surface are sediments of the Selma group, Midway group and possibly Claiborne group. A generalized columnar section showing the 10 formations, together with their lithologic descriptions, is given in Plate 5.

CRETACEOUS SYSTEM

GULF SERIES

The oldest sediments exposed in Kemper County are in the upper part of the Gulf series. They represent only a small part of the belted, crescent-shaped outcrop pattern of the Upper Cretaceous deposits, which are some 500 miles in length, 40 to 50 miles wide and of an estimated thickness of about 2,000 feet.

The Gulf series rests unconformably on the Comanche series or Lower Cretaceous which does not crop out in this part of the Gulf Coastal Plain.

The Mesozoic-Cenozoic contact is well exposed in Kemper County. Here the glaring bluish-white, hard chalks of the Prairie Bluff of Cretaceous age are unconformably overlain by basal calcareous sands of the Clayton formation of Midway age. The contact is one of disconformity, evidences for which are a lithologic change, a sedimentary hiatus, worm borings, and a reworked zone containing admixed chalk conglomerate and sandstone.

The Gulf series is composed of units of the Selma group, which are differentiated on the basis of lithologic character. The Selma rests disconformably on the Eutaw formation from the Mississippi-Tennessee line southeast to Macon County, Alabama, where the lower part grades laterally into the lower part of the Blufftown formation.

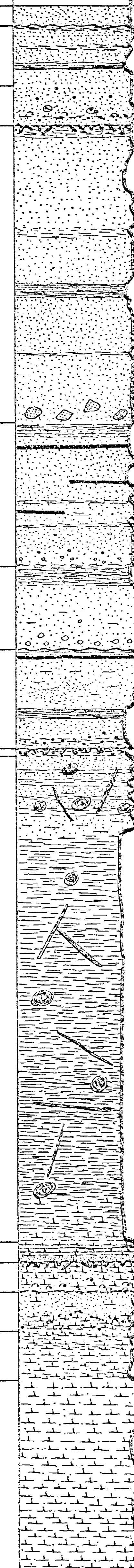
The Selma group in Kemper County is composed in ascending order of the Demopolis chalk, the Ripley formation, and the Prairie Bluff chalk.

SELMA GROUP

DEMOPOLIS CHALK

First reference: E. A. Smith, 1888. In broad sense. (Smith, 1888.) Demopolis (Rotten limestone) is applied on map to rocks between Eufaula (Ripley) above and Eutaw below.

Nomenclator: E. A. Smith, 1903.



ERA	SYSTEM	SERIES	GROUP	FORMATION AND MEMBER	MAP SYMBOL	LITHOLOGY	THICK-NESS (FEET)	DESCRIPTION
CENOZOIC	QUATERNARY	HOLOCENE		Alluvium	Qal		25+	Flood plain sands and silts
	TERTIARY	EOCENE	CLAIBORNE	Tallahatta formation	Ttm		20+	Cross-bedded sand
				Meridian sand member				
				Hatchetigbee formation	Th		51-60	Interbedded gray and olive fine sands, dark clays and fissile shales. Lignite beds throughout.
				Bashi marl member			9-40	Olive to yellow-brown, glauconitic fine sands containing fossil prints
			WILCOX	Tuscahoma sand	Tt		300	Olive-colored, firm, fine sands, thinly laminated in places, and dark clays and fissile shales. Locally at base are large angular to rounded blocks of bedded silt.
				Nanafalia formation	Tna		20-130	Olive gray, argillaceous fine sand massive to cross-bedded and silty clay and clay-shales with numerous lignite beds. Very coarse sand at base.
				Fearn Springs sand member			10-85	Gray laminated fine sand and silty clay underlain by white to red gravelly very coarse sand,
		PALEOCENE	MIDWAY	Naheola formation	Tn		15-100	Red to yellow, massive to cross-bedded, fine to medium sand and black carbonaceous clay-shales, laminated silts and clays.
				Matthews Landing marl member			5-8	Green to brown glauconitic sandy clay with limonite concretions.
				Porters Creek clay	Tpc		500+	Slate to chocolate gray blocky, hackly clay with conchoidal fracture. Upper beds are laminated sands and clays. Flattened- to irregularly-shaped siderite (clay ironstone) concretions throughout entire thickness but more prevalent in upper part. Joints numerous containing platy limonite.
				Clayton formation				Buff, sandy, silty glauconitic chalk and calcareous clays, fossiliferous with amber-colored, massive, glauconitic, medium to fine sand at base.
				Chalybeate limestone member	Tcc		20	
MESOZOIC	CRETACEOUS	GULF	SELMA	Prairie Bluff chalk	Kpb		30	Bluish-gray to glaringly white, massive slightly sandy chalk. Phosphatic molds of fossils in upper and lower parts.
				Ripley formation	Kr		40	Gray, massive to irregularly bedded, muscovitic, glauconitic chalky sand and calcareous sandy clay, abundantly fossiliferous.
				Bluffport marl member	Kdb		50	Gray, argillaceous silty chalk, grading upward into calcareous sandy clay at top. Abundantly fossiliferous.
				Demopolis chalk	Kd		210	Bluish-gray, massive, slightly sandy and argillaceous chalk, glaringly white and flaky on weathered surfaces.

100 0 100 200 300

SCALE IN FEET

GENERALIZED COLUMNAR SECTION OF SURFACE ROCKS IN KEMPER COUNTY

Type Locality: Bluff on Tombigbee River at Webb and Sons Cotton Warehouse in Demopolis, Marengo County, Alabama.

Original Description: E. A. Smith, 1903. (Smith, 1903.)

"The Selma Chalk or Rotten Limestone

"Geological horizon. — The Cretaceous formation of Alabama is susceptible of classification into four divisions which are, in ascending order —

"1. The Tuscaloosa, a formation of fresh-water origin, made up in the main of sands and clay in many alternations. In places the clays occur in deposits of sufficient size and of such a degree of purity as to make them of commercial value.

"2. The Eutaw, which is of marine origin and composed of sands and clays more or less calcareous, but nowhere showing beds of limestone properly so called.

"3. The Selma chalk, which as its name indicates, is of marine origin, and is composed, in part at least, of the microscopic shells of foraminifera. This formation throughout the western part of the belt covered by it in Alabama is about 1,000 feet in thickness and is made up of beds of chalky and more or less argillaceous limestone. In a general way it may be said that the lower or upper thirds of the formation contain 25 percent and upward of clayey matters mixed with the calcareous material, while the middle third will hold less than 25 percent of these clayey impurities.

"4. The Ripley. This, like the preceding, is a marine formation in which generally the calcareous constituents predominate, but in places contains sandy and clayey beds.

"From this summary it will be seen that the Selma chalk is the only one of our Cretaceous formations which offers limestone in such quantity and of such composition as to be fit for Portland-cement material.

"General description. — As has been stated above, the Selma chalk is a calcareous formation throughout its entire thickness of about 1,000 feet. The rock, however, varies in composition between somewhat wide limits, and taking account of the composition we may readily distinguish three divisions of it. The rock of the upper or Portland division is highly argillaceous, holding from 25 percent and upward of clayey matters, some of the strata being rather calcareous clays or marls than limestone, and in these beds are found great numbers of fossils, mainly oysters. Along the Tombigbee River these beds make the bluffs from Pace's Landing down nearly to Moscow, and on the Alabama they make the banks of the river from Elm Bluff down to Old Lexington Landing. The strata as exhibited in these bluffs, consist of dark colored fossiliferous calcareous clays, alternating with lighter colored and somewhat more indurated ledges of purer, less argillaceous rock. At Elm Bluff, which is about 125 feet high, the upper half of the bluff is of this character. The lower half of the bluff is composed of rock more uniform in composition and freer from clay, and is the top of the middle part of the Selma formation (the Demopolis division), which is made up of limestone containing generally less than 25 percent of clayey matters and of more uniform character.

"In this middle or Demopolis division of the Selma formation the fossils are rarer than in either of the others, oysters and anomias being the most common forms. This variety of the rock forms the bluffs along the Alabama River from Elm Bluff up to Kings Landing. It is seen in its most typical exposure at White Bluff, where it is at least 200 feet in thickness and makes on the right bank of the river an almost perpendicular bluff. On the Tombigbee River it extends from near Bartons Bluff past Demopolis up to Arcola and Hatchs Bluff. Its lowermost beds, a compact limestone of great purity, form the upper parts of Bartons and Hatchs bluffs. On the Little Tombigbee River the same rock makes the celebrated bluffs at Bluffport and at Jones Bluff (Epes), beyond which for several miles it is shown in the bluffs of the river.

"From the width of its outcrop this division of the rotten limestone must be about 300 feet in thickness, and it underlies the most fertile and typical prairie lands of the Black Belt. At intervals throughout this region the limestone rock appears at the surface in what are known as "bald prairies," so named from the circumstance that these spots are lacking in tree growths. The disintegration and leaching out of the limestone leaves a residue of yellowish clay, which accumulates sometimes to a thickness of several feet in low places. This clay is used at the Demopolis plant in the manufacture of cement, and in most localities where suitable limestone is found the clay is present in sufficient quantity to supply the needs of the cement manufacturer.

"At the base of this middle or Demopolis division occurs a bed consisting of several ledges of compact, hard, pure limestone which weathers into curious shapes and has received the names horse-bone rock and bored rock. This bed, as above mentioned, appears at the top of Hatchs Bluff, also at Arcola Bluff, and between Demopolis and Epes, at Jordans Ferry, etc. Where it outcrops across the country it makes a ridge easily followed and characterized by the presence on the surface of loose fragments of the limestone.

"The lower part of the formation (the Selma division), like the upper, is composed of clayey limestone, in many parts being rather a calcareous clay. The color is dark gray to bluish, and in most exposures there is a striping due to bands of lighter colored, purer limestone alternating with the prevailing quality. Along the Alabama River the strata of this division are seen in the bluffs from Kings Landing up to Selma and beyond. On the Warrior River they are seen in the bluffs at Arcola, Hatchs, Millwood, and Erie, occupying in the last named locality the upper part only of the bluff. On the Tombigbee the bluffs at Gainsville, at Roe's and Kilpatrick's are formed mainly of the rocks of this division, while above Roe's at Jordan's, occurs the line of junction of this with the middle division. Near this line of division there is a very characteristic feature to be observed at many points, viz., about ten or fifteen feet below the hard ledges of pure limestone forming the base of the middle (Demopolis) division, the dark-colored argillaceous rock shows a tendency to flake off and weather into caves, sometimes several feet deep and twenty or more long. These holes are sometimes to be seen for long distances along the bluffs, as on the Alabama River just above Kings Landing; on the Tombigbee River below Roes Bluff and at Jordans Ferry. The outcrop of the argillaceous rocks of this division gives rise to black prairie soils, in which beds of fossil shells, mainly oysters are common."

Other Descriptions: In 1903 Smith (Smith, 1903) in his original description used Demopolis in a restricted or narrow sense as the middle division of his tri-part division of the Selma chalk, the name which he introduced in 1894 to replace "Rotten limestone." Concerning the name, Wilmarth (Wilmarth, 1938) says, "Middle or Demopolis division (of Selma chalk). Of more uniform composition than the upper division of the Selma, and freer from clay, being made up of limestone, generally containing less than 25 percent of clayey matter. Fossils rarer than in other divisions. The lowermost beds of Demopolis division are a compact limestone of great purity called horsebone rock. Overlain by Portland division of Selma chalk and underlain by Selma division of the Selma. Thickness about 300 feet."

History of Usage: The original use of Demopolis in a broad sense by Smith in 1888 applied to rocks between the Eufaula (Ripley) above and Eutaw below. His restricted Demopolis division of the Selma chalk in 1903 is the equivalent of the Arcola limestone member of the Mooreville chalk and the lower part of the Demopolis chalk of present day writers. Monroe (Monroe, 1941) uses Demopolis as a member of Selma chalk to include all chalky and marly beds between the diastem above the Arcola limestone member below and the Ripley formation above.

In 1945 at the time of publication of their Geologic Map of Mississippi, the Mississippi Geological Society raised the term Selma to the rank of group to include all the outcropping Cretaceous beds younger than the Eutaw formation. The Demopolis and other members were given formation rank. In east central Mississippi the Demopolis chalk lies between the Ripley formation above and the Mooreville chalk below. In northern Mississippi it is overlain by the Owl Creek tongue of the Ripley and underlain by the Tupelo tongue of the Coffee sand.

Areal Extent: The Demopolis chalk extends as a belt of outcrop which varies in width from about 5 miles at the Tennessee State line to as much as 16 miles or more in its southern extent in Mississippi. It crops out in Alcorn, Prentiss, Union, Lee, Pontotoc, Chickasaw, Monroe, Clay, Oktibbeha, Lowndes, Noxubee, and Kemper Counties, and extends southeasterly into Alabama.

In Kemper County the Demopolis chalk crops out over an area of approximately 25 square miles in the northeast portion of the county, where it is divided into an upper unit, the Bluffport marl member and the lower typical chalk (Plate 1).

Thickness: The Demopolis chalk has a total thickness of about 260± feet in Kemper County. Of this thickness the chalk is about 210± feet thick and the marl member above approximately 50 feet thick.

Lithologic character: The typical Demopolis chalk consists of approximately 210± feet of bluish-gray, massive chalk which weathers to glaring white. The base is not exposed within the area mapped. The chalk is iron-stained and contains irregularly shaped nodules and rods of marcasite altering to limonite. On exposed surfaces the chalk is very flaky. A thin section of the Demopolis chalk (Figure 5) shows tests of foraminifera as well

Figure 5.—Photomicrograph of thin section of typical Demopolis chalk showing minor amounts of silt and clay and numerous microfossils. Uncrossed nicols. x110. (SE.¼, Sec.5, T.12 N., R.14 E.).

as minor amounts of clay minerals. Chemical analysis was made of a sample of the chalk from the SE.¼, Sec.5, T.12 N., R.19 E. The main constituent is calcium carbonate which represents 81.9 percent of the sample, mainly in the form of foraminiferal tests and finely divided calcite. The remainder of the sample, the insoluble residue, is 18.1 percent. Petrographic analysis of the insoluble particles shows quartz of silt size and a few sand grains to be the main constituents, which are mixed with subordinate amounts of clay, selenitic and massive gypsum, and muscovite in small rounded cleavage flakes.

Excellent exposures of the typical chalk can be seen in SE.¼, Sec.5, T.12 N., R.19 E., just north of Binnsville along a north-south road. Here the chalk is glaringly white and hard, and contains abundant small foraminifera and a megascopic fauna. The gently to moderately rolling smooth surface produced by more nearly uniform erosion than that on a surface underlain by sand does not afford the relief that is exhibited by the sandy Ripley, Midway, or Wilcox belts to the southwest. The section is as follows:

SECTION (SE.¼, SEC.5, T.12 N., R.19 E.) APPROXIMATELY 0.7 MILE NORTHEAST OF BINNSVILLE.

	Feet	Feet
Top Soil		2.0
2. Gray, chalky, sandy top soil	2.0	
Demopolis chalk		38.5
1. Glaring white, hard, very slightly sandy, muscovitic fossiliferous chalk containing nodules of marcasite altering to limonite	38.5	
Total Section		40.5

Overlooking Wahalak Creek Valley in Sections 3, 9, 17 and 19, T.12 N., R.18 E., is an excellent section of the Cretaceous. The stream has cut down through a thickness of approximately 100 feet, laying bare the Prairie Bluff, the Ripley, the Bluffport marl member and the Demopolis chalk. The contact between the Demopolis chalk and the marl member above is conformable and the change from the massive hard chalk to the clayey, silty chalk or chalky clay is abrupt. A good exposure showing the contact of the typical chalk and the overlying marl member is in a gully (Sec.3, T.12 N., R.18 E). Just northeast the contact is again well exposed at Nicholson's Hill on the north-facing slope overlooking Wahalak Creek. Here the Demopolis chalk, the Bluffport marl member, and the Ripley formation are exposed. The section is as follows:

SECTION (NE.¼, SEC.3, T.12 N., R.18 E.) AT NICHOLSONS HILL, IN A GULLY JUST NORTH OF MT. PLEASANT CEMETERY. (FIGURE 6)

	Feet	Feet
Top Soil		8.4
4. Buff to yellow-brown sandy, silty argillaceous top soil. Basal foot or so weathered Ripley	8.4	
Ripley formation		36.1
3. Gray to buff muscovitic sandy chalk containing irregular shaped marcasite nodules altering to limonite; also numerous fossils, *Exogyra costata*, and others	36.1	
Demopolis chalk		74.0

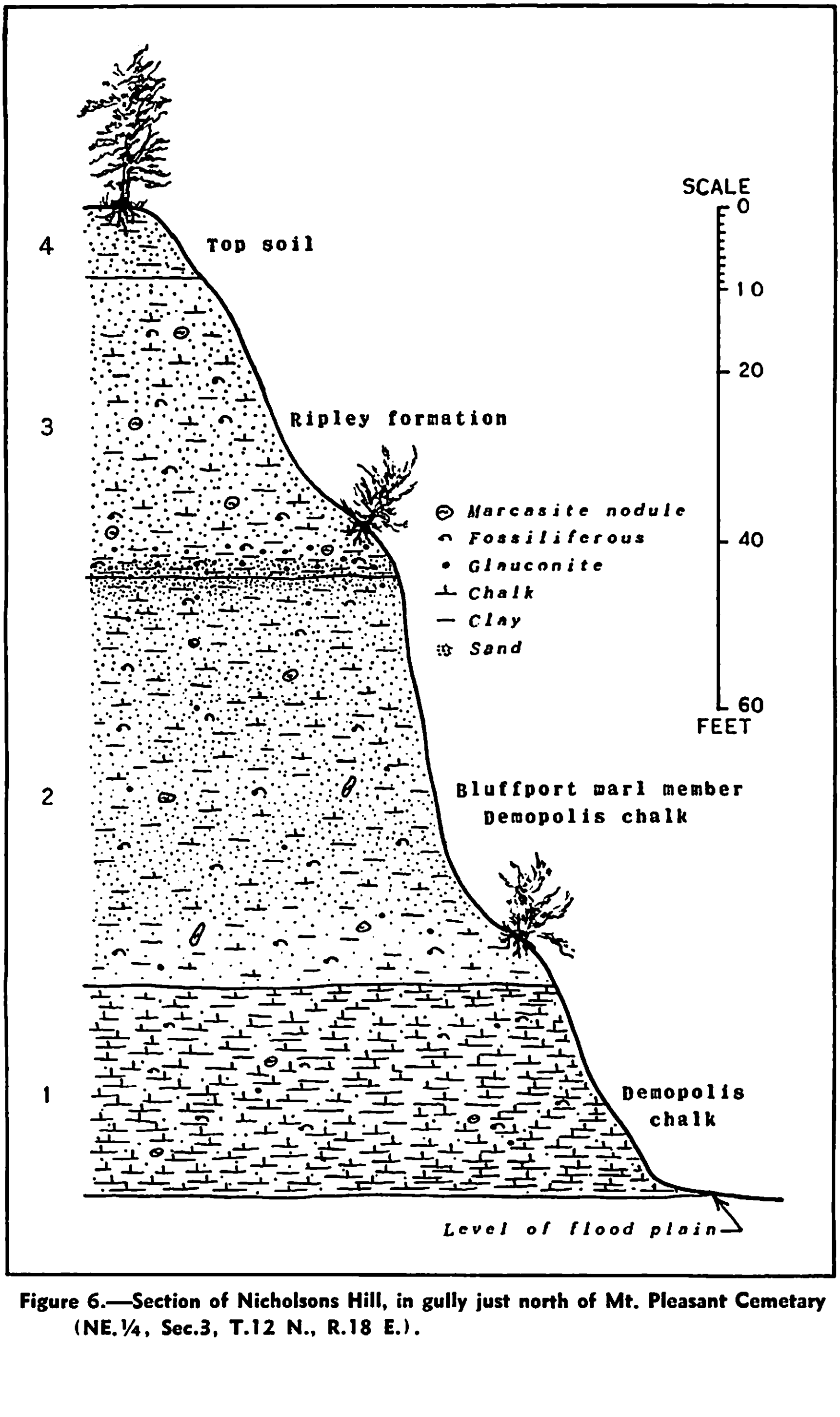


Figure 6.—Section of Nicholsons Hill, in gully just north of Mt. Pleasant Cemetary (NE.¼, Sec.3, T.12 N., R.18 E.).

Bluffport marl member		
2. Blue-gray muscovitic, silty marl containing marcasite nodules and numerous fossils, *Exogyra cancellata* Stephenson, *Gryphaea mutabilis* Morton, *Anomia tellinoides* Morton, *Paranomia scabra*	49.0	
Demopolis chalk typical		
1. Glaring, bluish-white, hard, fossiliferous chalk, iron-stained, with marcasite nodules; flaky on surface; contains *Exogyra cancellata, Anomia tellinoides* and others	25.0	
Total section		118.5

Bluffport Marl Member

Type locality: Old Bluffport road (NW.¼, Sec.27, T.19 N., R.1 W., Sumter County, Alabama).

Nomenclator: W. H. Monroe, 1956. (Monroe, 1956.) Named from Bluffport Bluff along Tombigbee River. The Bluffport marl was previously mapped and described as an undifferentiated part of the Demopolis chalk.

The Bluffport marl member may be easily distinguished from the underlying chalk by its texture and color. Its color is a dull gray, its texture fine and silty. The upper member of the Demopolis chalk, designated "Bluffport marl member" consists of about 50 feet of material which ranges from gray clayey chalk at the base to calcareous sandy clay at the top. The top of the member grades imperceptibly into the overlying sandy Ripley formation, and the contact between the two may vary as much as 5 feet. The marl member at the Nicholson's Hill locality contains 55.8 percent calcium carbonate, mostly calcite and foraminifera. The remainder of the sample, the insoluble residue, is 44.2 percent. Of the insoluble residue, the arenaceous material is mostly silt with some sand which is subrounded to rounded and slightly polished. Selenitic gypsum is present, the grains being angular to subangular, showing cleavage faces. Clay, small flakes of chlorite, glauconite, and hexagonal muscovite flakes are present. Figure 7 shows a thin section of the marl.

It weathers to a gray-brown, very sticky calcareous clay. Exposures of the weathered phase may be seen along a northeast road from Millington to Binnsville. The weathered contact with the underlying chalk is exposed on the same road approximately one mile southwest of Binnsville (about NE.¼, SW.¼, Sec.7, T.12 N., R.19 E.). Other outcrops are at a road-T (extreme SW.¼, Sec.20, T.12 N., R.19 E.; SE.¼, SW.¼, Sec.29, T.12 N., R.19 E). On Mississippi Highway 16 approximately 1¼ miles east of Giles, and at the Alabama line only a few feet into Alabama the top of the chalk is in view. The top of the marl member shows in the banks of Bodka Creek where 6 to 7 feet of the material are

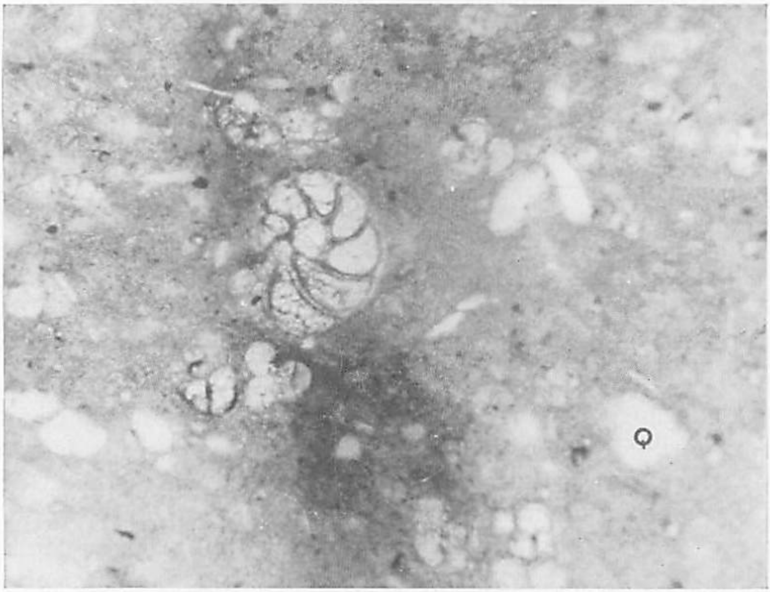


Figure 7.—Photomicrograph of thin section of Bluffport marl member of Demopolis chalk. Extremely fine-grained quartz (Q) in a carbonate groundmass containing considerable clay and iron staining and microfossil fragments and tests. Uncrossed nicols. x110. Nicholsons Hill, (NE.¼, Sec.3, T.12 N., R.18 E.).

exposed (NW.¼, SE.¼, Sec.18, T.11 N., R.19 E.). Figure 8 is a photomicrograph of a thin section of the marl. It is interesting to note on the photomicrographs (Figures 7, 8) how the member becomes coarser toward the top.

In April of 1955, W. H. Monroe of the U. S. Geological Survey accompanied the writer in the field to review the Upper Cretaceous stratigraphy in northeastern Kemper County. At the time, Monroe was completing a mapping problem in the northwestern part of the Epes Quadrangle of adjacent Sumter County, Alabama. His map has since been published as Oil and Gas Investigations Map OM 167, "Geology of the Northwestern Part of the

Epes Quadrangle, Sumter and Greene Counties, Alabama," 1955. It was at this time that Monroe called to the present writer's attention the existence of a separate and distinct lithologic unit, which he had mapped in Alabama as the "Upper marly member of the Demopolis chalk, some 65 feet of a fine, sandy, silty marl, which had been previously an undifferentiated part of the Demo-

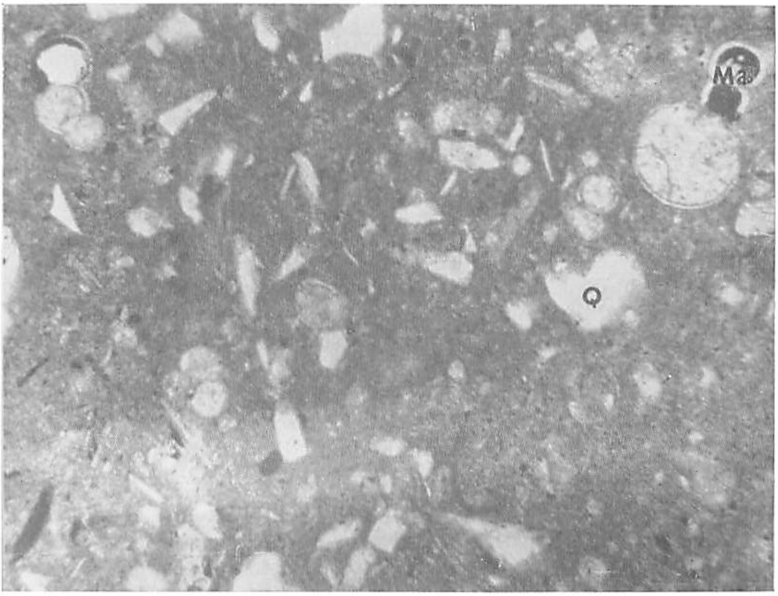


Figure 8.—Photomicrograph of thin section of Bluffport marl member of Demopolis chalk. Very fine-grained, angular quartz (Q) and microfossils being replaced by marcasite (Ma). Shreds of muscovite and biotite and some small glauconite grains in a carbonate-clay groundmass. Upper part of marl member becomes sandy like overlying Ripley. Uncrossed nicols. x110. Bodka Creek, NW.¼, SE.¼, Sec.18, T.11 N., R.19 E.).

polis chalk. He further proposed, on the basis of differing lithology, the name "Lower chalky member" of the Demopolis chalk, for some 275 feet of chalk which constituted all the remainder of the Demopolis chalk of previous usage. The two-fold division of the Demopolis Monroe had mapped as such in Alabama. The writer accompanied Monroe to a place (NW.¼, Sec.27, T.19 N., R.1 W.) in Sumter County, Alabama, where 53.0 feet of the marl is overlain by 10 feet of Ripley, and underlain by 62 feet of typical massive chalk. Monroe designated this Sumter County, Alabama, locality the type locality for the marl, and named the unit the Bluffport marl member of the Demopolis chalk. The section is described below. The writer agreed that the Demopolis should be subdivided, and the Bluffport marl member of the Demopolis chalk was mapped in Kemper County and designated as such.

SECTION (NW.¼, SEC.27, T.19 N., R.1 W.) OF BLUFFPORT MARL MEMBER, DEMOPOLIS CHALK, OLD BLUFFPORT ROAD, SUMTER COUNTY, ALABAMA.

	Feet
"Demopolis chalk, Bluffport marl member	
Clay, calcareous, silty, slightly micaceous, very slightly sandy, yellowish gray (5Y 7/2) - weathered material, grades downward into fresher marl; top is at crest of hill on road, but cuts in more highly weathered material extend about 4 feet higher; abundant fossils including *Exogyra cancellata* Stephenson, *Gryphaea mutabilis* Morton, *Anomia tellinoides* Morton, and others	9.0
Clay, very chalky, silty, very finely micaceous, very light olive-gray (5Y 7/1); clay becomes slightly less micaceous and slightly more calcareous downward; scattered balls of marcasite common; thin (½ foot) slightly indurated chalk-like layers about 2, 5, and 11 feet above base; fossils very abundant including reef-like layers (Fig. 2) of *Ostrea falcata* Morton and *Gryphaea mutabilis* Morton; abundant *Exogyra cancellata* Stephenson and *Anomia tellinoides* Morton	44.0
Demopolis chalk (typical lithologic character)	
Chalk, very compact, rather massive, very slightly micaceous, yellowish-gray (5Y 8/1); fossils much scarcer than in overlying marl member, but *Exogyra cancellata* Stephenson and *Anomia tellinoides* Morton are present in upper 50 feet	62.0
	115.0"

Stratigraphic Relations: The Demopolis chalk, the base of which is not exposed within Kemper County, lies disconformably on the Arcola limestone member of the Mooreville chalk. The small, pronounced resistivity kick at the top of the Arcola is easily picked on electric logs. The Bluffport marl member above is overlain conformably by the Ripley formation, and the contact is well exposed in Kemper County.

Physiographic Expression: The Demopolis chalk forms the surface of the middle and southern parts of the Black Prairie Belt. The more pure, chalky middle part of the formation gives rise to the gently rolling, hilly topography with large, bare patches of chalk, called bald spots (Figure 9). There is a paucity of black soil because the purer part of the chalk weathers to the common bald spots. The upper part of the Demopolis, that part mapped as the Bluffport marl member, does, however, give rise to a grayish brown, very sticky top soil. The maximum relief averages 50 to 75 feet but in places as much as 100 feet have been measured.

Figure 9.—View looking northeast showing gently rolling topography and bald spot of Demopolis chalk. One-fourth mile east of Binnsville, (SW¼, Sec.5, T.12 N., R.19 E.) July 21, 1954.

Paleontology: The Demopolis chalk has a prolific macrofauna and microfauna. The lithologies of the Bluffport marl member of the Demopolis chalk and the overlying Ripley formation are very similar and the writer used paleontology as an aid in establishing stratigraphic boundaries.

The biozones of the Demopolis chalk have been previously established. The upper 50 feet of the typical chalk and the marl member is characterized by the presence of the fossil *Exogyra cancellata*, and is referred to as the *Exogyra cancellata* subzone. In association with *Exogyra cancellata* in the lower two-thirds of the zone, and also present for at least 50 feet below the zone, and perhaps just as prevalent, is the mollusk, *Anomia tellinoides*. The contact of the Bluffport marl member of the Demopolis chalk, and the overlying Ripley formation is rather indistinct.

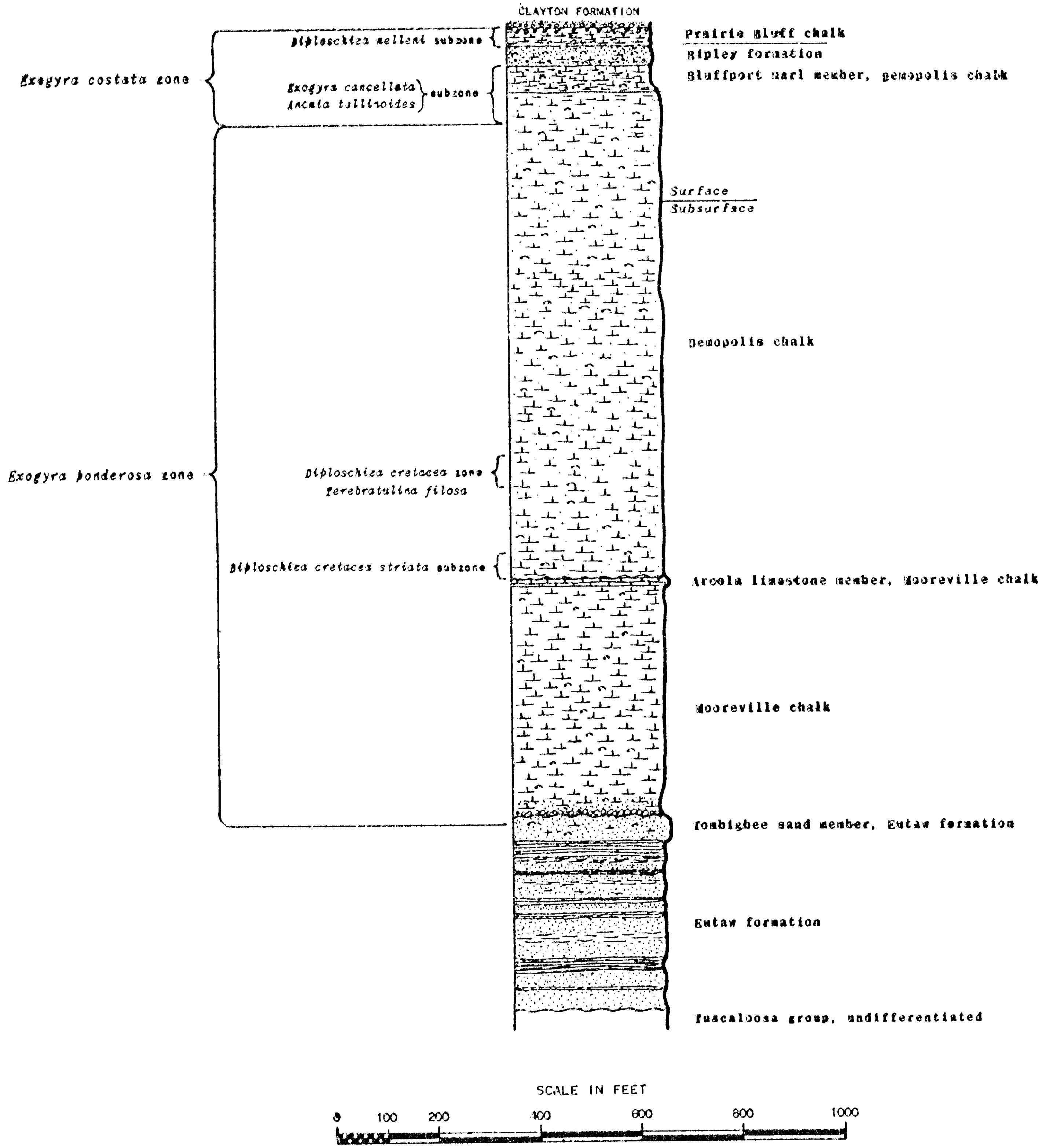
Minor lithologic variations have been pointed out (Section, Nicholsons Hill). The highest stratigraphic position of *Exogyra cancellata,* considered the top of the Demopolis chalk, is about 5 feet below the actual top where the more pronounced sandy lithology of the Ripley is seen. The base of *E. cancellata* is about 50 feet below the top of the typical chalk, about 110 feet below the top of the Demopolis chalk and marl member, and the zone extends upward to a horizon about 5 feet below the top of the Demopolis. Thus, the *E. cancellata* ranges through about 105 feet of chalk and marl. The faunal chart, Plate 6 shows the range of the important guide fossils. Fossils collected and identified, Demopolis chalk:

Mollusca
- Pelecypoda
  - Ostrea plumosa Morton
  - Ostrea mesenterica Morton
  - Ostrea falcata Morton
  - Ostrea panda Morton
  - Ostrea (Gryphaeostrea) vomer (Morton)
  - Gryphaea mutabilis Morton
  - Gryphaea convexa (Say)
  - Exogyra costata Say
  - Exogyra cancellata Stephenson
  - Anomia tellinoides Morton

Vertebrata
- Vertebrae

Fossils collected and identified, Bluffport marl member, Demopolis chalk:

Mollusca
- Pelecypoda
  - Ostrea plumosa Morton
  - Ostrea mesenterica Morton
  - Ostrea falcata Morton
  - Ostrea (Gryphaeostrea) vomer (Morton)
  - Gryphaea mutabilis Morton
  - Exogyra costata Say
  - Exogyra cancellata Stephenson
  - Anomia tellinoides Morton
  - Anomia argentaria Morton
  - Paranomia scabra



LITHOLOGIC AND FAUNAL UNITS OF THE SURFACE AND SUBSURFACE UPPER CRETACEOUS ROCKS IN KEMPER COUNTY

Two major fossil zones, *Exogyra ponderosa* Roemer and *Exogyra costata* Say, are recognized in the Selma group. The lower, or *E. ponderosa* zone, has the longest range and extends from the upper one-half of the Tombigbee sand member of the Eutaw formation to approximately 100 feet below the top of the Demopolis chalk. The upper or *Exogyra costata* zone, ranges from the upper 100 feet of the Demopolis chalk through the Prairie Bluff chalk, and is subdivided into the *E. cancellata* - *Anomia tellinoides* subzones and an upper *Diploschiza melleni* subzone.

Most fossils in the Selma have long ranges and are of little value as stratigraphic markers, such as *Exogyra ponderosa* and *E. costata*. Other long range forms of the Upper Cretaceous that are common in the Selma exposures are the ubiquitous *Ostrea plumosa* Morton, the upper valve of which is most frequently preserved, and the serrated *O. falcata* Morton. *Gryphaea convexa* (Say) and *G. mutabilis* Morton are common in the upper Selma. *G. convexa* is especially prominent near the top of the *Exogyra ponderosa* zone and in the Prairie Bluff. *Paranomia scabra* Morton, a thin-shelled form, very resistant to weathering, and the translucent but tough valves of *Anomia argentaria* Morton are easily recognized and commonly found throughout the chalk. *Hamulus onyx* Morton and the wide-flanged *H. squamosus* Gabb range from the Eutaw sands into the Prairie Bluff.

Short range forms such as *Exogyra cancellata* Stephenson and *Anomia tellinoides* Morton are both restricted to the Bluffport marl member of the Demopolis chalk and the upper 50 feet of the Demopolis chalk proper, or a range of about 100 feet. *Diploschiza melleni* is confined to the Prairie Bluff chalk as is the gastropod *Turritella bilira*. The cephalopods *Discoscaphites conradi* Morton and *Sphenodiscus lobata* Tuomey are restricted to the latest Ripley and Prairie Bluff. *Diploschiza cretacea* Conrad and the small brachiopod *Terebratulina filosa* Conrad are restricted to a vertical range of approximately 60 feet. *Diploschiza cretacea striata* is found in the lower 30 feet or more of the Demopolis chalk just above the Arcola limestone. According to Mellen (Mellen, F. F., 1958) *Diploschiza cretacea striata* is stratigraphically higher than *D. cretacea*. On page 35 he states "It would appear from the relationship of *Diploschiza cretacea* with its varietal form that the variety has either no individual status as an index fossil or that its stratigraphic position or identification in Alabama was incorrect."

Vertebrata

Bone fragments; Mosasaur probably
Tooth; Mosasaur probably

Age and Correlation: The Demopolis chalk is the equivalent of the European Campanian and lower Maestrichtian stages. It is the correlative of the Taylor marl and the lower part of the undifferentiated Navarro group of Texas, and of the Cusseta sand of Alabama.

RIPLEY FORMATION

First Reference: E. W. Hilgard, 1860. (Hilgard, 1860).*

Nomenclator: E. W. Hilgard, 1860.

Type Locality: No type locality for the Ripley was specifically designated by Hilgard but the exposures near the town of Ripley, Tippah County, Mississippi, were so named. In his monumental work he mentions several localities, among which are the section on Tippah Creek at Ripley, Tippah County (paragraph 132, Sec. 13) and the section of Owl Creek Bluff, near Ripley (Sec. 14). Owl Creek Bluff, 2½ miles northeast of Ripley, seems to be the accepted "type locality," although (paragraph 132, p. 87) Hilgard says "The general features of the outcrops may best be studied at an exposure in the S. portion of the town, at a bluff on the S. side of Tippah Creek, where we obtain the following section." In the same paragraph at the bottom of the page he writes "The locality on Owl Creek, 3 miles N.E. of Ripley, on S.7, T.4, R.4, (first visited by me in May 1856) where Dr. Spillman's fossils were obtained forms part of the bluff mentioned above, (the Tippah Creek Sec.) which continues on the west side of Owl Creek for several miles; at the point mentioned it affords the following section."

Original Description: Hilgard's description is (p. 83)

"There are two materials especially, which in their various modifications, compose the strata of this group, viz., hard crystalline limestone, more or less sandy and glauconitic, which forms the highest strata; and bluish micaceous marls, more or less sandy, and often interstratified with subordinate ledges of sandy limestone, which latter become less and less frequent as we descend in the series towards the strata forming a palaeontological as well as lithological transition into the Rotten Limestone."

Sections described by Hilgard near Ripley are as follows:

"SEC.13, SECTION ON TIPPAH CREEK AT RIPLEY, TIPPAH COUNTY

	Feet	Inches
4. Concretionary ("bored") Limestone with hard and soft ledges alternating; containing (sparingly) *Exogyra costata,* and numerous other, imperfectly preserved shells, mostly throughout in great abundance, a *ceripora,* which in the lowest, hardest ledges is associated with *Turritellae* and Gryphaea vomer	25	
3. Coarse glauconitic sand with disintegrated shells	1	
2. Seam of yellow, non-fossiliferous sand		3
1. Micaceous marl (Owl Creek) with *Baculites, Legumen* and *Siliquaria*	3	"

"SEC. 14, SECTION OF OWL CREEK BLUFF, NEAR RIPLEY

	Feet	
2. Concretionary limestone with *Exogyra costata, Ceripora* and *Turritella,* same as No. 4 of preceeding section and No. 3 of Sec.12 (Kindricks Mill, Tippah County)	25	
1. Dark, bluish, micaceous marl, more or less clayey in its different portions, containing numerous fossils, whose shells retain their natural iridenscence	20	"

Other Descriptions: L. W. Stephenson (Stephenson, 1914) states:

"The typical materials of the Ripley formation consist of marine more or less calcareous and glauconitic sands, sandy clays, impure limestones, and marls. These were originally described by Hilgard. The bluffs of Owl Creek, 3 miles northeast of Ripley, Tippah County, Mississippi, may be considered the type locality of the formation."

History of Usage: The term Ripley was used by Hilgard in a group sense and was intended to include all strata between the top of the Rotten Limestone (Selma chalk) and the base of the overlying Tertiary deposits. The formation included a few feet of limestone and overlying fossiliferous sand and clay now known to belong to the Clayton formation of Midway age. The error was corrected by Harris (Harris, 1896). In 1871 Hilgard applied the name to deposits of similar age in Alabama. Smith and Johnson (Smith and Johnson, 1887) accepted Hilgard's name and later with Langdon (Smith, Langdon, and Johnson, 1894) expanded the term in eastern Alabama to include strata older than any included in the Ripley in Mississippi. Their uppermost Ripley, in western Alabama was of Tertiary age, belonging to the present Clayton formation. This error was corrected in part by Smith (Smith, 1910) and Stephenson (Stephenson, 1914). Below Smith's uppermost Ripley (Clayton) is a continuous thin chalk unit extending east from the main body of chalk in Sumter County, Alabama. In 1917 Stephenson (Stephenson, 1917) gave this unit the name Prairie Bluff tongue of the Selma chalk. Later, in 1937 Stephenson and Monroe (Stephenson and Monroe, 1937) showed that this chalk was part of a widespread formation and named it the Prairie Bluff chalk. In the same paper Stephenson and Monroe showed that the 35 to 40 feet of argillaceous, glauconitic sand and sandy clay exposed in the bluffs of Owl Creek, 2½ miles northeast of Ripley, designated the Owl Creek marl by Hilgard and included by him in the Ripley, rested disconformably on the underlying beds. The Owl Creek marl was thus treated as a separate geologic unit and named Owl Creek formation by Stephenson and Monroe. The name Ripley is now restricted to that part of Hilgard's Ripley group which lies between the Owl Creek formation and Prairie Bluff chalk above and the Demopolis chalk below. Except in the extreme northern part of Mississippi, the Ripley formation occupies that part of the *Exogyra costata* zone above the *Exogyra cancellata* subzone and below the overlying Owl Creek formation and Prairie Bluff chalk. In northern Alcorn County and in Tennessee the Ripley includes the upper part of the *Exogyra cancellata* zone. From the latitude of New Albany north the Ripley formation is composed of three members, the Coon Creek tongue at the base, the McNairy sand member, and an unnamed upper tongue. In east central Mississippi the Ripley formation consists of an undifferentiated sandy fossiliferous chalk.

Areal Extent: The Ripley formation crops out in Mississippi in a belt nearly 17 miles wide at the Tennessee state line and continues south where it decreases in width to about 2 miles in southern Noxubee and northern Kemper Counties. Exposures may be seen in parts of Alcorn, Tippah, Prentiss, Union, Pontotoc, Chickasaw, Clay, and Oktibbeha. In Noxubee County the strike changes to southeast and so continues through the extreme northeastern part of Kemper County into the northern part of Sumter County, Alabama. Farther eastward in Alabama the strike is east-southeast and east, and the width of outcrop increases to about 8 miles with minor variations in width caused by varying topography. From the Tennessee line north the Ripley crops out in a belt 5 to 20 miles wide through Tennessee and Kentucky to the head of the Mississippi Embayment in the southern part of Illinois, and in Crowleys Ridge in the southeastern part of Missouri in the western limb of the Embayment.

The Ripley formation crops out in Kemper County in a narrow belt that trends west northwest across the extreme northeast part of the county (Plate 1). The width of outcrop across the

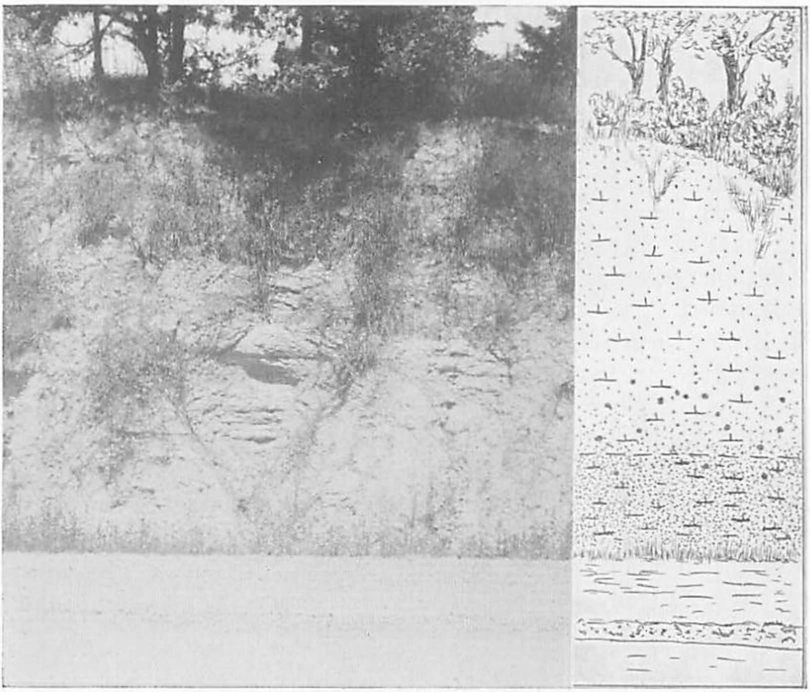


Figure 10.—Ripley-Bluffport marl contact in a road cut on east side of road on old U. S. Highway 45 just south of Wahalak Creek. Note irregular bedding of Ripley. (SW.¼, SE.¼, Sec.9, T.12 N., R.18 E.) June 22, 1954.

county is approximately 1.5 to 2.0 miles and is fairly constant. The strike of the formation is northwest and the regional dip computed from electric logs is approximately 45 feet per mile.

Thickness: The Ripley formation averages 40 feet in thickness in Kemper County. It thickens to the north in Mississippi and east in Alabama where its thickness varies considerably locally due to structural deformation contemporaneous with deposition. According to Monroe (Monroe, 1955) the thickness within the mapped area varies from 90 feet to as little as 35 feet,

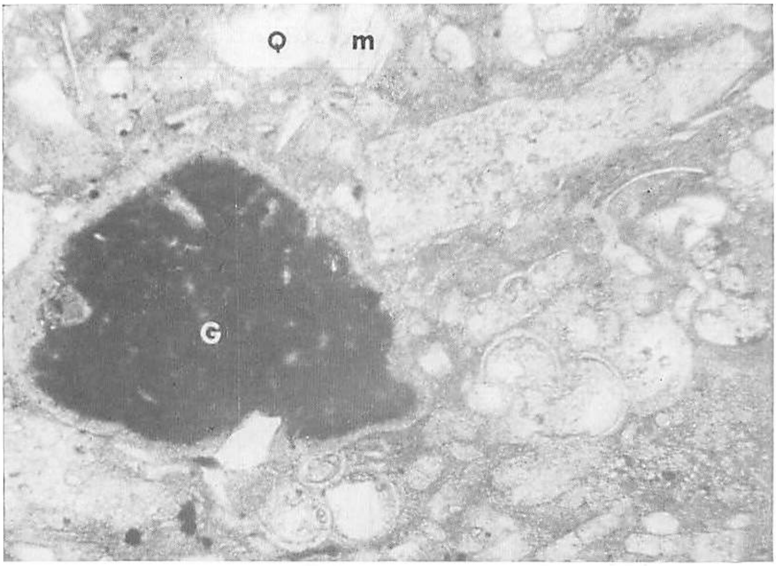


Figure 11A.—Photomicrograph of thin section of Ripley formation showing angular fragments of quartz (Q), shreds and flakes of muscovite (m), glauconite (G), minor amounts of feldspar and fossil fragments cemented by calcium carbonate containing considerable clay material. Uncrossed nicols. x110. Pete Tiller farm, (SW.¼, Sec.9, T.12 N., R.18 E.).

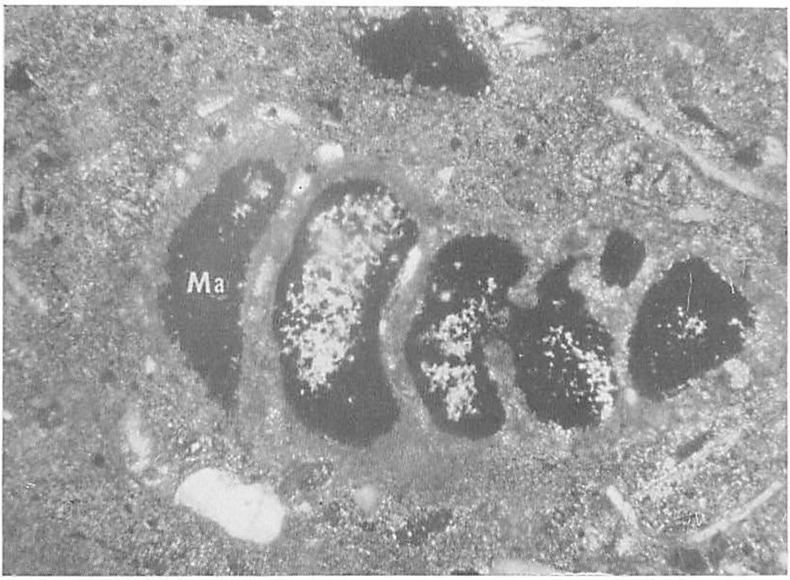


Figure 11B.—Photomicrograph of thin section of Ripley formation. Same as Figure 11-A, but many microfossil remains replaced with marcasite (Ma). Uncrossed nicols. x110. Road cut, west side of road, (NW.¼, NE.¼, Sec. 26, T.12 N., R.18 E.).

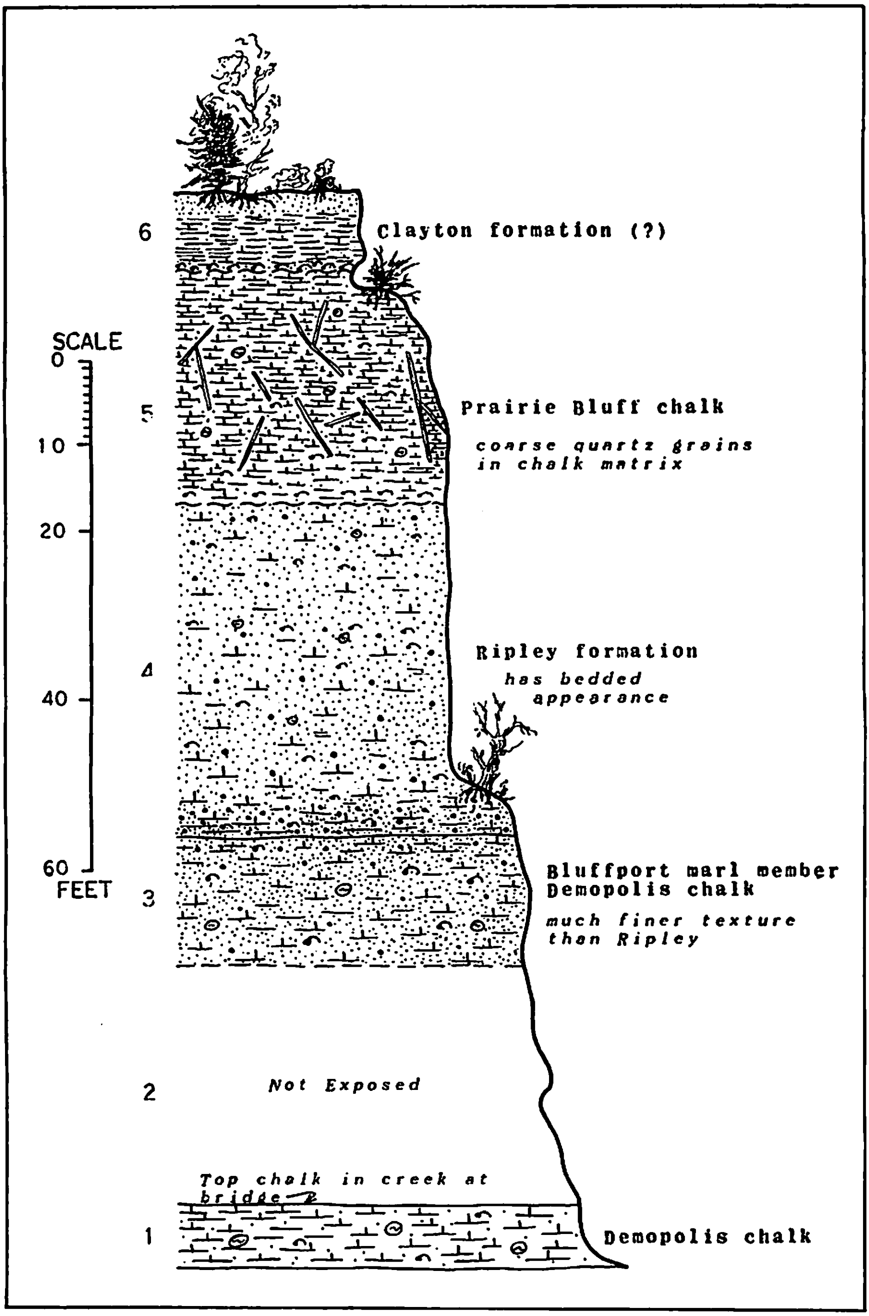


Figure 12.—Section (SE.¼, NE.¼, Sec.9, T.12 N., R.18 E.) on Old U. S. Highway 45, south of Wahalak Creek.

while two miles east of the mapped area the formation is at least 120 feet thick.

Lithologic Character: The Ripley formation in Kemper County is similar to the Ripley of western Alabama where it is referred to as the chalky facies. It consists of a gray muscovitic and glauconitic chalky sand and calcareous sandy clay, massive to irregularly bedded (Figure 10), and containing an abundant macro and micro fauna. Analyses show that it contains 48.3 percent calcium carbonate. The insoluble residues constitute the remaining 51.7 percent of the sample. Quartz is the predominant mineral and sieve analyses show that it is generally finer than ½ mm. or a fine-to medium-grained sand. Muscovite and biotite are present as shreds and small rounded flakes. Glauconite is present as spheres and capsules, and gypsum is primarily selenitic crystals and some cleavage flakes. Figures 11-A and 11-B are photomicrographs of thin sections showing the lithologic character of the Ripley. The lower part of the formation grades downward imperceptibly through a 5-foot interval into the Bluffport marl member of the Demopolis chalk from which it is differentiated by its greater content of sand.

The Ripley formation is well exposed on old U. S. Highway 45 (SW.¼, SE.¼, Sec.9, T.12 N., R.18 E.) and on a hill overlooking Wahalak Creek valley. Here it is overlain by the Prairie Bluff chalk and underlain by the Bluffport marl member of the Demopolis chalk.

SECTION (SW.¼, NE.¼, SEC.9, T.12 N., R.18 E.) ON OLD U. S. HIGHWAY 45, SOUTH OF WAHALAK CREEK. (FIGURE 12)

	Feet	Feet
Clayton formation (?)		9.1
6. Yellow to brown sandy clay containing abundant phosphatic molds of fossils at base. Upper 3 feet soft top soil	9.1	
Unconformity (?)		
Prairie Bluff chalk		27.5
5. Hard, bluish-gray, sandy, silty, massive chalk, fossiliferous, exhibiting irregular joint patterns and containing marcasite nodules	27.5	
Unconformity		
Ripley formation		39.3
4. Hard, gray to buff, very sandy, micaceous, slightly argillaceous chalk. 26.1 feet on gentle slope is in weathered condition	39.3	

Demopolis chalk		51.8
Bluffport marl member		
3. Blue-gray argillaceous, muscovitic, slightly glauconitic chalk containing marcasite nodules, fossiliferous with *E. cancellata*	16.2	
2. Not exposed	28.6	
Demopolis chalk, typical (creek bed at bridge)		
1. White, hard, muscovitic chalk containing marcasite nodules, and *E. cancellata*	7.0±	
Total section		127.7

To the northeast in the Nicholson's Hill area (NE.¼, Sec.3, T.12 N., R.18 E.) 36.1 feet of gray, muscovitic argillaceous chalky sand, abundantly fossiliferous, overlies the Demopolis chalk (see Section of Demopolis chalk, Nicholson's Hill). On the road to Millington 31.0 feet of typical Ripley is well exposed in a road cut on the west side of the road (NW.¼, NE.¼, Sec.26, T.12 N., R.18 E.). The section is described below:

SECTION (NW.¼, NE.¼, SEC.26, T.12 N., R.18 E.) OF RIPLEY FORMATION IN A ROAD CUT ON WEST SIDE OF THE ROAD 1.1 MILE SOUTH OF MILLINGTON.

	Feet	Feet
Top Soil		7.0
3. Light brown, sandy, clayey soil	7.0	
Ripley formation		31.0
2. Gray, hard, sandy, chalky medium-to fine-grained sand and silt, badly fractured and containing lime nodules in upper part	10.8	
1. Bluish to light gray, hard, micaceous chalky, fossiliferous sand, containing marcasite nodules altering to limonite	20.2	
Total section		38.0

Stratigraphic Relations: The Ripley formation overlies conformably the Bluffport marl member of the Demopolis chalk and is distinguished from the Demopolis by its greater content of sand. The interval through which the change is noticed is about 5 feet. The Ripley formation is overlain disconformably by the Prairie Bluff chalk and the contact between the two is obscure, because of the similarity of the lithologies of the two formations. Monroe (personal communication) called to the attention of the writer that the two formations may be distinguished by careful study, for the Prairie Bluff chalk is massive as compared with the irregularly bedded Ripley. On examination of the massive Prairie Bluff chalk with a hand lens it is seen to contain much coarser sand grains than the Ripley. Abundant phosphatic molds of fossils are found in the Prairie Bluff at many localities. None has been seen by the writer in the Ripley.

Physiographic Expression: The Ripley formation in Kemper County forms an imperfect cuesta with a northeast facing scarp. To the north the sands, clays and chalks of the Ripley crop out in the Pontotoc Hills which rise notably above the Black Prairie Belt on the east and the Flatwoods on the west. To the north into Tennessee relief may be as much as 250 feet locally with elevations to almost 800 feet. Toward the south the relief and elevations are much less and reflect a change in character of the underlying material. The change in topography and the narrowing of the hills is evidence of an increase in chalk and clay content which are more susceptible to erosion.

Paleontology: Fossils collected and identified, Ripley formation:

Coelenterata
- Micrabacia hilgardi Stephenson

Mollusca
- Pelecypoda
  - Exogyra costata Say
  - Ostrea falcata Morton
  - Ostrea (Gryphaeostrea) vomer (Morton)
  - Ostrea panda Morton
  - Ostrea testicasta Gabb
  - Ostrea plumosa Morton
  - Paranomia scabra (Morton)
  - Anomia argentaria (Morton)
  - Gryphaea mutabilis Morton
  - Pecten venustus
  - Legumen ellipticum Conrad
- Gastropoda
  - Gyrodes abyssinus
- Cephalopoda
  - Eutrephoceras dekayi

Vertebrata
- Vertebrae
- Sharks' teeth

Age and Correlation: The Ripley formation is entirely within the *Exogyra costata* zone. It incorporates strata that lie between the top of *Exogyra cancellata* subzone and the disconformity at the base of the Prairie Bluff chalk. As exposed in Kemper County, it is the age equivalent of the Ripley of western Alabama, and the lower part of the Ripley in Tippah and Union Counties, Mississippi. It is the time equivalent of the Nacatoch sand of Texas and Arkansas, the equivalent of the upper part of the Peedee formation of the Carolinas, and the Navesink marl of New Jersey. The Ripley is equivalent to the basal part of the Maestrichtrian stage of the European section (Monroe, 1941, p. 127).

PRAIRIE BLUFF CHALK

First Reference: A. Winchell, 1857. (Winchell, 1857.)

Nomenclator: A. Winchell, 1857.

Type Locality: Prairie Bluff on Alabama River, Wilcox County, Alabama.

Original Description: Concerning the Prairie Bluff "limestone" at the type locality Winchell says:

"White limestone, 6 feet thick, exposed at the top of the section at Prairie Bluff. Embraces in the upper part a bed of dark-colored disintegrated limestone 4 feet thick, containing obscure casts of fossils, lower portion abounds in them, and the base is almost entirely made up of *Exogyra costata* and *Gryphaea mutabilis* in very fine state of preservation. I have not seen the Tertiary beds in immediate superposition above this, but I presume the Prairie Bluff limestone is the equivalent of Blacks Bluff limestone and is the uppermost member of the Cretaceous series of Alabama."

Other Descriptions: Thompson stated in 1933 (Thompson, 1933):

"The upper few feet of the Selma chalk is remarkably uniform lithologically from Houston (Miss.) to Alabama. It is a rather hard, massive, light to medium bluish-gray, fossiliferous, chalky limestone. In Kemper and Noxubee Counties the average calcium carbonate content is approximately 70 percent, and this decreases rather uniformly from here to approximately 55 percent near Houston. According to the small number of samples examined, the size and percentage of sand increases at approximately the same rate and in the same direction as the decrease of calcium carbonate.

"In fresh exposures the upper 3 or 4 feet of the Selma chalk even where overlain by Eocene beds shows signs of weathering much more pronounced than the part immediately underneath; there are iron stains along joints and in scattered patches, the calcium carbonate is leached, and in general the rock has a weathered appearance. It is perhaps not impossible that this appearance could have been developed in part by waters coming from the more porous Eocene sediments above, but the inference is that the chalk was weathered before the younger sediments were deposited.

"For a depth of several feet down in the Cretaceous there are many worm borings in many of the exposures. These borings are filled with sediments that do not resemble the Selma chalk, but have the appearance of the overlying Eocene sediments."

Stephenson and Monroe (Stephenson and Monroe, 1940) say of the Prairie Bluff chalk:

"In the southern part of its area of outcrop in Mississippi the Prairie Bluff unit is a hard, brittle chalk characterized in its lower part by abundant phosphatic internal molds of fossil shells. In contrast the extreme upper part is nearly barren of fossils other than those of microscopic size. In Oktibbeha County the lower part of the formation contains scattered grains of coarse angular sand. Farther north, especially in Pontotoc and Union Counties, the formation becomes increasingly sandy and argillaceous to an extent such that it might appropriately be called calcareous sand or chalky clay; phosphatic molds of fossils are present in the basal beds throughout the northern extension of the formation . . .

"The thickness of the Prairie Bluff chalk varies in measured sections from only 12 feet at the type locality on Alabama River to more than 70 feet near Livingston, Sumter County, Alabama. So far as is known the formation does not much exceed 70 feet in thickness in its belt of outcrop. As the formation is overlapped to greater or less extent by Paleocene deposits, it probably increases in thickness in its buried extensions down the dip."

Monroe (Monroe, 1941) describes the Prairie Bluff chalk of western Alabama as follows:

"The Prairie Bluff chalk consists in the western part of Alabama of hard, brittle chalk, except near Livingston, Sumter County, where the lower and northern parts contain very much coarse sand. The lower part of the formation contains abundant phosphatic internal molds of mollusks, many fossil shells, and a few pebbles and cobbles reworked from underlying indurated beds. Farther east the chalk gradually merges into marl that also contains phosphatic molds, and in which cobbles are more common . . . . On the Alabama River the upper beds of the Ripley dip steeply downstream to the south but the overlying Prairie Bluff chalk has a normal gentle dip, and thus rests on truncated beds of the Ripley formation. The contact here, therefore, is an angular unconformity."

History of Usage: The original use of Prairie Bluff "limestone" by Winchell in 1857 was that of modern usage but included perhaps the basal unit of the Clayton formation. Stephenson (Stephenson, 1917) formulated the concept of the inter-tonguing of formations, thus reviving the Prairie Bluff "limestone" of Winchell at the type locality and calling it the Prairie Bluff tongue of the Selma chalk, formerly treated as a part of the Ripley formation. It is contemporaneous with the Oktibbeha tongue, a thin tongue of phosphatic chalk overlying the Ripley formation at the extreme top of the Selma chalk in Noxubee, Oktibbeha, Clay and Chickasaw counties.

In 1937 Stephenson and Monroe (Stephenson and Monroe, 1937) proposed that the Prairie Bluff deposits be given formation rank and designated the name Prairie Bluff chalk for those deposits in Mississippi and Alabama unconformably overlying the restricted Selma chalk, and elsewhere unconformably overlying the Ripley formation. The Prairie Bluff chalk was expanded to include the "Oktibbeha tongue of the Selma chalk," which was discarded.

In northern Mississippi the Prairie Bluff chalk inter-tongues with the Owl Creek formation which is an abundantly fossiliferous marine sandy clay. The Owl Creek formation extends into southern Tennessee where it is overlapped by basal Tertiary deposits, but is again exposed in southeastern Missouri.

Stephenson and Monroe say (op. cit., pp. 807-808):

"From Sumter County, Alabama, the upper chalk extends northwestward into Mississippi in a narrow strip through Kemper, Noxubee, Oktibbeha, Clay, Chickasaw, and Pontotoc Counties, and into Union County. From Noxubee County northward this chalk overlies the southward extension of the Ripley formation, a sandy, non-chalky unit of upper Selma age . . . Throughout its extent in Mississippi this phosphatic chalk unit is now known to be in unconformable relationship with beds which underlie it; at one place in Noxubee County it overlaps on the Selma chalk proper, cutting out a considerable thickness of that unit; its basal beds are everywhere characterized by their phosphate content.

"From the foregoing account it appears that the upper phosphatic zone of the Selma chalk of previous papers, and the contemporaneous so-called Prairie Bluff and Oktibbeha tongues of the Selma, constitute a persistent lithologic unit generally 50 feet or less in thickness, extending from Wilcox County, Alabama, to Union County, Mississippi, a distance of more than 200 miles. Throughout the length of this unit an unconformity separates it from the older beds beneath it, and in places, as at Prairie Bluff, the beds below the unconformity are in obvious angular relationship to those above. The unit carries a distinctive fauna, a considerable part of which is preserved as phosphatic internal molds; the phosphatic material is present mainly in the lower part of the unit, though by no means restricted to the lowermost bed. It is now proposed to raise the Prairie Bluff unit, heretofore called a tongue, to formation rank and to extend the application of the name Prairie Bluff to include the upper phosphatic zone in west-central Alabama and east-central Mississippi, previously considered a part of the Selma chalk, and the unit in Mississippi heretofore called the Oktibbeha tongue of the Selma. The name Oktibbeha is abandoned.

"The Prairie Bluff chalk as here redefined is unconformably overlain by strata of the Midway group (Eocene) except in Pontotoc County, Mississippi, where sandy, non-chalky strata, having a maximum thickness of about 15 feet, intervene between the Prairie Bluff and the Midway. These sandy beds appear to be conformable with the Prairie Bluff chalk and are unconformably overlain by the Midway."

Areal Extent: The Prairie Bluff chalk crops out in a narrow belt northwest through Kemper County, half a mile to a little more than a mile wide in places (Plate 1). It extends southeast and east into Alabama; and in eastern Alabama it merges into the Providence sand; northwest and north it extends through Noxubee, Oktibbeha, Clay, and Chickasaw Counties, Mississippi. In Pontotoc and Union Counties the chalk merges into the southward extending non-chalky marine sand of the Owl Creek formation. The belt of outcrop varies in width along strike from a maximum of about 5 miles near Starkville, Oktibbeha County, and Houston, Chickasaw County to a feather edge in the northern part of Union County.

Thickness: The thickness of the Prairie Bluff chalk in Kemper County is approximately 30 feet. Elsewhere along the strike its thickness varies. It is 12 feet thick at the type locality on the Alabama River and more than 70 feet near Livingston, Sumter County, Alabama. This variation in thickness is due to overlap by formations of the Midway group.

Lithologic character: The Prairie Bluff chalk in Kemper County consists of massive, hard, brittle, glaring white to blue-gray chalk, exhibiting numerous joint or fracture patterns, containing marcasite nodules and having phosphatic molds of fossils in the upper and lower parts. At Wahalak Creek on U. S. Highway 45 (NE.¼, NE.¼, Sec.13, T.12 N., R.17 E.) about a mile south of Wahalak the Prairie Bluff is well exposed in the creek bed at the bridge where it is approximately 9 feet thick and its outcrop may be seen at several places in the stream bed. Here the typical chalk may be examined. It is blue-gray, hard, contains embedded fossils, marcasite nodules, and has joints or fractures. It is overlain by a mottled greenish-brown, sandy, silty clay, the basal part of which exhibits weathering from the chalk. In a ditch paralleling the highway the chalk can be seen to grade up into the brown clay mentioned above. Several fossils (*Gyrodes*, etc.) were found lying in the ditch. To the west on Wash Mosely's property several feet of Prairie Bluff chalk may be seen in the creek bed. Here it is overlain disconformably by the basal sandstone of the Clayton formation which forms a ledge some 8 feet in breadth, and is about a foot in thickness (Figure 13). Elsewhere the Upper Cretaceous-Paleocene contact may be seen (Secs.17, 18, 19 and 20, T.12 N., R.18 E.) along the north facing

Figure 13.—Contact (arrow) of Prairie Bluff chalk and basal sandstone of Clayton formation. Wash Mosley property, (NW.¼, Sec.13, T.12 N., R.17 E.). June 7, 1955.

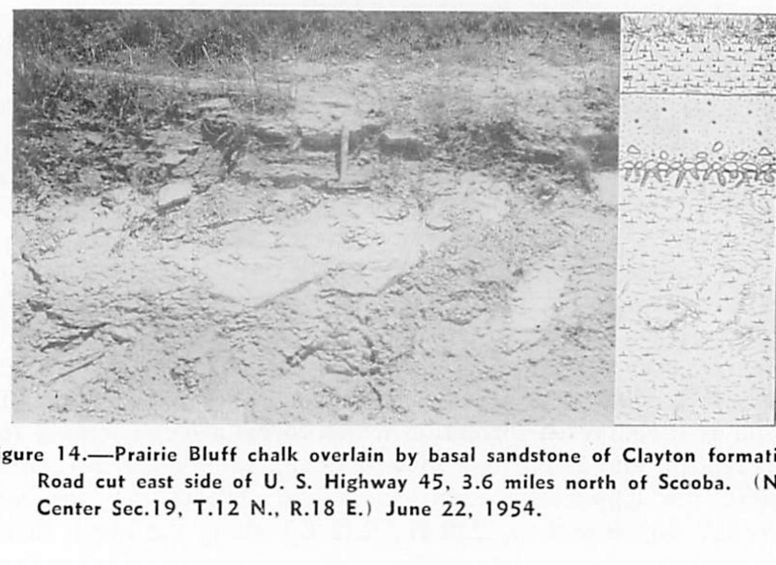


Figure 14.—Prairie Bluff chalk overlain by basal sandstone of Clayton formation. Road cut east side of U. S. Highway 45, 3.6 miles north of Scooba. (Near Center Sec.19, T.12 N., R.18 E.) June 22, 1954.

bluffs of Wahalak Creek valley. Perhaps one of the most photographed and described sections (near center, Sec.19, T.12 N., R.18 E.) of the Upper Cretaceous-Paleocene contact is that on U. S. Highway 45, 3.6 miles north of the intersection with State Highway 16 at Scooba (Figure 14). The contact is well exposed. Worm borings in the chalk are filled with sand from the overlying Clayton. The Prairie Bluff chalk here is 7.7 feet in thickness. The overlying basal sandstone of the Clayton formation is 1.6 feet in thickness, thinning to a feather edge to the south in the road cut. It is overlain by 8.8 feet of the typical buff-colored chalk of the Clayton, and *Ostrea pulaskensis* Harris abound here.

SECTION ON U. S. HIGHWAY 45, 3.6 MILES NORTH OF SCOOBA

	Feet	Feet
Clayton formation		10.4
Chalybeate limestone member		
3. Buff, sandy, silty, slightly argillaceous chalk, glauconitic; contains *Ostrea pulaskensis* Harris	8.8	
2. Yellow to brown medium-to fine-grained glauconitic friable to indurated massive to thin-bedded calcareous sandstone	1.6	
Unconformity		
Prairie Bluff chalk		7.7
1. Gray, hard, silty, slightly muscovitic chalk containing marcasite nodules	7.7	
Total section		18.1

The Prairie Bluff chalk is well exposed on old U. S. Highway 45 just south of Wahalak Creek. The section here consists of bluish to yellowish, hard, mottled, slightly glauconitic chalk containing marcasite nodules; abundantly fossiliferous in the upper 10 feet. (See section of Ripley formation at this locality.)

The greatest thickness of the Prairie Bluff chalk was measured in southern Noxubee County on U. S. Highway 45, 2.75 miles north of the Kemper-Noxubee County line. Here, in a road cut on the east side of the road are 38.5 feet of chalk overlain by the Clayton formation.

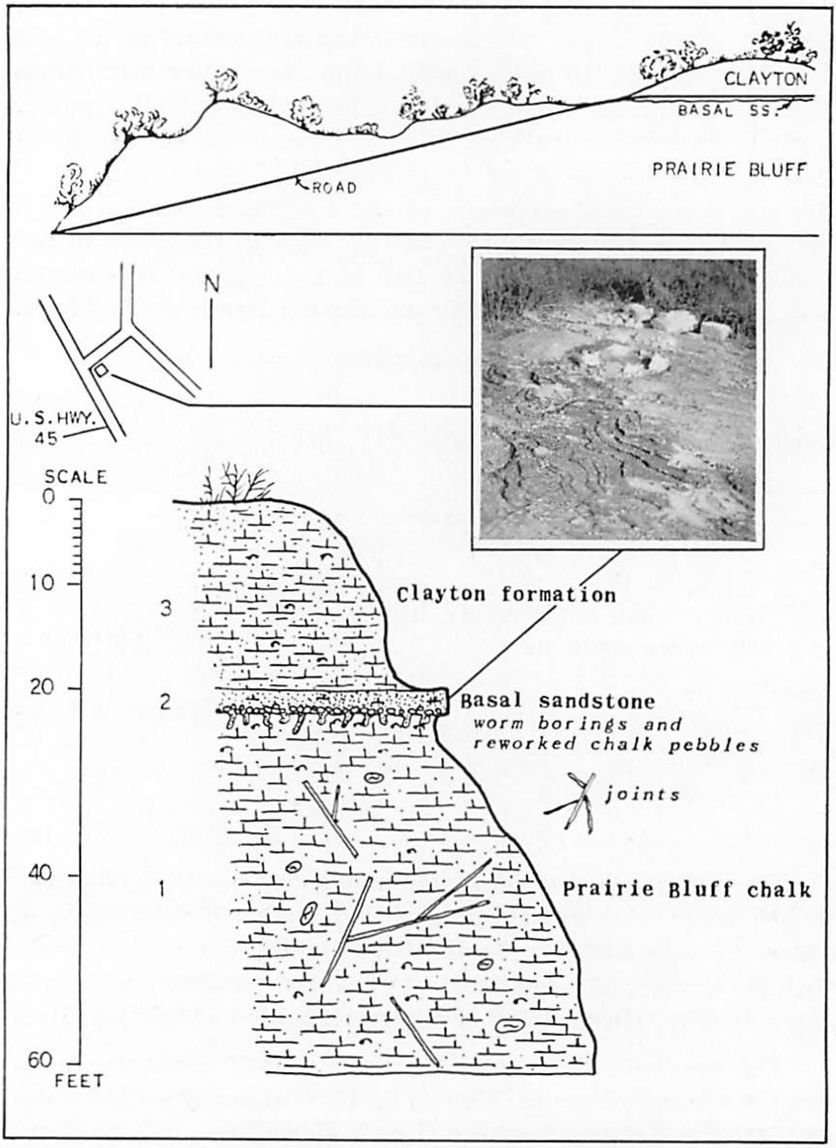


Figure 15.—Section of Prairie Bluff chalk and Clayton formation on U. S. Highway 45, 2.75 miles north of Kemper-Noxubee County line (SE.¼, Sec.22, T.13 N., R.17 E.).

SECTION (SE.¼, SEC.22, T.13 N., R.17 E., NOXUBEE COUNTY) OF PRAIRIE BLUFF CHALK ON U. S. HIGHWAY 45, 2.75 MILES NORTH OF KEMPER-NOXUBEE COUNTY LINE. (FIGURE 15)

	Feet	Feet
Clayton formation		22.7
Chalybeate limestone member		
3. Buff, sandy, silty, slightly argillaceous chalk—poorly exposed; contain *Ostrea pulaskensis* Harris	20.0	
2. Yellow to brown, glauconitic, calcareous, massive sandstone containing reworked pebbles of Prairie Bluff chalk at base and numerous worm borings	2.7	
Unconformity		
Prairie Bluff chalk		38.5
1. Light gray, hard, massive to irregularly bedded, slightly sandy, muscovitic chalk, iron-stained and containing marcasite nodules altered to limonite. Jointing prominent. Phosphatic molds of fossils	38.5	
Total section		61.2

The described section is overlain by a few feet of brown, sandy, clayey soil. On a private road a little farther northeast is what appears to be a small outlier of Clayton. The basal sandstone is absent here and the chalk is generally more glauconitic than the Prairie Bluff. The top of the exposure at this locality is stratigraphically near the top of the Cretaceous for this area, and the few feet of weathered clay at the top seem to resemble the residual clays of the Cretaceous elsewhere. The basal interval of 5 feet or so is sandy and partly weathered. The abundance of coarse sand grains disseminated throughout a matrix of chalk serves as a means of differentiating the Prairie Bluff chalk from the underlying Ripley. The Prairie Bluff chalk, generally speaking, is massive as compared to the bedded appearance of the Ripley, and contains much less muscovite than the Ripley.

Figure 16 is a photomicrograph of a thin section of the Prairie Bluff chalk. Chemical analyses of a sample (SE.¼, NW. ¼, Sec.1, T.12 N., R.17 E.) show 62.90 percent calcium carbonate with 37.10 percent insoluble residue. Quartz grains, subrounded, ¼ to ½ millimeter in size, angular selenitic gypsum, glauconite, muscovite and biotite, clay, and limonite constitute the insoluble residue.

To the east in Alabama the Prairie Bluff chalk weathers to a distinctive light brown loamy, coarse sand that contains numerous white grains of highly weathered microcline as large as 2 mm.; no other soil in the area resembles this (Personal Communication, W. H. Monroe). The writer has not seen this type of weathering above the Prairie Bluff in Kemper County.

Stratigraphic Relations: The Prairie Bluff chalk lies disconformably on the Ripley formation, the contact being obscured

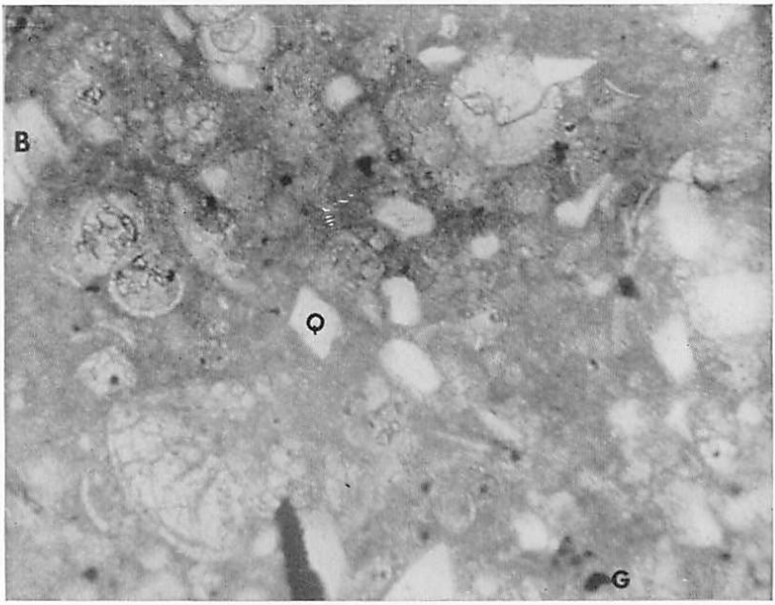


Figure 16.—Photomicrograph of thin section of Prairie Bluff chalk consisting of calcite, microfossil fragments and tests, shreds of altered biotite (B) mostly to chlorite, and minor amounts of quartz (Q) and glauconite (G). Uncrossed nicols. x110. (SW.¼, NW.¼, Sec.1, T.12 N., R.17 E.)

by the lithologic similarity of the two units near the contact. It is overlain unconformably by the Clayton formation of Midway age. The contact between the two formations is evidenced in some localities by a basal sandstone resting on chalk, with numerous borings into the chalk, a basal conglomerate of chalk worked well up into the sandstone and a zone of impure chalk, representing a weathered erosional surface. Elsewhere, the basal sandstone is missing and the sandy, yellowish, slightly indurated chalk rests directly on the Prairie Bluff. This is well exposed on a north facing bluff just west of old U. S. Highway 45 about three-quarters of a mile north of Wahalak (SE.¼, NE.¼, Sec.2, T.12 N., R.17 E.).

Physiographic Expression: The narrow, belted outcrop pattern of the Prairie Bluff chalk forms an integral part of the Black Prairie in Kemper County and gives rise to a gently rolling topography. The low hills formed by the Prairie Bluff and the more sandy Clayton formation form the western border of the Pontotoc Hills. Although rather subdued as compared with the rugged Wilcox topography, the Prairie Bluff and Clayton topography is nevertheless in contrast to the featureless Flatwoods which parallel the Pontotoc Hills on the west. The altitude of the Prairie Bluff in Kemper County is as much as 250 feet in places. Drainage is to the southeast, south of the bluffs overlooking Wahalak Creek valley. The southeast flowing creeks, Bodka, Sucarnoochee, and their tributaries drain into the Tombigbee River system. Wahalak Creek drains northeast to where it joins the Noxubee River.

Paleontology: The Prairie Bluff chalk is the uppermost formation included in the *Exogyra costata* zone in Mississippi. The lower part of the formation contains the index fossil *Diploschiza melleni* Stephenson and the echinoids *Hemiaster slocumi* Lambert and *Linthia variabilis* Slocum. Although not everywhere present, large numbers of phosphatic molds of fossils are found in the basal part. Other fossils that are restricted to the Prairie Bluff are *Cucullaea capax, Liopistha protexta,* and the cephalopod *Baculites columna.* Fossils collected and identified are as follows:

Coelenterata:
- Micrabacia hilgardi Stephenson

Brachiopoda:
- Terebratulina floridana (Morton)

Mollusca:
- Pelecypoda:
  - Crassatellites vadosus Morton
  - Cyprimeria alta Conrad
  - Diploschiza melleni Stephenson
  - Exogyra costata Say
  - Gryphaea convexa (Say)

Gryphaea mutabilis Morton
Cucullaea (Idonearca) antrosa Morton
Cucullaea (Idonearca) capax (Conrad)
Liopistha protexta (Conrad)
Nucula percrassa Conrad
Ostrea falcata Morton
Ostrea plumosa Morton
Ostrea teticosta Gabb

Gastropoda:

Anchura rostrata
Epitonium sillimani (Morton)
Gyrodes abyssinus (Morton)
Gyrodes petrosa (Morton)
Liopeplum leiodermum (Conrad)
Turritella vertebroides Morton
Xenophora leprosa

Cephalopoda:

Baculites aquilaensis
Baculites carinatus Morton
Baculites ovatus
Belemnitella americana (Morton)
Discoscaphites conradi (Morton)
Eutrephoceras dekayi

Vertebrata:

Sharks' teeth

Age and Correlation: The Prairie Bluff chalk extends northward in Mississippi as a thin unit to where it merges with the Owl Creek formation in southern Tippah County. In Alabama in western Lowndes County the Prairie Bluff chalk merges laterally with the Providence sand. In Texas the Corsicana marl is the lithologic equivalent of the Prairie Bluff. It is the equivalent of upper Maestrichtian of the European section.

TERTIARY SYSTEM

PALEOCENE SERIES

In Kemper County the Paleocene series consists of sediments of the Midway group. The Midway group includes in ascending order: the Clayton formation, 20 feet thick; the Porters Creek clay, about 500 feet thick; and the Naheola formation, approximately 80 feet thick.

The contact of the Clayton formation with the underlying Prairie Bluff chalk of the Gulf series of the Cretaceous is disconformable. In many exposures the underlying Cretaceous chalk is in direct contact with the chalks of Paleocene age, and the similarity of these beds adjacent to the contact is especially noticeable from Houston, Mississippi, to the western edge of Alabama.

A relatively long lapse of time is indicated by the hiatus and the great faunal change. In regard to the faunal change, Dana (Dana, 1895) said "The disappearance of species at the close of Mesozoic time was one of the two most noted in all geological history. Probably not a tenth part of the animal species of the world disappeared at the time, and far less of the vegetable life and terrestrial Invertebrates; yet the change was so comprehensive that no Cretaceous species of Vertebrate is yet known to occur in the rocks of the American Tertiary, and not even a *marine* Invertebrate. The only species in North America known to have continued on into the Tertiary are plants, some of which existed still in the Miocene, and a few differ little from existing species. Here ended not only the living species of Dinosaurs, of Mosasaurs, and Pterosaurs, but these tribes of Reptiles. This was true also of the Belemnites, so far as fossils give information, and, with a single doubtful exception, of the Ammonites; and among other Mollusks, of the genera Exogyra, Diceras, Requienia, Hippurites, Radiolites, Pterinea, Inoceramus, and others."

Since Dana's account of the Mesozoic-Cenozoic faunal break, many other noted geologists have described the major paleontologic hiatus between the Cretaceous and Paleocene beds in the Atlantic and Gulf Coastal Plains. Stephenson (Stephenson, 1915) mapped the contact from New Jersey to the Rio Grande, and his work, defining the ages of the beds at the contact as then interpreted, emphasized the immensity of the break between the systems. The vastness of the hiatus was questioned in 1926 by Scott (Scott, 1926), who compared Midway fauna of Texas with fauna of Danian age in Europe. Scott identified *Enclimatoceras ulrichi* White with *Hercoglossa danica* (Schlotheim). Scott's correlation was questioned by Gardner (Gardner, 1926).

The phenonomal development of the study of subsurface geology in the Gulf Coastal Plain arising from the tremendous petroleum exploration and development of the twentieth century has resulted in the accumulation of a wealth of specialized knowledge concerning micro-faunas, which has been accepted as the basis for many of our modern criteria for division of the sediments. Plummer (Plummer, 1926) was one of the most outstanding of the early investigators of Foraminifera in the Gulf Coast region. Cushman (Cushman, 1946) added much to the knowledge of the Cretaceous-Paleocene boundary. Tromp (Tromp, 1949) among numerous other workers, offered detailed microfaunal criteria for the distinguishing of the uppermost Cretaceous and basal Eocene.

MIDWAY GROUP

A really comprehensive study of the historical background of the Midway involves a review of the work of early 19th century paleontologists, Say (Say, 1824); Morton (Morton, 1829); Conrad (Conrad, 1832); Issac Lea (Lea, Issac, 1833); and Henry Lea (Lea, Henry, 1841), who founded Coastal Plain paleontology. A summary of these and other early investigations by Harris (Harris, 1896) in his "Midway Stage" covered the work done on the Midway Mollusca of the Atlantic and Gulf Coast to 1896. In this work (op. cit, p. 7) Harris states that a federal geologist, G. W. Featherstonhaugh, was the first to cite specifically a fossiliferous locality carrying Midway fossils. In writing of his reconnaissance in Arkansas, Featherstonhaugh (Featherstonhaugh, 1835) notes that "at a very limited locality on the bank (of the Arkansas River) I found a calcareous deposit containing marine fossil shells belonging to the Tertiary beds. (*Ostrea, turritella, calyptrea, cerithium,* etc.). Three miles west from Little Rock, this deposit reappears in considerable quantities, and is quarried for the purpose of making lime." The deposit cited by Featherstonhaugh is probably the limestone of the lower Midway which crops out in a narrow belt southwest of Little Rock. The name Midway was not introduced into the literature until fifty-one years later.

Winchell (Winchell, 1857) in 1857 referred beds of Midway age to the Eocene. Credit is due to Loughridge (Loughridge, 1884) as the first to recognize Midway beds both as a topographic feature and as a stratigraphic group. This observation, under the heading "Tertiary" is as follows:

"The line of low hills at the eastern edge of the black prairie region in Limestone and Falls Counties (Texas), known as the Tehuacana hills and Blue ridge, are composed of Tertiary rocks, with a few fossils, *Venericardia planicosta,* etc.; while northward at Corsicana and Will's point (in Van Zandt County), as well as on the southwest, near Bremond are soft sandstones, with Tertiary fossil casts, overlying lignite beds at 40 feet or more below the surface."

A great contribution was made in Alabama in 1886 by E. A. Smith (Smith, 1886) who described the "Midway or Pine Barren section," equivalent to the Pine Barren member of the Clayton formation of present day usage. In the same report, Smith's co-worker, T. H. Aldrich, called the same beds "Midway Group." A year later, in 1887, the recognition of the Midway "series" by Smith of the Alabama Survey, and Johnson of the Federal Survey (Smith and Johnson, 1887) was the first use of Midway as a formal name, thus delimiting the formation. Their description of the type locality is as follows:

"The bluff at Midway is half a mile or more in length, the dip of the strata quite variable, but very considerable, in places as much as one in thirty, and in some places the beds are nearly horizontal. At the lower end of the bluff appear black clays similar to those at Matthews Landing or Black Bluff, a few feet only showing, and these apparently without fossils. These clays overlie about 10 feet of light colored argillaceous limestone, with projecting hard ledges. This limestone contains the large Nautilus (Enclimatoceras) which characterizes the lowermost Tertiary beds about Pine Barren Creek below mentioned and it is no doubt identical with the Nautilus rock of eastern Wilcox.

"This Nautilus rock has been recognized in that part of Wilcox County lying west of the Alabama River, and it has been traced thence across Marengo County to Moscow, on the Tombigbee River. Southward of the localities where it forms the surface appears always a strip of black prairie soils, derived from the disintegration of the calcareous clays (or Black Bluff Group), which immediately overlie the Nautilus limestone, and southward still of this prairie belt lies the belt of Post-Oak Flatwoods, the soils of which come from the disintegration of the non-calcareous clays of the Black Bluff Group. The Flatwoods belt, as has already been intimated, does not appear to extend beyond the Alabama River towards the east, while the prairie belt attains to greater and greater importance in that direction.

"Midway is some 4 miles down the river from Prairie Bluff, where occurs the first outcrop of Cretaceous rocks on the Alabama."

D. W. Langdon in 1891 (Langdon, 1891) used "Midway or Clayton Group" in a formation sense. Smith in 1892 (Smith, 1892) proposed the names Clayton or Rutledge limestone for the impure limestone previously known as Midway Group.

In 1894, the publication by Smith, Johnson, and Langdon (Smith, Johnson, and Langdon, 1894) of the Report on the Geology of the Coastal Plain of Alabama established the Tertiary section in Alabama which became the cornerstone of the standard section for the Tertiary of other parts of the Gulf Coastal Plain. In this report the writers used Clayton to replace Midway, "This division was formerly placed with the Lignitic under the name of Midway or Pine Barren section, but because of the great development of the formation in the eastern part of the State, and the absence of any lignite beds in it, the name Clayton has been substituted, from the county seat of Barbour where the limestones and other characteristic beds are so well exposed." (op. cit. p. 192.)

G. D. Harris in 1894 and 1896 (Harris, 1894a; Harris, 1894b; Harris, 1896) used Midway in a group sense and stage term to include the Matthews Landing marl (substage), Black Bluff clays (substage), and the Midway clay and limestone (substage). Harris in these reports made a monumental first attempt at a correlation of the Atlantic and Gulf Coastal Plain Midwayan sediments; and his usage of Midway stage in a broad sense, as a stratigraphic unit is the first distinction in the literature between time-stratigraphic and rock-stratigraphic units of the Midway, and is the basis for the modern usage of Midway group and Midway stage. Actually, Harris' use of "stage" was in a biostratigraphic sense, as defined in Report 5 of the American Commission on Stratigraphic Nomenclature (Bull. Amer. Assoc. Petrol. Geol., Vol. 41, No. 8, Aug. 1957, pp. 1877-1891) which states:

> "Biostratigraphic units are bodies of rock strata which are characterized and unified by features of their content of fossils. Commonly they are roughly parallel with rock-stratigraphic and time-stratigraphic units, but they do not necessarily conform to such units nor are they necessarily restricted by the boundaries of such units. They are relatively objective units delimited by the actual physical occurrences of fossil forms in rocks. They are quite different in fundamental nature from time-stratigraphic units. Time-stratigraphic units are more subjective and, while commonly drawing on the interpreted time-significance of fossils, are not exclusively based on fossils nor necessarily restricted by the physical distribution of fossil forms."

In Part I of Harris's classic report (op. cit., pp. 5-44) he describes the geological features of the Midway terrane; and Part II of the report (op. cit., pp. 45-156) in the author's words was "intended to include original descriptions, localities, whereabouts of types, figures, etc., of all well authenticated molluscan species known from the Midway." His emphasis seems objective and bio-stratigraphic.

Clayton Formation

First Reference: D. W. Langdon, 1891, (Langdon, 1891). Langdon speaks of Midway or Clayton at typical locality on Alabama River and describes a section of 220 feet on Chattahoochee River (p. 595).

Nomenclator: E. A. Smith, 1892. Smith proposed Clayton or Rutledge limestone (p. 388) for impure limestone previously known as Midway group. Rutledge was soon dropped and Clayton was used synonymously with Midway for a while, then applied only to basal formation of the modern Midway. Of the Tertiary, Smith says (p. 413), "The subdivisions of the Tertiary have been given fully in the table (p. 388) at the head of the present article. A few words of explanation may be added: At the base of the Tertiary is found an impure limestone, thin and inconspicuous in west Alabama, but thickening eastward until, on the Chattahoochee river, it is fully 200 feet.

"This we have called the Clayton limestone, formerly known as our Midway group, from a locality on the Alabama River."

Type Locality Section: C. W. Cooke in 1926, (Cooke, 1926a) writes of the type section of the Clayton formation:

"Section on Central of Georgia Railway east of Clayton

	Feet
Clayton Formation:	
5. Brittle calcareous light-gray clay, resembling fuller's earth	15
4. Coarse rusty yellow sand at base, passing upward into irregularly indurated calcareous sand and sandy limestone; upper part of of limestone contains many shells of *Ostrea crenulimarginata;* thickness about	35
Unconformity	
Ripley formation (Providence sand member):	
3. Greenish-gray, compact coarse sand	3
2. Concealed, about	20
1. Coarse pale-blue sand and clay."	

Original Description: Of the Midway or Clayton group Langdon's described section on the Chattahoochee River (p. 595) is as follows:

"Section of Midway or Clayton Group; Chattahoochee River

	Feet
1. White calcareous sand, containing a few obscure casts and *Ostrea* sp. (?). The sand sometimes becomes irregularly indurated and is the source of numbers of small lime springs. It	

forms the lowest part of the bluff at Fort Gaines, Ga., and in its uppermost 10 feet contains pockets of white sand enclosed by black clay, the clay resting in "potholes" in the limestone. Estimated at 200

2. Light-yellow, siliceous limestone, containing a large *Ostrea* and numerous obscure casts 10

3. Massive, coarse-grained sandstone, almost a conglomerate 8

Ripley Group."

Other Descriptions: E. A. Smith, (Smith, 1892) states:

"The Midway or Pine Barren Section; Clayton limestone. The thickness of this section along the Alabama and Tombigbee Rivers is perhaps 25 feet. The strata are a white argillaceous limestone holding a large fossil of the Nautilus family, which is characteristic of the horizon, calcareous sands and crystalline limestone with Turritellas, Carditas, and Corals. This section is best seen in eastern Wilcox on Pine Barren Creek, and in adjoining part of Butler in the Little Texas Region, but the upper or Nautilus rocks occur at Midway on the Alabama River and westward across Marengo. In going eastward we find the rocks of this section increasing in thickness till on the Chattahoochee it includes over two hundred feet of limestones and other calcareous strata."

The Clayton formation is described by Lowe (Lowe, 1933):

"The Clayton beds in Mississippi are highly calcareous, largely glauconitic marine deposits. The lower half of the formation (20 to 25 feet) consists of hard, yellowish semi-crystalline limestone, highly fossiliferous, which occurs in beds ranging in thickness from 2 to 6 feet. On long exposure to the weather the surface of the rock becomes very rough, cellular, and nodular, the cavities having been formed by solution of the softer parts. The projecting nodules are usually due to the more resistant calcitic fossils, especially the large univalve shell *Turritella mortoni,* the most abundant fossil, from which the rock has been called the "Turritella rock."

"The more uniformly persistent member of this formation is the sandy marl that overlies the limestone. This member is rather uniform both in character and in thickness. It consists of 25 to 35 feet of calcareous glauconitic sand, micaceous at many places, greenish-gray where unweathered, but orange-red to Indian-red where exposed to the weather."

In 1933, Thompson (Thompson, 1933) subdivided the Clayton into five recognizable zones based on lithologic character from Houston, Mississippi, to Alabama. The zones, from oldest to youngest are:

"Zone 1 — Basal greensand marl: With one exception this zone was found only in exposures where there is a basal Eocene conglomerate. It seems to occur only in depressions of the Cretaceous surface, and is composed of brownish-to-greenish brown, glauconitic, massive, calcareous, sandy marl. In a few places it contains small, rounded pebbles of the underlying Cretaceous. The thickness varies up to 1 foot, with an average, where present, of about 3 inches. Many fossils occur as fragments in this zone, but their state of preservation is, in most cases, too poor for collecting. In one locality small fragments of *Baculites* molds of white chalk are associated with pebbles of similar chalk. The division between this zone and the overlying zone is very sharp due primarily to a difference in the degree of cementation, and there is little doubt that this is a part of the basal Midway group; the *Baculites* were derived mechanically from the underlying Cretaceous.

"Zone 2 — Conglomerate: Basal conglomerate is very irregular in thickness and pinches out entirely from a thickness of 3½ feet within 100 yards. It is composed of rounded pebbles to boulders of the underlying chalk up to 8 inches in diameter, in a matrix of medium-to-fine grained glauconitic quartz sandstone highly cemented with calcium carbonate. The chalk fragments are more easily weathered than the matrix and in places only the matrix is left, with cavities from which the chalk has been removed. The maximum thickness found is 3½ feet. The transition from this zone to the overlying sandstone is very gradual and conformable. No fossils were seen.

"Zone 3 — Sandstone: This zone like Zones 1 and 2 is variable and changes from several feet in thickness to zero within short distances. It is composed of medium-to-fine-grained, dense-to-friable, massive-to-thin bedded, micaceous, glauconitic, brown, quartz sandstone. In most places the base is more highly cemented with calcium carbonate than the upper part. The thickness varies from nothing to 5 feet, and the transition to the overlying limestone is gradual. It is probable that the upper foot or so that is included in this zone in some of the section is a leached phase of the lower more sandy part of Zone 4.

"Zone 4 — Limestone: This zone is relatively uniform in thickness from Houston to Alabama and has not been found missing in a single section throughout this distance. It is medium, greenish-gray, arenaceous, very micaceous, glauconitic, very fossiliferous, thin-bedded limestone. There is a decrease in sand from the base upward and an increase in clay near the top. It ranges in thickness from 3 feet to 11 feet and has an average of approximately 8 feet. In passing south from Houston the yellow nodular limestone of the typical Clayton formation north of Houston can be traced as far south as the southern edge of Clay County where it retains its nature in the form of a 1 foot bed of yellowish nodular limestone, very full of gastropod casts, 1½ feet from the top. Farther south this yellowish limestone grades into the more typical phases of Zone 4.
"Zone 5 — *Ostrea pulaskensis* Limestone: Although very thin, this zone is very persistent and is apparently continuous from Houston to Alabama. It is composed almost entirely of the shells of the small oyster *Ostrea pulaskensis* Harris in a matrix of shaly to silty limestone. The calcium carbonate content of this zone is relatively high, in places as high as 80 percent. The only megascopic fossil that can be definitely referred to this zone is *Ostrea pulaskensis* Harris. The average thickness of the zone is a little over 1 foot, the maximum is 3 feet, and the minimum 1 foot. The contact with the overlying Porters Creek clay is conformable."

F. S. MacNeil (MacNeil, 1946b) describes the Clayton as follows:

"At Clayton, Ala., the section consists of a lower zone of about 35 feet of sand and limestone, grading from non-calcareous, *Halymenites*-bearing sand at the base, through coarse sandy limestone to sand-free, hard, white limestone at the top. This Chalybeate limestone member of the Clayton formation in Mississippi contains hard, crystalline, extremely fossiliferous limestone; interbedded soft to tough marls; dark leaf-bearing shales; glauconitic sand, and a fossiliferous siltstone at the top. The leached appearance of the sand near the top suggests that part of it may have been calcareous sand or sandy limestone.

"From Chickasaw County, Mississippi, to the Tombigbee River the beds referred to the Chalybeate limestone member of the Clayton, above the basal sandstone, are glauconitic sandy to silty chalks and calcareous clays with bed or reefs of the small oyster, *Ostrea pulaskensis*. There are no key beds that can be traced through or that would suggest a direct correlation with the named members or parts of them in central Alabama."

MacNeil also defined in the Clayton:

"an upper zone of about 15 feet of hackly gray clay that has been unsuccessfully mined for fullers earth. The formation thickens eastward to nearly 130 feet on the Chattahoochee River, where the upper clay is represented by smooth-textured argillaceous limestone. Most exposures away from the rivers, however, show only compacted sand, residual from the solution of the limestone, and crumpled clay. Most of the crumpling is due to the complete solution of the non-clastic zone in the limestone immediately below the clay."

Mississippi Geological Society Guidebook, Tenth Field Trip, Sept. 24-26, 1953; Wilcox and Midway groups, West Central Alabama, (p. 6) states:

"On the Chattahoochee River in eastern Alabama the Clayton formation consists of about 140 feet of massive limestone and some sand at the base. The Clayton formation in Wilcox County consists of about 150 feet of limestone, and red-weathering sand, underlain by calcareous clay and silt and fine sand. In western Alabama the Clayton formation (U. S. G. S. classification Chalybeate limestone member of Porters Creek clay) consists of a fossiliferous clayey limestone less than 20 feet thick that underlies the Porters Creek clay.

"Pine Barren member — The '*Turritella* rock' consists of a sandy limestone, yellow to yellowish gray, crystalline, hard, very fossiliferous, and coarse quartz sand and glauconite. The lower part of this sandy limestone weathers rapidly to coarse red sand with residual limestone boulders. The lower part of the member consists of gray calcareous silt that weathers yellowish gray. Exposures of this part of the formation are characterized by many siltstone ledges about a foot thick. At the base at some localities is an irregular bed of coarse glauconitic sand with phosphatic nodules and reworked fossils from the underlying Cretaceous deposits. The total thickness of the Pine Barren member of the Clayton formation in eastern Wilcox County is estimated at 125 feet.

"McBryde limestone member — . . . "of Wilcox County contains in abundance the large nautiloid *Hercoglossa ulrichi*, . . .and in its type area it consists of about 20 feet of light-gray fine sandy to silty chalk with indurated layers. These beds lie directly on the '*Turritella* rock' of the Pine Barren member. To the east in eastern Wilcox and Butler Counties the McBryde member thickens to about 30 feet. Farther east it becomes the middle bed of the undifferentiated Clayton formation. West of north-central Wilcox County the McBryde limestone member becomes more clayey and intertongues with the lower part of the Porters Creek."

History of Usage:

Midway or Pine Barren Section — (Smith, 1886). Although no mention is made of Clayton, Pine Barren is used as equivalent of Pine Barren and McBryde members of the Clayton formation of Alabama of modern usage. (Same description in U. S. G. S. Bull. 43, 1887).

Midway or Clayton Group — (Langdon, 1891). The term Clayton is used synonymously with Midway.

Clayton or Rutledge limestone — (Smith, 1892a). Proposed Clayton or Rutledge limestone for impure limestone previously known as Midway group. Rutledge was soon abandoned and Clayton was used synonymously with Midway for a while, then later applied only to basal formation of modern Midway.

Clayton Formation — (Thompson, 1933) was subdivided by Thompson in 1933 into 5 recognizable zones, from oldest to youngest, (1) basal greensand marl, (2) conglomerate, (3) sandstone, (4) limestone, and (5) *Ostrea pulaskensis* limestone.

Clayton formation — (Conant, 1941; 1942). Conant in these two publications subdivides the Clayton into two unnamed members, a basal limestone and marl member, and an upper "marl" member, which is composed of marls, clays, and sands.

Pine Barren member of the Clayton formation — (MacNeil, 1946b). MacNeil proposed the Pine Barren member as the lower member of the Clayton formation in Wilcox and Butler Counties, Alabama. "The type exposures of the Pine Barren member of the Clayton are in the road cuts and ditches on the south side of Pine Barren Creek, along State Highway No. 100, from the southern junction with State Highway No. 11 to the bed of the Creek at McConnicos Mill in the SE.¼, Sec.21, T.12 N., R.10 E., Wilcox County, Alabama. The lower beds of the member are well exposed in cuts along State Highway No. 43 in Secs. 27 and 28, T.13 N., R.9 E., Dallas County, Alabama, and on the road descending the bluff to old Canton Landing on the Alabama River in Wilcox County."

McBryde limestone member of Clayton formation — (MacNeil, op. cit., p. 7). MacNeil proposed the name McBryde limestone member of the Clayton formation to replace Nautilus rock of early writers. Type locality for the McBryde limestone member is "in road cuts along State Highway 100 in Secs. 28 and 33, T.12 N., R.10 E., Wilcox County, Ala., about 3 miles west of McBryde Station. In its type area it is a hard, white, fine-grained, sandy limestone, 20 to 25 feet thick."

Chalybeate limestone member of Clayton formation — (MacNeil, op. cit., p. 9) was proposed by MacNeil in 1946 "to designate those beds of the Clayton formation that are in Mississippi and west of the Tombigbee River in Alabama. The type locality is a ravine just north of the main street of Chalybeate, probably in the south-center of Sec.3, T.2 S., R.4 E., Tippah County, Mississippi. From there, southeastward along the strike to the Tombigbee River it thickens to about 25 feet."

The Chalybeate limestone member of the Clayton formation will be used in this report.

Priority: Ft. Gaines limestone — (Smith, 1888). On this map Fort Gaines is applied to rocks between the Midway above (probably only upper part of Midway group of present usage) and Ripley below. As thus used the name applies to the lower part of the Midway formation of eastern Alabama. The Nanafalia is also well exposed at Fort Gaines, Ga. (Wilmarth, 1938).

Of the Fort Gaines limestone, MacNeil (MacNeil, op. cit., p. 6) says: "If the Midway group were to be subdivided here for the first time, the writer would probably not treat the Clayton formation as he does. It was the feeling of several geologists with whom the writer discussed this problem, however, that the concept of the Clayton should not be changed. Actually the name Fort Gaines limestone has priority over Clayton."

Areal Extent: The Clayton formation constitutes a zone half a mile to approximately a mile wide passing diagonally northwestward through Kemper County (Plate 1). The width of outcrop from the Alabama line to Tennessee varies along the strike from a fraction of a mile to 10 miles or more. In Chickasaw and Pontotoc Counties, the strike is generally north-south and from southern Union County to the Tennessee line, the trend is north-northeast. From Chickasaw County south, through Clay, Oktibbeha, and Noxubee Counties, the strike is in a southeasterly direction.

Thickness: In Kemper County the Clayton formation is approximately 20 feet thick. To the north at Chalybeate its thickness is approximately 80 feet. In Clay County it is approximately 10 feet thick and from there southeastward along the strike to the Tombigbee River in Alabama it thickens to about 25 feet. In eastern Alabama on the Chattahoochee River the total thickness of the Clayton is approximately 130 feet.

Lithologic Character: The lithologic character of the Clayton formation varies along the strike. In general, the beds are highly calcareous, glauconitic marine deposits. In Kemper County they consist of an amber-colored basal unit, a medium-to-fine-grained, consolidated to friable, massive, glauconitic, muscovitic quartzitic sandstone cemented by calcium carbonate (Figure 17). Chemical

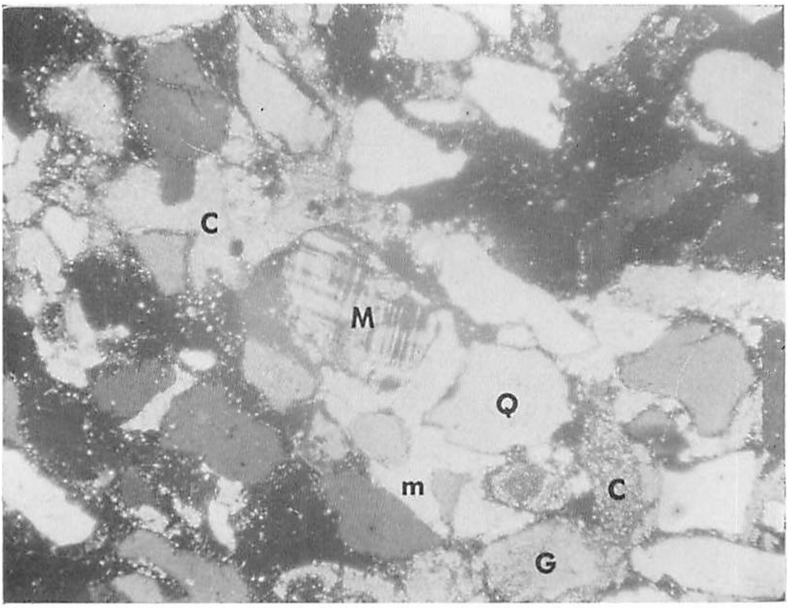


Figure 17.—Photomicrograph of thin section of basal sandstone of Clayton formation. Sandstone consists of medium-to-fine-grained quartz (Q), muscovite (m), biotite, microcline (M), plagioclase and glauconite (G) in a carbonate and clay matrix. Carbonate cement (calcite, C) makes up about 35 percent of the section. Black is Canada Balsam. Crossed nicols. x53. (NE.¼, NE.¼, Sec.19, T.12 N., R.18 E.)

analyses of the basal sandstone show that it contains 38.1 per cent calcium carbonate. The remainder of the sample, the insoluble residue, is 61.9 per cent. The constituents are clear, subhedral quartz, glauconite, limonite, hematite, massive gypsum, microcline and occasional small elongated crystals of tourmaline. The thickness of the basal sandstone varies from almost nothing to a foot or more, and in places the unit is missing. The sandstone is overlain by some 19 feet of yellow-gray sandy to silty, muscovitic, glauconitic, fossiliferous chalk and calcareous clays, containing beds or reefs of the small oyster *Ostrea pulaskensis* Harris in the upper 2 to 3 feet (Figure 18). Chemical analyses of the typical chalk from the SW.¼, NE.¼, Sec.19, T.12 N., R.18 E., show that it contains approximately 55.0 per cent calcium carbonate, the insoluble residue constituting the remaining 45.0 per cent. The insoluble constituents are clay, sponge-like, with sand and silt, muscovite and biotite, glauconite, and selenitic gypsum. There is a decrease in sand from the base upward and the top

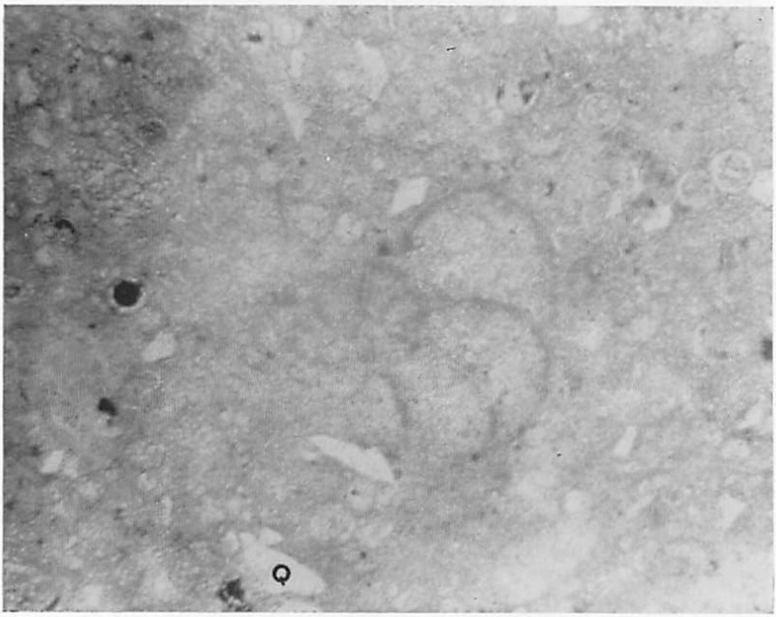


Figure 18.—Photomicrograph of thin section of typical chalk of Clayton formation. Fine-grained quartz (Q), shreds of muscovite and biotite, glauconite, and microfossil remains in a carbonate-clay matrix. Uncrossed nicols. x110. (SW.¼, SW.¼, Sec.12, T.12 N., R.17 E.)

part consists of calcareous clay, grading imperceptibly into the Porters Creek clay.

Exposures of the Clayton formation may be examined along the south bluff of Wahalak Creek, in the creek itself (NE.¼, Sec. 13, T.12 N., R.18 E.) and just 50 yards west of old Highway 45, ¾ mile north of Wahalak (SE.¼, Sec.2, T.12 N., R.17 E.). South of these outcrop areas exposures are less prominent, and differentiation of the Clayton from the underlying Prairie Bluff chalk is less certain, because of the absence of the basal sandstone. In the NE.¼, NW.¼, SE.¼, Sec.23, T.11 N., R.18 E., at the west end of a small lake, pieces of the basal sandstone are lying about not in place, and the contact with the underlying Prairie Bluff chalk in that area may be inferred. A rather glauconitic yellowish-gray chalk overlies the more compact, massive, blue-gray chalk of the Prairie Bluff, and the contact is taken between the two.

The Clayton-Prairie Bluff contact is well exposed in several localities. On U. S. Highway 45, 3.65 miles north of the inter-

Figure 19.—Contact of Prairie Bluff chalk and basal sandstone of Clayton formation in a field approximately one-half mile N.60°E. from exposure on U. S. Highway 45. (NE.¼, NE.¼, Sec.19, T.12 N., R.18 E.) June 22, 1954.

section with Mississippi Highway 16 at Scooba (near center Sec.19, T.12 N., R.18 E.) the Clayton disconformably overlies the Prairie Bluff chalk. Approximately 2 feet of the basal sandstone here rests on the Prairie Bluff chalk. Worm borings are prevalent. The sandstone is overlain by almost 9 feet of yellowish sandy, silty, slightly argillaceous chalk, and in a field at the top of the road cut, *Ostrea pulaskensis* Harris may be found in abundance. Also, at a place N. 60° E. from the Highway 45 locality 300 yards (NE.¼, NE.¼, Sec.19, T.12 N., R.13 E.) the basal sandstone may be seen resting on the Prairie Bluff chalk (Figure 19). The basal sandstone here measured 1.1 feet in thickness and in its lower half considerable reworking has taken place, as shown by worm borings into the underlying Prairie Bluff. The basal conglomerate consists almost entirely of Prairie

Bluff chalk with some admixed sandstone of the Clayton. Boulders of the Clayton sandstone are strewn over the Prairie Bluff surface. Overlying the sandstone is about 19.0 feet of yellowish, argillaceous, fossiliferous chalk, containing *Ostrea pulaskensis* Harris.

SECTION (NE.¼, NE.¼, SEC.19, T.12 N., R.18 E.) IN A FIELD APPROXIMATELY 300 YARDS NORTHEAST OF U. S. HIGHWAY 45, AND 3.65 MILES NORTH OF INTERSECTION WITH MISSISSIPPI HIGHWAY 16 AT SCOOBA.

	Feet	Feet
Top soil		0.5
4. Buff, sandy, silty, clayey top soil	0.5	
Clayton formation		19.6
Chalybeate limestone member		
3. Buff, sandy, silty, argillaceous chalk containing *Ostrea pulaskensis* Harris and other fossils	18.5	
2. Yellow to brown, medium to fine-grained, friable to indurated, massive to thin-bedded, calcareous sandstone containing biotite	1.1	
Unconformity		
Prairie Bluff chalk		8.9
1. White to blue-gray hard, silty, massive chalk, fractured and containing marcasite nodules	8.9	
Total section		29.0

The basal sandstone is well exposed in Wahalak Creek on the Wash Mosley property (Secs.12, 13, T.12 N., R.17 E.). The sandstone here is about 2 feet thick and forms a projecting ledge as wide as 8 feet in places.

As mentioned previously, the contact of the Clayton with the overlying Porters Creek clay is gradational, and nowhere in Kemper County are good exposures showing the contact. On old U. S. Highway 45, just north of Wahalak, the lithologic change from the yellowish-gray chalks to a weathered reddish-brown clay may be seen in a ditch on the west side of the road.

SECTION ON NORTH-FACING SLOPE AND IN DITCHES ON WEST SIDE OF OLD U. S. HIGHWAY 45 JUST NORTH OF WAHALAK. SECTION STARTS IN CREEK AT BOTTOM OF HILL AND IS CONTINUOUS TO TOP OF HILL.

	Feet	Feet
Top soil		6.5
4. Reddish to yellow-brown fine sand and clay with ferruginous concretions	6.5	
Porters Creek clay		8.0
3. Dark-gray somewhat mottled clay having conchoidal fracture	8.0	

Clayton formation		20.9
Chalybeate limestone member		
2. Buff, sandy, silty chalk; glauconitic basal 1 foot indurated; *Ostrea pulaskensis* Harris	20.9	
Unconformity		
Prairie Bluff chalk		20.0
1. White to gray, hard, massive, slightly silty muscovitic chalk with marcasite nodules—to creek bed	20.0	
Total section		55.4

Stratigraphic relations: In Kemper County the Clayton formation is conformably overlain by the Porters Creek clay. The contact is gradational from the calcareous clays of the Clayton to the blocky, hackly clays of the Porters Creek. The Clayton is underlain disconformably by the Prairie Bluff chalk of the Upper Cretaceous. Where the basal sandstone is present the contact is sharp and in great contrast to the massive bluish-white chalk of the Prairie Bluff. The basal sandstone is not everywhere present, and where absent the contact between yellowish-gray chalk and the underlying Prairie Bluff is difficult to determine. The weathered upper Prairie Bluff resembles remarkably the chalks of the Clayton. Generally, the Clayton may be distinguished by its greater content of glauconite.

Physiographic expression: The Clayton formation is manifested by broad, gently undulating and rolling uplands which weather to rich tan to brown soils. The relief of its topography is small as compared with that of the chalks of the Selma group, but otherwise its topographic surface is remarkably similar to the surface of the Upper Cretaceous chalks. Drainage within the Clayton outcrop area is to the south and southeast.

Paleontology: The Clayton formation is not abundantly fossiliferous in Kemper County. Its fossils are not rare nor are they abundant. They are nearly all in the form of casts, partly or totally phosphatized and so badly weathered and poorly preserved that positive identification of some was impossible. Pelecypods and gastropods constitute the largest part of the collection, and the lower Paleocene guide fossil, the small oyster *Ostrea pulaskensis* Harris can be found in great numbers in several localities. Such forms as *Turritella mortoni* (?) or *Turritella saffordi* Gabb (?), *Cucullaea saffordi* (?) with worm tubes, *Dentalium mediaviensi* (?), *Ostrea pulaskensis* Harris, the corals *Flabellum conoideum* (?), *Balanophyllia ponderosa* (?).

Age and correlation: The Clayton formation is the lowermost unit of the Midway group of the Paleocene series in the Gulf Coast region. It is correlated with the Kincaid formation of Louisiana and central and east Texas. It is the age equivalent possibly of the lower beds of the Pine Barren member of the Clayton formation of central Alabama.

PORTERS CREEK CLAY

First reference: J. M. Safford (Safford, 1864). Safford referred to the Porters Creek as Porters Creek Group (Provisional). On page 361 he lists the groups of West Tennessee as:

9.	Bottom Alluvium	Modern
8.	Bluff Loam	Post-Tertiary
7.	Bluff Gravel	Post-Tertiary
6.	Bluff Lignite (Provisional)	Tertiary?
5.	Orange Sand, or LaGrange Group	Tertiary
4.	Porters Creek Group (Provisional)	Tertiary?
3.	Ripley Group (Provisional)	Cretaceous
2.	Green Sand, or the shell-bed	Cretaceous
1.	Coffee Sand	Cretaceous

Also on this page is a cross section along the Memphis and Charleston Railroad, 120 miles, showing disposition of the above units.

Nomenclator: J. M. Safford, 1864. See reference mentioned above. Also see "Flatwoods Clays" of Hilgard, 1860, pp. 110, 111, in "Report on the Geology and Agriculture of the State of Mississippi"; "Black Bluff Series," Smith, E. A. and Johnson, L. C., 1887, U. S. Geol. Survey Bull. 43; "Black Bluff or Sucarnoochee Series" of E. A. Smith, L. C. Johnson, and D. W. Langdon in Alabama, "Report on the Geology of the Coastal Plain of Alabama," pp. 27, 186. 1894.

Porters Creek clay has priority over "Sucarnoochee" or "Black Bluff" of Smith; thus the last two names have been abandoned in Alabama. Porters Creek clay, a geographic name, replaces the descriptive term "Flatwoods" of Hilgard.

Type locality: Porters Creek, Hardeman County, Tennessee, approximately 1.5 miles west of the railroad station at Middleton.

Original description: Of the Porters Creek Group, Safford (Safford, 1864, p. 368) says:

"I have heretofore included this series in the Orange sand. It may be well however to keep it separate until its age is more satisfactorily ascertained. There is no marked distinction between this and the adjacent groups, except that it contains proportionally much more laminated or slaty clay. The clay has the usual characters, contains mica-scales, is dark when wet and whitish-gray when dry. The thickness of the series is perhaps 200 or 300 feet. In this are usually several beds of slaty clay from five to fifty feet in thickness. In Hardeman County, on Porters Creek (The first creek on the map, west of "M," (Middleton) on the M. and C. R. R., is a heavy bed said to be 100 feet thick. I have seen as much as 50 or 60 feet of it exposed.

"Along the Memphis and Charleston Railroad, the belt of surface occupied by the group is about eight miles wide. It becomes narrower as we follow it northward (4,4, on the map). The belt appears to be the northern extension of Hilgard's 'Flatwoods' region, the group itself forming the lower part of his 'Northern Lignitic.' I have met with hard layers, 'rocks,' in this series containing shells, but as yet have found no determinable ones. In several of the cuts along the M. & C. Railroad, specimens of leaves are found in the clays and sometimes in thin local sandstones. The leaves in my collection from this group, which are not many, have not been examined. One is much like *Quercus* Saffordii, Lsqx., of the succeeding group, and may be that species; the others are unknown to me."

Other descriptions: Hilgard, in his "Report on the Geology and Agriculture of the State of Mississippi," (Hilgard, 1860) describes well the Porters Creek clay under the name "Flatwoods." Of these clays he (Hilgard, 1860, p. 165) says:

"In the Flatwoods, and the hills immediately adjoining them to the westward, the material of the formation is usually a hard, gray or whitish clay, sometimes laminated, but more usually of a massy cleavage, with a tendency to conchoidal or nodular forms, which are conspicuous in most of the outcrops found on whitened hillsides in the Flatwoods. This clay shows but little tendency to disintegrate by the atmospheric agencies alone; it does not 'slake' readily, so long as it retains its original structure, and hence it is very generally worn into genuine pebbles by the streams. When, however, it has once been broken up and worked into a plastic mass by mechanical means (as for instance by denudation and re-deposition, or in roads), it resumes this condition with extraordinary facility. Such is the nature of the surface material of the Flatwoods, obviously derived from the (originally hard and intractable) clays of the underlying strata, which it covers to a depth of from two to ten feet, forming to a great extent both the soil and subsoil. These surface clays possess a cleavage strictly massy, the cleavage planes being generally of a reddish tint; a rain falling on this mass, instantly converts it into the toughest mud. This toughness is rarely impaired through the presence of sand; the uncombined siliceous matter contained in the mass is usually in a state of fine division, and is to a great extent perhaps derived from subsequent infiltration with siliceous solutions, which evidently have been active within the mass after its deposition. For not only do we often find the clay itself indurated into a claystone of considerable hardness, through the intervention of a siliceous cement, but we frequently meet, within the mass, irregular veins and lenticular sheets of a very hard, gray, or brown siliceous rock (at times almost a pure hornstone, at others, consisting in part of clay), whose drusy, nodular surface plainly shows its origin.

"166. Stratified claystones (6 to 18 inches in thickness) are of common occurrence at or near the top of the Lignitic strata of Tippah and Pontotoc at no great distance from the border of the cretaceous formation. These claystones sometimes differ from the clay itself in little less than their greater hardness, but usually they are somewhat sandy, and contain numerous black grains — in some instances, *grains of greensand.* Through these claystones, every degree of lithological transition from the pure, almost white clay, to the fossiliferous sandstone of N. Tippah (P. 168) may be traced, and careful examination will sometimes detect in them unequivocal remnants of marine fossils. Such is the case with the (glauconitic) claystone overlying the lignitic clays at Mr. Brougher's place S.7, T.5, R.2 E., Tippah County, and at an outcrop a mile W. of Pontotoc. At the latter place a *Turbinolia* ! and part of the nucleus of a *Natica* ? was found, with other impressions too indistinct to be recognized; at the former the exterior cast of a small, deeply ribbed *Venericardia* ? or *Arca* ?

"I have not met with any of *these* claystones on the territory of the Northern Lignitic S. of the outcrop mentioned, near the town of Pontotoc. Thence S. to the Sucarnoochee River. I have seen only the whitish 'Flatwoods Clay;" where the latter is massy or nodular, it rarely contains unequivocal signs of vegetable fossils. Westward of the Flatwoods proper, however, the clays are commonly laminated, less uniform in their character, and interstratified more or less with sand. Such usually are the clays associated with the lignite beds, and containing impressions of leaves; nevertheless, the genuine 'Flatwoods Clay' character frequently re-appears, locally, over the whole region."

In 1915 Lowe (Lowe, 1915) described the formation as follows:

"This formation consists of about 150 feet of dark gray clay, which usually does not show distinct stratification, weathers nearly white, and on drying breaks into rounded nodular masses that shell off in conchoidal thin plates. It forms a dense, cold, wet clay soil difficult to cultivate, especially in wet seasons . . .

"These clays are non-fossiliferous, except locally where they become lignitic, indistinct leaf impressions occur. In Alabama the basal portion of these clays are black calcareous, and contain marine fossils, but these fossiliferous clays do not occur in Mississippi except sparingly near the base. The whole formation, with that exception, so far as we have yet discovered, is fresh water deposits, probably laid down in shallow, quiet waters with low surrounding lands, whose streams carried only the finest sediment.

"The thickness of the Porters Creek Clay is at least 150 feet, and dips westward at an angle of a minimum of 15 feet to the mile — more probably, not less than 25 feet to the mile."

In his "Coastal Plain Stratigraphy of Mississippi," Lowe (Lowe, 1933) says of the Porters Creek:

"The typical material of the Porters Creek formation is a tenacious gray joint clay of distinct conchoidal fracture, which varies from very light gray to lead gray, and on drying becomes much lighter in color and at last almost white. It separates readily along the joint planes into fragments that average about the size of a hen's egg, and that tend to shell off along spherical surfaces and thus assume a nodular appearance. Stratification planes are usually not very evident, the more typical material being massive.

"The clay varies from this typical character at many places. Locally it becomes highly lignitic and is associated with small deposits of lignite; and in places it becomes sandy and micaceous and thin bedded. These variations occur especially toward the western border of the formation, where as just stated, the clays merge without break into the lowermost division of the Wilcox.

"The local occurrence of thin beds and lenticular concretions of spathic iron ore in the Porters Creek Clay has been noted at some places in northern Mississippi. This iron ore is generally closely associated with beds of lignite or lignitic clays and lies well up toward the contact with the Wilcox. This relation prevails in the iron deposits 4 miles west of Blue Mountain, in the vicinity of Flat Rock Church, which was Hilgard's old locality — Hurley's School House.

"In Kemper County, 3 miles north of Scooba a deposit of light gray calcareous clay, which yielded marine fossils was referred by C. Wythe Cooke, who examined it, to this formation.

"The black slaty clay, bearing marine fossils, exposed at Black Bluff, on the Tombigbee River, in Alabama, has not yet been identified in Mississippi, unless it occurs at a point a few miles west of New Albany, where a few impressions of small shells were found in the dark clay, or unless the clay at the locality near Scooba, where the physical aspects of the material are entirely different, is an equivalent."

A study of the stratigraphy of the Midway and Wilcox groups of Mississippi and Alabama as part of extensive bauxite investigations conducted jointly by the U. S. Geological Survey and Bureau of Mines in 1942 and 1943 culminated in 1946 in the publishing of a report of the results. MacNeil (MacNeil, 1946) describes the Porters Creek clay as follows:

"In addition to the typical clay facies it includes the Tippah sand lentil in the lower part, in the northern part of Tippah County, Miss., and the Matthews Landing marl member at the top, from Winston County, Miss., to Butler County, Ala. At the outcrop in northern Mississippi the Porters Creek is about 200 feet thick, but it thickens southward in the subsurface to about 600 feet. It is typically a dark, sparsely to moderately silty and micaceous, montmorillonitic, marine clay, with conchoidal fracture and scattered glauconite zones and lime nodules. The highest beds are laminated and sandy and have a considerable number of ferruginous indurations along sand partings. Large flattened concretions of siderite that alter to limonite upon exposure are common in the upper part. In many sections in northern Mississippi the laminated sandy clays at the top of the Porters Creek are leached white.

"The typical clay facies of the Porters Creek clay extends from southern Illinois and southeastern Missouri to the Tombigbee River in western Alabama. East of the Tombigbee River the clay becomes decidedly calcareous and thins between the thickened Clayton formation below and the thickened Matthews Landing marl member of the Porters Creek above. This calcareous clay is responsible for the narrow band of clay prairie, or "flatwoods," in Marengo, Wilcox and western Butler Counties, Ala. In Butler County the Porters Creek clay is less than 20 feet thick. Equivalent beds east of Butler County are included in the Clayton formation. The algal limestone at Rutledge, Crenshaw County, Ala., is a very argillaceous limestone which is characterized by large umbrella-shaped calcareous algae and which weathers to a sticky gray clay, and is the eastward extension of clay facies of the Porters Creek.

The name Sucarnoochee clay, formerly used for the entire Porters Creek clay of western Alabama as well as for the calcareous clay east of the Tombigbee River, has been abandoned."

History of usage: Safford's original use of Porters Creek group of Tennessee was in a provincial sense for sediments of questionable Tertiary age between his Orange Sand, or La-Grange group of the Tertiary and the underlying Ripley group of the Cretaceous, which included the Clayton formation of modern usage.

In 1915 Lowe (Lowe, 1915, p. 64) described a series of marine or estuarine fossiliferous sandstones in northern Mississippi, which he placed atop his Porters Creek clay. He considered these to be a separate formation, which he named the Tippah sandstone for exposure in that county. Subsequent authors, Cooke, 1925 (Cooke, 1925); Stephenson, Logan, and Waring, 1928 (Stephenson, Logan and Waring, 1928) treated the Tippah sandstone as a member overlying the Porters Creek. Lowe in 1933 (Lowe, 1933, pp. 22-23) recognized that the Tippah sandstone was a local phase "developed within the Porters Creek at different levels, and not continuous very far southward. It seems to interdigitate into the Porters Creek, especially in the lower half of the formation. This phase probably should not receive a name, unless it be regarded as representing the Naheola formation of Alabama."

Grim in 1936 (Grim, 1936) used the term Tippah sand and assigned it member rank. "This sand, therefore, does not comprise a separate formation, but rather a member, for which the term Tippah sand should be used." Both Grim in Mississippi, and Whitlatch in Tennessee (Whitlatch, 1936) considered the sands to be lenticular deposits within the clay.

Mellen in 1939 (Mellen, 1939) subdivided the Porters Creek clay into three parts. A basal part consists of 50 feet more or less, of mostly fine-grained silty clay containing foraminiferal shells, and enclosing erratic lenses, commonly two to four inches thick, and a few feet in diameter, of sandy, glauconitic, calcareous material containing small molluscan and foraminiferal shells. A second zone, above the basal sandy part, consists of 350 to 450 feet of fine-grained slightly silty dark gray or black carbonaceous jointed clay which weathers to a dove-gray clay with conchoidal fracture. The upper part is made up of 50 to 100 feet of very silty, in part glauconitic, micaceous, sandy clay, distinctly laminated, and in places containing beds and lenses of sand up to a foot or more in thickness. Silty sideritic beds in this part of the formation Mellen considers equivalent to the Naheola formation of Alabama.

Foster in 1940 (Foster, 1940) uses the name Porters Creek clay and does not subdivide the unit. He does, however, describe a glauconitic marl bed which he places at the base of the Naheola formation. This is the Matthews Landing marl, now considered as the upper marly member of the Porters Creek clay.

Conant in 1941 (Conant, 1941) and 1942 (Conant, 1942) subdivides the Porters Creek clay into a basal phase, a typical phase including the Tippah sand member, a laminated upper phase, and a bauxite kaolin zone at the top (Betheden formation of Mellen). The Tippah hand lentil is now known to be near the base of the Porters Creek and is stratigraphically lower than the type exposures of the Porters Creek clay.

Priddy in 1943 (Priddy, 1943) separated the Porters Creek into three lithologic divisions:

"A lower zone 30 to 50 feet in thickness, comprised of gray or greenish-buff calcareous, glauconitic coarse sands interbedded with greenish-buff waxy clays, greenish-black micaceous silts, and dark-colored montmorillonitic clays; a middle zone 150 to 200 feet in thickness, comprised of nearly black montmorillonitic clay and subordinate lenses of gray micaceous silty clay or greenish-black micaceous silt which are more numerous toward the top; and an upper zone 100 to 250 feet in thickness which is chiefly comprised of the greenish-black micaceous silt lenses and thinner lenses of black clay and gray clayey silt."

These represent the same phases as those of Conant in Tippah and Union Counties. Priddy also recognizes as uppermost Porters Creek, the Betheden residuum of Mellen which is the age equivalent of the bauxite-kaolin zone of Conant.

In his "Summary of the Midway and Wilcox Stratigraphy of Alabama and Mississippi," MacNeil (MacNeil, 1946, pp. 10-12) considers the Porters Creek clay as the main lithologic unit with the Tippah sand lentil near the base in northern Mississippi, and the Matthews Landing marl member at the top in east-central Mississippi and west-central Alabama. Previous usage placed the Matthews Landing in the basal part of the Naheola formation. Its present usage as upper marly member of Porters Creek clay in east-central Mississippi includes upper marls and limestones of the Graveyard Hill section of Smith, Johnson and Langdon, (Smith, Johnson, and Langdon, 1894, pp. 190-191) in central Alabama. Inclusion in the Porters Creek is due to lithologic differences. The contact of the Matthews Landing marl with the overlying shales and loose yellow to white sands of the Naheola formation is always sharp, whereas the base of the Matthews Landing marl is sombre and clayey like the underlying Porters Creek and the transition from one to the other, in many places, is very much a matter of opinion, and may extend through 2 or 3 feet.

Areal extent: The Porters Creek clay occupies a belt 3 to 12 miles wide entering Mississippi in western Tippah County and passing southward through the western half of Tippah County and through Union, Pontotoc, Chickasaw, Clay, Webster, Oktibbeha, Winston, Noxubee and Kemper Counties. Its strike is east northeast through Tippah and Union Counties. From southern Union County through Pontotoc and Chickasaw Counties the strike of the Porters Creek is north-south. In Clay County the strike changes to a northwesterly direction, and remains so through Oktibbeha, northeastern Winston and western Noxubee Counties. In Kemper County also its strike is northwest and the maximum width of outcrop is about 12 miles (Plate 1). To the east in Alabama the formation strikes generally west northwest. In western Alabama, and at least as far north as southeastern Winston County in Mississippi the Porters Creek clay outcrop belt is bounded on the east by the Clayton formation and on the west by the Naheola formation.

Thickness: The Porters Creek clay is approximately 500 feet thick in Kemper County. It thins along strike to the north and in northern Mississippi it is approximately 200 feet thick. It thins also to the east in Alabama. Down dip in the subsurface in southwestern Kemper, northwestern Lauderdale and eastern Neshoba Counties, the Porters Creek clay thickens to 600 feet or more.

Lithologic character: The Porters Creek clay in Kemper County consists of the typical clay facies, somewhat sandy and laminated toward the top.

The typical clay facies consists of a massive blocky to hackly, slightly to moderately silty, muscovitic, montmorillonitic, marine clay, having conchoidal fracture and containing scattered glauconite zones. Its color is dark slate to chocolate gray in fresh exposures, but on exposure changes to a light gray. Weathered surfaces generally are flaky representing spalling on a very small scale. On being struck with a hammer, the clay tends to break into nodular, conchoidal-shaped fragments about the size of a hen's egg. The whole unit is traversed by many joint planes, having no definite trend or pattern, each containing thin, soft platy limonite. The highest beds of the Porters Creek clay are laminated sands and clays and contain large flattened concretions of siderite (spathic iron ore, clay ironstone) that alter to limonite on exposure. These concretions are very abundant in the upper 30 to 40 feet of the Porters Creek and are generally found along sand partings. They are not, however, restricted to the upper Porters Creek. Although they are much less prevalent in the blocky massive clays, the writer has seen them throughout the thickness of the formation.

The base of the Porters Creek in contact with the Clayton formation is poorly exposed in road ditches on the west side of old U. S. Highway 45 just north of Wahalak. The clay here is dark gray, somewhat mottled, exhibiting weathering, but having conchoidal fracture. The area to the west of the road is so heavily timbered and covered that it was impossible to find exposures of Porters Creek, but is high enough to contain the unit. Elsewhere, the basal Porters Creek is poorly exposed. Along the Giles road (State Highway 16) approximately 1.5 miles east of U. S. Highway 45 at Scooba, the same weathered clays may be seen, but the position of the contact with the underlying Clayton is difficult to ascertain. Exposures of the middle Porters Creek may be examined in several localities. The western part of the outcrop belt is more hilly, and there the upper Porters Creek exposures are numerous.

Southwestward from Scooba to DeKalb, along State Highway 16, the complete section of Porters Creek clay is visible. The massive joint clays characteristic of the middle Porters Creek are well exposed along this highway, and especially in the center of Sec.16, T.11 N., R.17 E., where approximately 70 feet of dark gray to black carbonaceous clay containing clay ironstone concretions crop out in a long hill.

SECTION (CENTER SEC.16, T.11 N., R.17 E.) ON MISSISSIPPI HIGHWAY 16 5.6 MILES EAST OF JUNCTION WITH STATE HIGHWAY 39 AT DEKALB.

	Feet	Feet
Top Soil		2.0
3. Brown, silty clay soil	2.0	
Porters Creek clay		77.6
2. Dark gray to black, carbonaceous, muscovitic, blocky, hackly clay having conchoidal fracture, containing flattened sideritic concretions, irregular beds of platy limonite, and fossil prints	67.6	
1. Brown weathered slightly sandy, soft clay grading upward into the typical dark gray clay—to stream bed at bottom of hill	10.0	
Total section		79.6

Figure 20.—Road cut on a long hill showing typical Porters Creek clay. Mississippi State Highway 16, 5.6 miles east of DeKalb. (Center Sec.16, T.11 N., R.17 E.) April 5, 1958.

Fossil prints were found about midway up the hill (Figure 20).

Probably the best exposure of the upper Porters Creek in the county is that just west of Sucarnoochee Creek on State Highway 16 (SW.¼, Sec.19, NW.¼, Sec.30, NE.¼, Sec.25, T.11 N., Rs. 16 and 17 E.) (Figure 21). A thickness of approximately 117 feet of clay is represented, including the upper sandy phase.

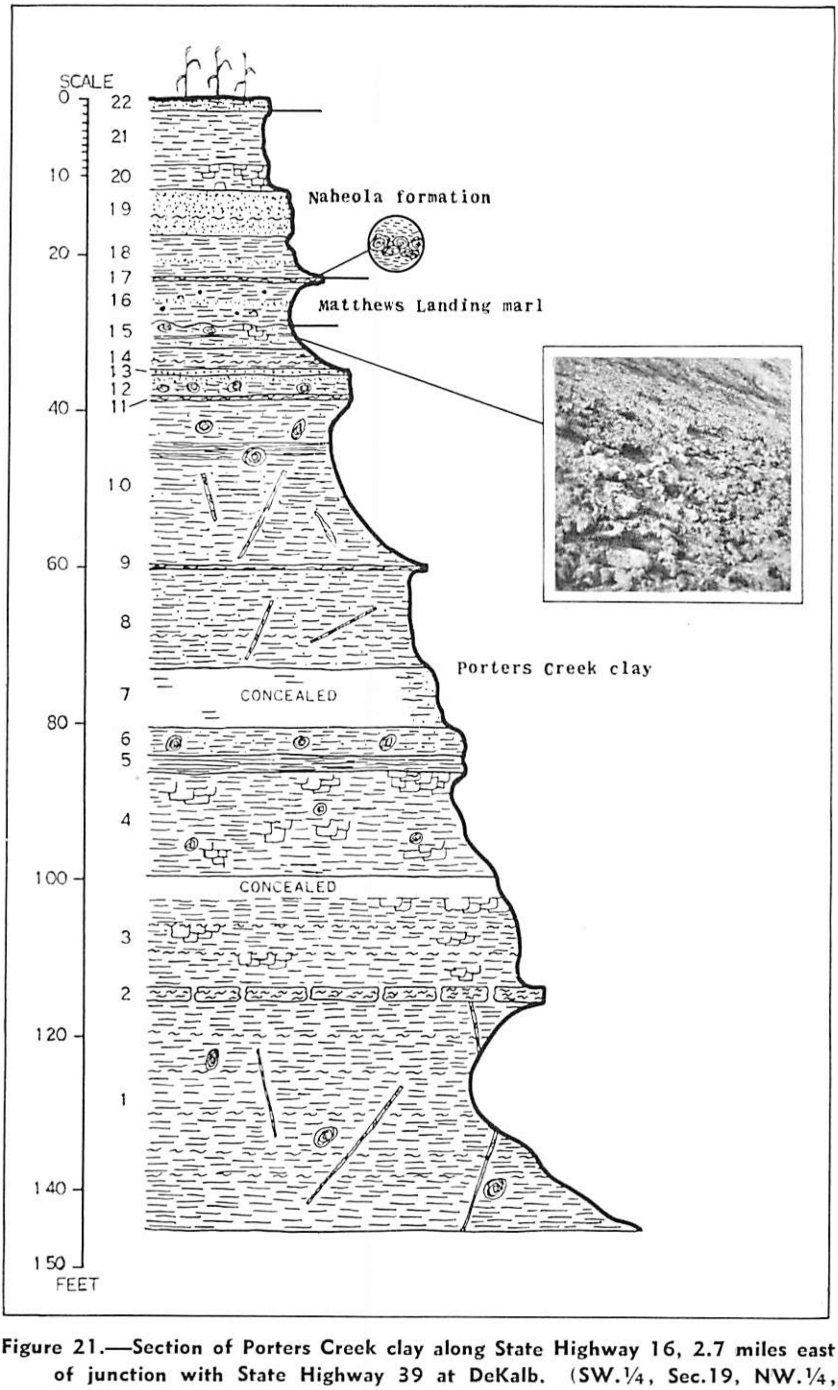


Figure 21.—Section of Porters Creek clay along State Highway 16, 2.7 miles east of junction with State Highway 39 at DeKalb. (SW.¼, Sec.19, NW.¼, Sec.30, T.11 N., R.17 E.).

SECTION (SW.¼, SEC.19, NW.¼, SEC.30, T.11 N., R.17 E.) ALONG STATE HIGHWAY 16 ON LONG HILL 2.7 MILES EAST OF JUNCTION WITH STATE HIGHWAY 39 AT DEKALB.

	Feet	Feet
Top Soil		1.6
22. Tan, sandy, clayey top soil	1.6	
Naheola formation		21.1
21. Brown, mottled, weathered silty, muscovitic clay	6.9	
20. Gray to brown blocky slightly muscovitic silty clay	2.8	
19. Yellowish to light-gray, laminated, unconsolidated, fine-grained, muscovitic, slightly argillaceous sand containing soft layers of platy limonite	5.9	
18. Black lignitic muscovitic clay alternating with yellowish-gray muscovitic sand. Lignitic clay bed about 4.1 feet thick	5.5	
Unconformity		
Porters Creek clay		122.3
Matthews Landing marl member		
17. Hard, rusty, red-brown nodular clay ironstone, concentrically weathered	0.4	
16. Dark-gray to black, carbonaceous, glauconitic, muscovitic, silty, sandy clay and alternating sands interlaminated, containing sharks teeth	5.5	
Porters Creek clay, typical		
15. Dark-gray to black, blocky, hackly, carbonaceous slightly silty clay and clay shale. Grades upward into a silty, sandy, muscovitic clay with many clay ironstone boulders exhibiting concentric weathering strewn over slope	3.1	
14. Dark-gray to light-gray, silty clay containing many thin beds of platy limonite	2.3	
13. Rusty brown, soft, friable, ferruginous sandstone	0.7	
12. Light-gray to tan silty, muscovitic clay containing clay ironstone boulders with ferruginous sandstone bed at top	2.7	
11. Red-brown, concentrically weathered clay ironstone boulders forming a projecting ledge	0.6	
10. Black carbonaceous, silty, muscovitic clay and clay shale containing irregular beds and joints filled with platy limonite. Upper part more silty and containing clay ironstone boulders	21.0	
9. Yellow-brown, limonitic ironstone ledge	0.6	
8. Dark-gray to gray, carbonaceous, silty, muscovitic clay having conchoidal fracture and containing beds and joints of highly muscovitic platy limonite	12.7	
7. Concealed interval. Badly weathered clay	7.5	

6. Dark-gray to tan, silty muscovitic clay, weathered and containing red-brown concentrically weathered clay ironstone boulders	3.7	
5. Dark-gray silty somewhat fissile muscovitic clay weathering to light gray	2.1	
4. Dark-gray carbonaceous blocky to hackly silty muscovitic clay with conchoidal fracture and containing clay ironstone boulders and joints of platy limonite	13.6	
3. Dark-gray to brown carbonaceous blocky, hackly clay with numerous layers of soft thinly bedded, muscovitic, platy limonite of varying thickness up to 4 inches. Upper part concealed by slumping	14.2	
2. Hard, rusty brown slabby clay-ironstone	1.7	
1. Dark-gray to brown weathering to light-gray and tan, blocky, hackly slightly muscovitic clay showing conchoidal fracture and containing many layers of soft platy limonite, also limonite-filled joints and clay ironstone boulders	29.9	
Total section		145.0

The typical Porters Creek clay is overlain by 5.9 feet of Matthews Landing marl, which is rather indistinct at this locality. An interesting feature of the Porters Creek here is the discordance of bedding. Toward the top of the hill, the beds are horizontal. Down slope, however, the beds are dipping at an angle of approximately 18° SE. It is probable that this local dip should be attributed to slumping rather than to a structural anomaly.

The laminated concretionary zone at the top of the Porters Creek, and the overlying Matthews Landing marl, are also well exposed along Mississippi State Highway 39, NE.¼, Sec.4, T.11 N., R.16 E., and along the same state highway into southern Noxubee County, SE.¼, Sec.34, T.13 N., R.16 E. The Porters Creek clay here totals 95.9 feet, the overlying Matthews Landing marl member being 5.4 feet thick.

SECTION (SE.¼, SEC.34, T.13 N., R.16 E.) ALONG STATE HIGHWAY 39 IN SOUTHERN NOXUBEE COUNTY 0.1 MILE NORTH OF KEMPER-NOXUBEE COUNTY LINE.

	Feet	Feet
Top Soil		1.5
27. Buff, fine, loose, sandy, silty top soil	1.5	
Naheola formation		13.9
26. Brown, weathered, muscovitic coarse-grained sand	7.7	
25. Brown, hard, clay ironstone ledge	0.2	
24. Gray to brown mottled silty clay, weathered	6.0	

Unconformity		
Porters Creek clay		101.3
Matthews Landing marl member		
23. Gray-brown, glauconitic, sandy clay containing clay ironstone concretions	5.0	
22. Brown, hard, clay ironstone ledge	0.4	
Porters Creek clay, typical		
21. Gray to black, muscovitic clay-shale containing layers of soft platy limonite, muscovite and clay ironstone concretions	11.0	
20. Covered interval	15.1	
19. Brown, soft, medium-grained sand with several dark-gray clay partings and thin streaks of dark-green sand, possibly glauconite	3.6	
18. Red-brown, hard clay ironstone ledge	1.0	
17. Brown, muscovitic, laminated, friable medium-grained sandstone with thin platy limonite at base	1.0	
16. Interbedded light gray, blocky, hackly clay and tan laminated fine sand	0.6	
15. Brown muscovitic, laminated, friable medium-grained sandstone with thin platy limonite at base	0.5	
14. Interbedded light-gray, blocky, hackly clay and tan, laminated fine sand	1.6	
13. Light-brown, muscovitic fine sand	1.2	
12. Light-brown to rust-brown muscovitic, coarse-grained sand containing a dark-gray clay-shale layer (0.1 ft.) and thin ferruginous sandstone partings	2.2	
11. Light-brown soft, platy limonite underlain by coarse-grained sand	0.3	
10. Rust-brown to gray argillaceous muscovitic sand with clay partings	1.6	
9. Interbedded gray to black carbonaceous clay-shale and rust-brown to light-tan muscovitic fine sand	2.9	
8. Red-brown, hard, ironstone ledge	0.3	
7. Dark-gray to black muscovitic, clay-shale with fine sand partings 1.0 ft. from top and having a thin limonite layer at top	9.7	
6. Red-brown ironstone ledge	0.5	
5. Dark-gray to black, sandy, silty, muscovitic clay-shale with ferruginous sand layers	5.0	
4. Red-brown, hard ironstone ledge	0.3	
3. Rust-brown soft, muscovitic, fine-grained, ferruginous sand with thin ironstone partings	0.4	
2. Dark-gray to black, weathering to light-gray sandy, silty, muscovitic clay-shale, containing layers of soft muscovitic, platy limonite and thin sand partings	18.5	

1. Grayish brown, blocky, hackly, silty, muscovitic clay having conchoidal fracture and containing joints filled with platy limonite	18.6	
Total section		116.7

Matthews Landing marl member: The term Matthews Landing marl, upper member of the Porters Creek clay in east-central Mississippi (more specifically, in Kemper, Noxubee, and southern Winston Counties only) and west-central Alabama, was first introduced by Smith and Johnson in 1887 (Smith and Johnson, 1887) for exposures at Matthews Landing on the Alabama River, N.½, Sec.12, T.12 N., R.6 E., Wilcox County, Alabama. The original description is as follows:

"1. Bluish or greenish black, micaceous, clayey sand, with finely preserved fossils, very dark when wet, but becoming grayish blue on drying; crumbles upon exposed slopes, liberating the fossils, which lie in the crumbs thus produced. This is capped by an indurated, sandy, concretionary ledge. (This is probably one of the glauconitic, concretion-forming sands which are so characteristic of the marl of the Naheola). The thickness of the marl deposit is .... about 5 to 6 feet

2. Gray sands with a slightly yellowish cast, showing a great tendency to indurate into lens-shaped boulders, 1 to 2 feet thick and 3 to 4 feet wide. The sands are also fossiliferous, but much less so than the preceding; the fossils are difficult to get out because of the hardness of the material .... 3 to 4 feet

3. Bluish, micaceous, clayey sand, much like No. 1, but not holding all of its characteristic fossils. Where this stratum lies exposed to the sun and weather upon flat or nearly horizontal benches, it disintegrates, like No. 1, into crumbs, in which the liberated fossils lie loosely, but where it forms vertical bluffs, it is firm and compact and resembles black clay .... 7 to 8 feet

"The lowermost bed is sandy above and clayey below, and the material of the whole bluff might be better described as a bluish black, sandy clay, divided into two parts by a bed of calcareous sand, which reaches up into the upper clay bed and down into the lower by gradual transition. The beds which compose this bluff are seen along the river for a mile or more, and are approximately horizontal in position, since the river in this part of its course runs in the direction of the strike of the beds."

The Matthews Landing in central Alabama is primarily a glauconitic sandy marl, containing sand and limestone. South of the town of Linden, Marengo County, Alabama, is an outcrop of the Matthews Landing marl, Highway 43, SE.¼, SE.¼, Sec.22, T.15 N., R.2 E., Marengo County, Alabama. At this locality it is called a greensand marl. It is a bluish-gray to greenish-gray glauconite arenite, consolidated, but friable (can easily be broken with the hand, and will break down readily in water), and containing a prolific megascopic fauna. To the north and west the unit passes into a sandy glauconitic clay that forms concretionary limonite on weathering. The member is continuous into Mississippi, and in Kemper County, the brown glauconitic sandy clay containing the limonite concretions forms a narrow outcrop belt through the county. Its thinness and persistency make it the best stratigraphic marker in the county. Its lithologic characteristics are very consistent, except in a few localities, more especially the Sciples Mill area, which will be discussed later. The farthest southeastward outcrop of the unit (NW.¼, SE.¼, Sec.35, T.9 N., R.18 E.) is not a good exposure due to the extreme flatness of the topography. Other exposures to the northwest show the member better. On the road to Enondale, in the NW.¼, SW.¼, Sec.8, T.9 N., R.18 E. are approximately 5.5 feet of brown glauconitic marl containing molds and casts of fossils. Approximately 86.0 feet of the typical Porters Creek clay underlie the Matthews Landing marl at this locality.

SECTION (SE.¼, SEC.8, T.9 N., R.18 E.) ON ROAD TO ENONDALE, APPROXIMATELY 1.3 MILES EAST OF U. S. HIGHWAY 45.

	Feet	Feet
Top Soil		1.0
6. Buff to tan, fine sandy, silty top soil	1.0	
Naheola formation		43.5
5. Red to yellow highly muscovitic medium-grained slightly cross-bedded sand with stringers and blebs of gray silt and clay in lower part and containing the marine crab *Halymenites major* Lesquereux	37.0	
4. Gray sublaminated clay, very glauconitic at base, becoming sandy toward top	5.0	
3. Gray, sublaminated to hackly, muscovitic, silty, glauconitic clay	1.5	
Porters Creek clay		91.5
Matthews Landing marl member		
2. Dark red-brown to yellow, sandy highly glauconitic clay marl with fossil prints and containing sandy limonite concretions and a bed of glauconitic gray clay at base	5.5	

Porters Creek clay, typical

1. Dark gray to black, blocky, hackly to conchoidal muscovitic clay containing layers of soft platy limonite and clay ironstone boulders. Upper 40.0 feet containing laminated sandy partings	86.0	
Total section		136.0

Also, on a small side road off U. S. Highway 45 about NE.¼, SW.¼, Sec.18,T.9 N., R.18 E. approximately 13.8 feet of Matthews Landing is well exposed. Fossil prints are numerous but no siliceous or calcareous shells were found.

On the L. R. Caraway property (SE.¼, Sec.36, T.10 N., R.17 E.) along a road leading southeast (first road to the left after passing through cattle gap which is 0.7 mile by speedometer from U. S. Highway 45) several bulldozer trenches expose well the Matthews Landing marl member. The farthest trench is approximately 0.55 mile from the junction of the abandoned road with the farm road. The member here also contains fossil prints.

Along a northeast road, NE.¼, Sec.34, T.10 N., R.17 E., the Matthews Landing marl was originally beautifully exposed in trenches along the south side of the road. Here it is a brown highly glauconitic sandy clay 5 feet thick containing limonite concretions. The presence of an unconformity is indicated by numerous borings filled with the sandy, silty muscovitic clay of the overlying Naheola formation. A recent visit to the above locality proved uninformative because bulldozers and road scrapers have very neatly grooved ditches for better drainage, thus destroying the evidence of the borings mentioned above.

On State Highway 39, just south of Sucarnoochee Creek (SW.¼, NE.¼, Sec.21, T.11 N., R.16 E.) the Matthews Landing marl is well exposed. The unit here measures 3.9 feet in thickness and consists of dark-green glauconitic sand containing fossil prints, and black glauconitic sandy clay like the Matthews Landing in western Alabama. Approximately 18 feet of Porters Creek clay lies beneath the marl, and the fine yellow to red sands and gray laminated clays of the Naheola formation on top of it. Approximately a quarter of a mile north of Sucarnoochee Creek, just out of the creek valley, the Matthews Landing is again exposed, being about 20 feet higher than the outcrop just to the south of the creek, mentioned above. The Porters Creek beds dip to the north, the angle of dip being 6°, whereas in the overlying Matthews Landing marl member the dip is only 1° to the north. The Naheola is absent from this section, probably due to truncation, and the coarse sands and pea gravels of the Fearn Springs sand member of the Nanafalia formation lie unconformably on the Matthews Landing (Figure 22). The relations here are not clear to the writer, but examination of units on both sides of the road indicate faulting.

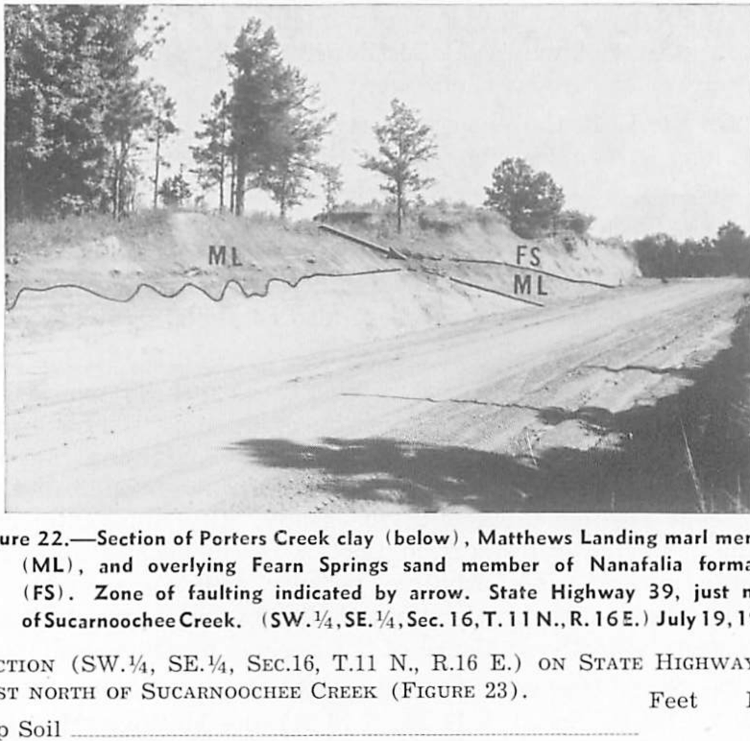


Figure 22.—Section of Porters Creek clay (below), Matthews Landing marl member (ML), and overlying Fearn Springs sand member of Nanafalia formation (FS). Zone of faulting indicated by arrow. State Highway 39, just north of Sucarnoochee Creek. (SW.¼, SE.¼, Sec. 16, T. 11 N., R. 16 E.) July 19, 1955.

SECTION (SW.¼, SE.¼, SEC.16, T.11 N., R.16 E.) ON STATE HIGHWAY 39 JUST NORTH OF SUCARNOOCHEE CREEK (FIGURE 23).

	Feet	Feet
Top Soil		0.5
9. Red to buff top soil	0.5	
Nanafalia formation		13.0
Fearn Springs sand member		
8. Red-brown, coarse sand with pea gravel near base	13.0	
Unconformity		
Porters Creek clay		24.8
Matthews Landing marl member		
7. Red to yellowish brown, highly glauconitic sand and clay with concretionary limonite and containing fossil prints	5.6	
Porters Creek clay, typical		
6. Gray to yellowish brown silty, muscovitic clay containing fine sand streaks and hard, platy limonite layers	5.7	

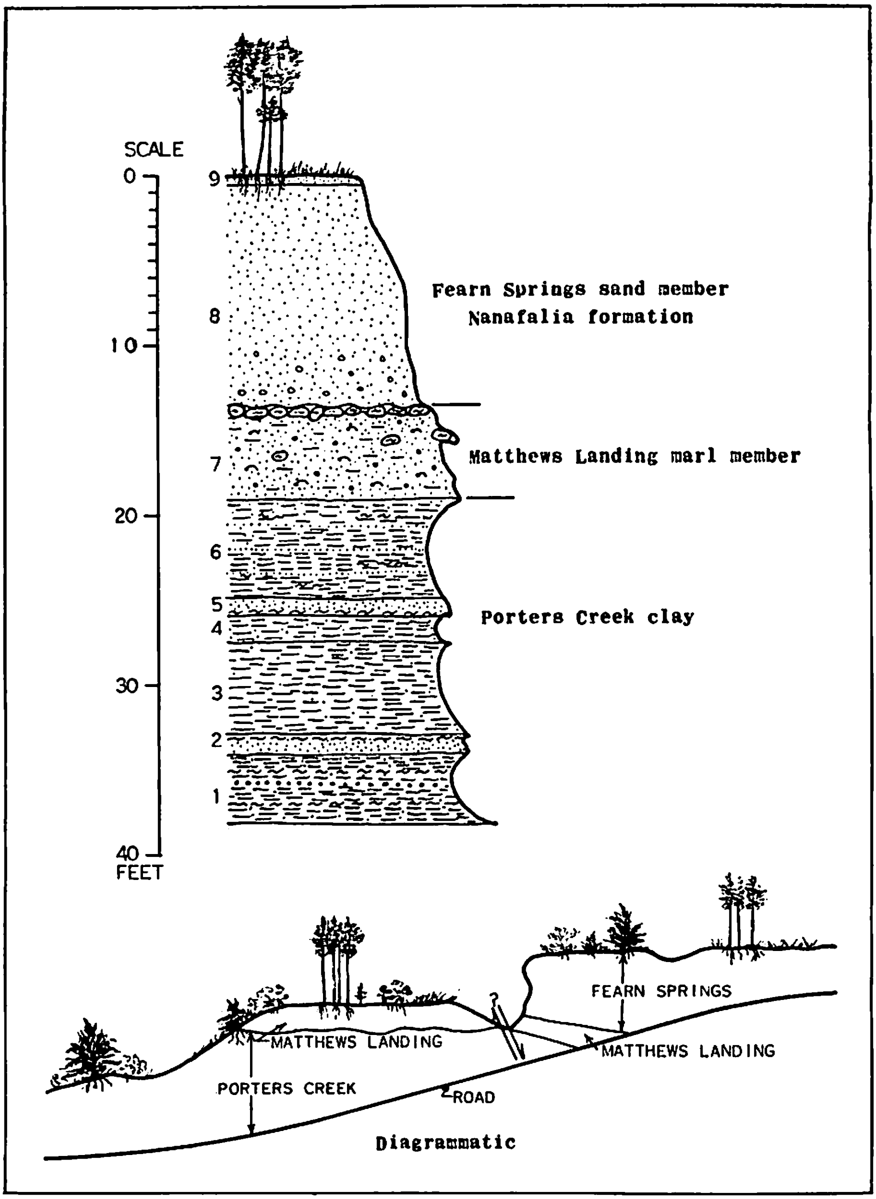


Figure 23.—Section of Matthews Landing marl on State Highway 39 just north of Sucarnoochee Creek (SW.¼, SE.¼, Sec.16, T.11 N., R.16 E.).

5. Light brown sand containing ironstone layers at base	1.0	
4. Tan to gray sandy, silty, muscovitic clay	1.5	
3. Gray to black carbonaceous, muscovitic, slightly silty clay	5.5	
2. Yellow-brown sand containing hard, brown ironstone layer at top	1.2	
1. Yellow-brown to light gray, mottled, weathered sandy, silty, muscovitic clay containing thin layers of soft platy limonite and a bed of glauconitic sand	4.3	
Total section		38.3

Two exposures containing the Matthews Landing, approximately half a mile from each other, show lithologic differences in the unit, as mentioned above. In the south center of Sec.33, T.12 N., R.16 E., the Matthews Landing, 7.1 feet thick, is yellowish brown, argillaceous, glauconitic, fossiliferous sands containing limonite concretions, and grades imperceptibly into the gray clays of the underlying Porters Creek. To the southeast about half a mile, on Mississippi Highway 39 (NE.¼, Sec.4, T.11 N., R.16 E.) at approximately the same elevation, are 8.6 feet of dark-green highly glauconitic argillaceous sands and blue-green silty muscovitic clays weathering to a light green.

At Sciples Mill (SW¼, Sec.24, T.12 N., R.15 E.) the Matthews Landing marl is exposed in the creek bed at the bridge (Figure 24). The writer was informed by F. E. Vestal of the Mississippi Geological Survey that a pit was dug near the creek May 7, 1952 by prospectors to explore the economic possibilities of phosphate, iron, manganese and "sphalerite," and referred to the Survey by one of the prospectors. The pit was about 20 feet deep. (Figure 25.) Samples from the pit to a depth of 15 feet were presented to the writer by Vestal for study. Although no fossil prints were seen in these samples, George Sciples said he collected quite a few from the diggings, and presented some to the writer for photography and possible identification.

The unusual thickness here of the Matthews Landing, which is consistently 5 to 8 feet elsewhere in the County, led the writer to suspect a depositional pocket of considerable magnitude. Edward Sciples pointed out exposures of the Matthews Landing along Running Tiger Creek, approximately a quarter of a mile south of the bridge, and along Indian Branch, NE.¼, Sec.25, T.12 N., R.15 E., about a mile from the store. In these two localities

Figure 24.—View of Sciples Mill showing Matthews Landing marl member of Porters Creek clay in creek (arrow). July 7, 1954.

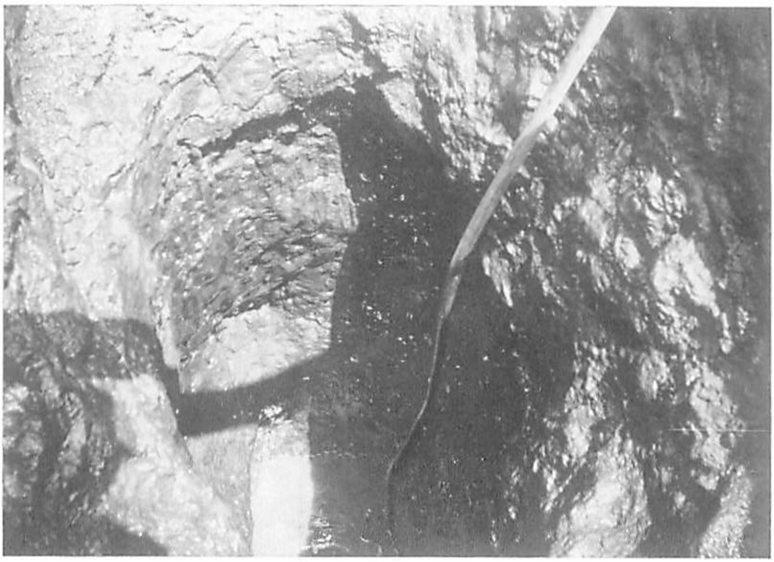


Figure 25.—Photograph of a dug pit at Sciples Mill exposing the Matthews Landing marl member of Porters Creek clay. F. E. Vestal photo. May 7, 1952.

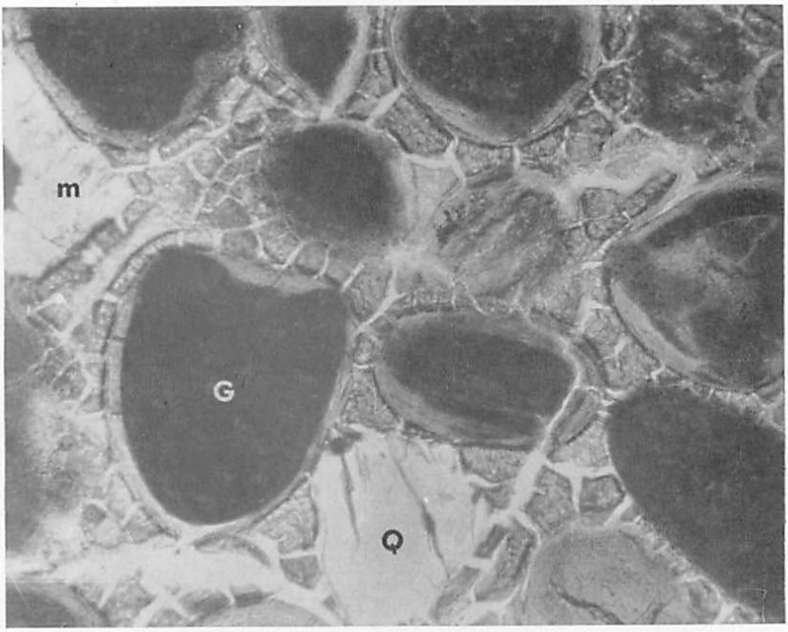


Figure 26.—Photomicrograph of thin section taken from a core of Matthews Landing marl member of Porters Creek clay showing glauconite grains (G) with altered biotite shreds, muscovite (m), and quartz (Q) with minor amounts of clay and a little carbonate. Cracks are in bakelite, the impregnation material. Uncrossed nicols. x93. Sciples Mill area, (SW.¼, Sec.24, T.12 N., R.15 E.).

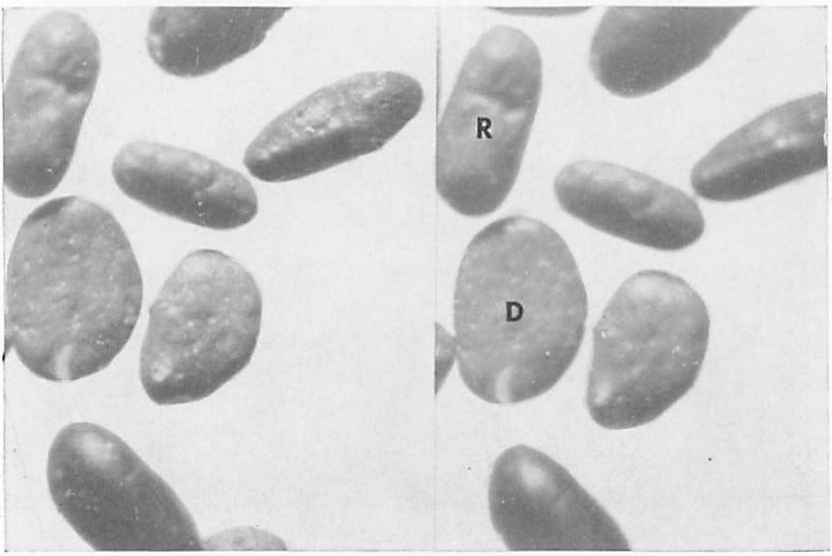


Figure 27.—Photomicro-Stereograph of glauconite grains. Rod-like or capsule-shaped (R) and discoidal (D) grains are seen. Note pitted surfaces. x54.

the Matthews Landing is dominantly a dark blue-green friable glauconitic sand, containing beds of siderite.

Later a hole was drilled by the Survey rig just east of the Sciples Store and continuous cores were taken through the entire thickness of the unit and including approximately 18 feet of the dark gray, muscovitic, silty clays of the Porters Creek. The Matthews Landing at this locality was found to be 34 feet thick and of the same lithology as that in the creeks, including very hard zones of siderite. Figure 26 is a photomicrograph of a thin section made from one of the cores and shows the grains. Figure 27 is a photomicro-stereograph showing the discoidal and capsule-shaped (roller) grains. The glauconite grains are green, blue, brown to pale, grayish-green and range in size from about 0.1 millimeter to 0.5 millimeter. The grains are spherical, oblate spheroid (discoidal or disc-like), bladed and prolate (rod-like or capsule) in shape, discoidal and rod-like or capsule-shapes being the most common. The soft, swollen, and spongy grains which can easily be mashed between finger nails show weathering and are often coated with clay material. Eighty-five to 98 percent glauconite is present in the samples examined. The log of the hole is shown in Figure 28.

Stratigraphic relations: The Porters Creek clay and its overlying Matthews Landing marl member lie between the Clayton formation below and the Naheola formation above. The Porters Creek clay overlies conformably the Clayton formation, the contact between the two being gradational, the black clays of the Porters Creek becoming calcareous and grading downward to a lighter colored clay. The Naheola formation overlies disconformably the Matthews Landing marl member of the Porters Creek.

Physiographic expression: The Porters Creek clay is expressed at the surface in a rather low, featureless to gently undulating plain commonly referred to as the Flatwoods (Figure 29). Elevations of 189 and 191 feet are from bench mark data at Electric Mills. Elevations of 220 to 230 feet are characteristic of the area in the eastern part of the County. In the western part of the outcrop belt a rolling, and even hilly topography is developed where the Flatwoods grade into the sand hills of the North-Central upland. Here elevations are as much as 270 feet above mean sea level.

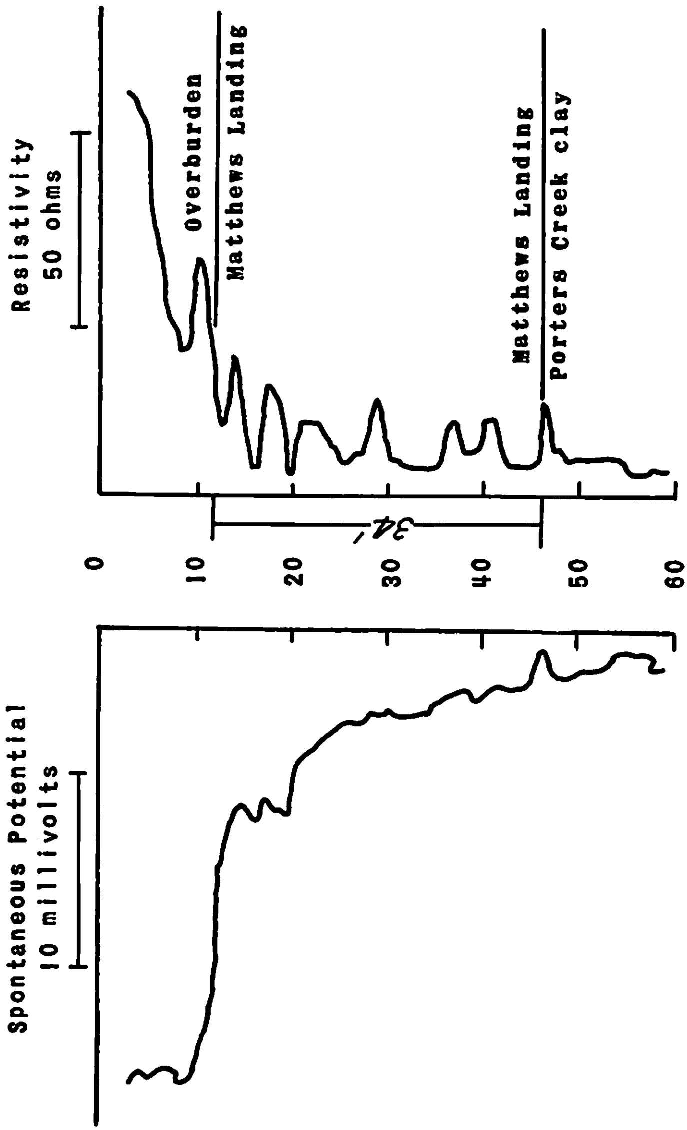


Figure 28.—Electric log of stratigraphic test at Sciples Mill showing thickness of Matthews Landing marl. (SW.¼, Sec.24, T.12 N., R.15 E.)

Drainage is mainly to the south and east, most of the streams heading in the rugged sand hills of the Wilcox.

Paleontology: The Porters Creek clay is a marine unit but in Kemper County no fossils except prints have been found in the clay. The formation may be said to be sparingly fossiliferous. The prints or impressions are hard to identify due to the lack of necessary morphological characteristics. Pelecypods prints have been seen by the writer (Figure 30).

Figure 29.—View looking north showing gently rolling to slightly hilly topography of Porters Creek clay (Sec.31, T.10 N., R.18 E.), just west of U. S. Highway 45. Oct. 12, 1957.

The Matthews Landing marl member, as does the underlying Porters Creek, contains only molds and casts of fossils, gastropods and pelecypods, in the main. The shells have been dissolved and replacement in most cases is very poor. A pelecypod print of the genus *Nemocardium* (?) from the Matthews Landing marl is shown (Figure 31).

Age and correlation: The Porters Creek clay is the middle formation of the Midway group of the Paleocene series. It is correlated with Porters Creek clay of western and central Alabama and with the Clayton of eastern Alabama. It is the correla-

Figure 30.—Pelecypod print in typical Porters Creek clay. x2.

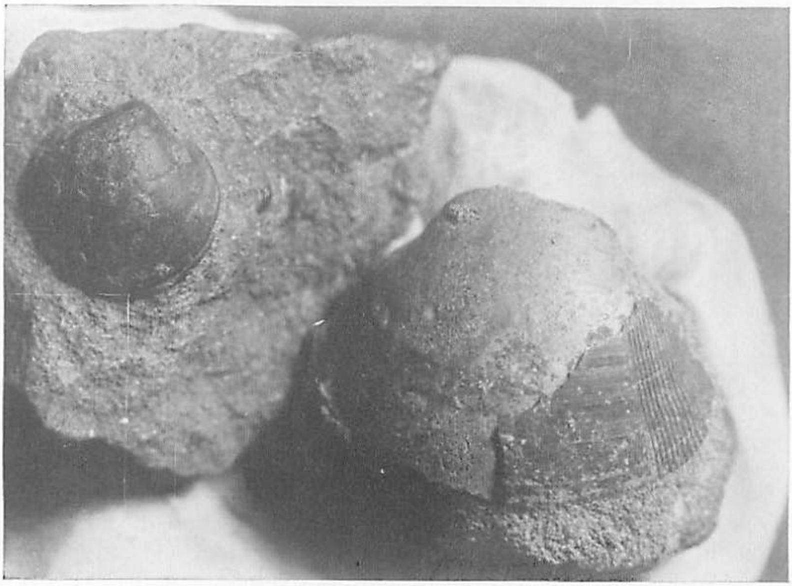


Figure 31.—Pelecypod prints of the genus Nemocardium (?). Dug pit in Matthews Landing marl at Sciples Mill. x1½. Courtesy of Mr. George Sciples.

tive of the Wills Point formation in Texas. Exact correlation with European stages is not justified. A suggested correlation is with the Thanetian stage.

NAHEOLA FORMATION

First reference: Smith and Johnson (Smith and Johnson, 1887).

Nomenclator: Smith and Johnson (Smith and Johnson, op. cit., pp. 51-60).

Type locality: Naheola Bluff, Tombigbee River, SE.¼, Sec. 30, T.15 N., R.1 E., Choctaw County, Alabama.

Original description: E. A. Smith and L. C. Johnson (Smith and Johnson, 1887, pp. 57, 58-59):

"The Naheola and Matthews Landing Series. The strata which make up this series are mostly gray, sandy clays alternating with cross bedded sands, with a bed at the base of the section containing marine fossils and consisting of glauconitic sands and dark gray, nearly black, sandy clays. The thickness of these strata varies from west to east, being 150 feet or more on the Tombigbee River, and not more than 125 to 130 at Oak Hill in Wilcox County."

"The lowest of these gray sandy clays are seen at the top of the bluff at Naheola, a few miles above Tompkinsville, where they are underlain by a marl, and black shaly clays at Naheola, as shown in the following section:

"Section at Naheola, Tombigbee River, Sec.31, T.1 S., R.1 E. (Plate XVIII, Fig. 3, p. 167)

1. Laminated, gray sandy clays, with two or three indurated ledges 8 to 10 inches thick, of light colored, sandier materials .... 18 to 20 feet
2. Ledge of greensand, oxidized into a brown iron ore of irregular thickness .... 3 to 6 inches
3. Black, shaly, sandy clay .... 3 feet
4. Ledge like No. 2, of irregular thickness .... 6 inches
5. Greensand marl, the upper part indurated forming a kind of limestone. Both the indurated marl and the limonite, or oxidized greensand above it, hold fossils prominent among which are an *Arca*, a *Venus, Petunculus, Broderipii* Lea, *Turritella Mortoni* Con., *Cardita alticosta* Con., and *Venericardia rotunda* Lea, *Rostellaria trinodifera*, &c. All the fossils are badly preserved. Thickness of bed .... about 3 feet

   (During the summer of 1886 this bed was more closely examined than in 1883, with the result of finding in its lower part a great number of the characteristic Matthews' Landing fossils. Wherever this bed has been exposed to the weather it crumbles down, liberating the shells exactly as at the last-named locality. In 1883 our attention was confined to the upper part of the Naheola bed, with its badly-preserved shells in a greensand matrix; and thus the identity of this bed with that at Matthews' Landing was not so clearly seen).
6. Black slaty clay like that occurring on the river above this point to Black Bluff .... 10 to 15 feet."

Other descriptions: In 1940 Foster (Foster, 1940) in his Lauderdale County report says:

"In Lauderdale and adjacent parts of Kemper Counties, the Naheola formation consists of sands and sandy clay shales with a concretionary clay and a glauconitic marl bed at the base. The lithology varies greatly over short distances, but in all exposures of the contact the Naheola sands or sandy shales grade downward into the Porters Creek clay through a basal clay very similar to the Porters Creek in general appearance, but separable from it by the presence of glauconite and the abundance of marly limonite lenses and nodules or discontinuous beds which are typically glauconitic, sandy, and fossiliferous. The marly limonite makes up about a fourth of the basal beds in some localities and is believed to be derived mainly from the weathering of glauconite rather than of siderite, as in the case in the upper Porters Creek. In a few exposures the actual contact is marked by an especially heavy concentration of marl and can be drawn within a zone only a few inches thick. In other places the transition is more gradual and includes 4 or 5 feet of indeterminate age.

"The major part of the formation is normally represented in outcrop by yellow and red sand, highly cross-bedded and containing thin clay and silt partings along the lines of lamination. In other exposures, however, the beds are seen to be much more highly argillaceous than is apparent from the normal hillside outcrop. In many places they present a definite shaly appearance, and the color ranges from light greenish gray to almost black. Locally also, some beds are slightly glauconitic."

Vestal (Vestal, 1952) in his Webster County Geology, describes the Naheola formation:

"The Naheola formation consists in general of laminated fine sand and thin layers of dark-gray to light-gray silty shale. Commonly shale and sand are interlaminated. Concretions and thin beds of siderite and limonite are present almost everywhere, and marcasite is abundant.

"The contact between the Porters Creek and Naheola formations is gradational; no exact stratigraphic position could be fixed for it. As in the Highway 15 and Bluff Creek section, so in other sections which include this contact, its position is somewhere or anywhere within an interval of several feet of strata. In fact, in most writings which concern the Midway of Mississippi, the beds which are in this report assigned to the Naheola are included in the Porters Creek, although their difference from the typical Porters Creek is noted. Apparently the Porters Creek formation becomes more sandy and silty and more distinctly bedded towards the top, and this upper part, some 50 to 100 feet thick, is correlative, at least in part, with the Naheola formation of Alabama."

Thicknesses of the unit mentioned by Foster range up to 75 to 150 feet in some places.

In Alabama the Naheola formation is divided into two members, the Oak Hill member below, which is 100 to 125 feet thick, and the Coal Bluff marl member above, about 60 feet thick. Descriptions of these members appear in the Tenth Field Trip Guidebook of the Mississippi Geological Society (Mississippi Geological Society, Sept. 24-26, 1953):

"The Oak Hill member consists of predominantly gray laminated carbonaceous clay, very fine sand, and micaceous silt. In places there are beds of very fine-grained cross-bedded sand. The fine sand bed contain many scattered fine grains of dark minerals. The lignite beds at the top of the member attains a thickness of as much as 7 feet in some places . . . Nearly everywhere the Coal Bluff marl member of the Naheola formation overlies the lignite unconformably. However, the lignite bed is not present at Oak Hill owing to its removal by erosion.

"The Coal Bluff member, named from exposures at Coal Bluff on the Alabama River in Wilcox County, consists of light colored sparsely glauconitic micaceous medium-grained sand and occasional layers of gray clay. It contains near the base, where freshly exposed, large calcareous glauconitic sandstone concretions as much as 4 feet thick and 6 or 8 feet in diameter enclosed in green, richly glauconitic sandy marl. Where exposed the member weathers rapidly to reddish-brown sand with many limonitic stains and plates. Borings are common in the sand . . . The Coal Bluff marl member is unconformably overlain by the basal sand of the Nanafalia formation of the Wilcox group."

History of usage: The original use of Naheola by Smith and Johnson applied to 150 feet or more of glauconitic sands and dark gray, nearly black sandy clays at Naheola Bluff on the Tombigbee River overlying the "Black Bluff" or Surcarnoochee and unconformably underlying the Wilcox.

According to Foster, (Foster, 1940, p. 24) bauxite and associated sands and clays, previously described as basal Ackerman, were suggested by Morse in 1927 as being possible correlatives of the Naheola formation.

In 1933, Lowe (Lowe, 1933, pp. 2, 3, 14, 21, 35, 49, 63) doubtfully correlated a series of beds of sands, glauconitic sandstone, and dark, shaly clay near Walnut, Tippah, County, with the Naheola formation of Alabama. "Later the identity of the Tippah and the Naheola was reasonably well established by the field work of the writer," he stated.

"However, throughout much of the Wilcox outcrop lying immediately west of the Wilcox-Porters Creek contact, a well-marked sand member has been traced with fair accuracy from Kemper County to the Tennessee line. This compares to the bauxite belt, and is believed to represent the Naheola of Alabama." (Lowe, 1933, p. 21). Lowe further states (Lowe, 1933, p. 35) "The lowest beds of the Ackerman formation are gray clays which appear to pass by easy transition into the underlying Porters Creek clay, with which they lie in contact throughout much of the length of its outcrop, though a zone of red sands and bauxite toward the base is probably to be correlated with the Naheola."

Lowe considered the Tippah sandstone as an upper member of the Porters Creek clay which he correlated with the Naheola formation. The Tippah sandstone is now regarded as the basal member of the Porters Creek in northern Mississippi.

In other areas Lowe correlated basal Ackerman beds or more properly the red sands and bauxite toward the base of the Ackerman with the Naheola formation.

Grim (Grim, 1936, pp. 33, 34, 52) in 1936 stated that the Naheola formation had not been traced farther west than Kemper County, Mississippi, where it seemed to merge with beds previously placed in the base of the Wilcox. In central and northern Mississippi transition beds containing bauxite between the Porters Creek clay and the base of the Wilcox were considered by Grim as being the possible equivalent of the Naheola formation of Alabama.

Mellen (Mellen, 1939, pp. 23-30) in 1939 considered the upper 50 to 100 feet of the Porters Creek clay in Winston County to be the equivalent of the Naheola formation of Alabama. (See Mellen, under Porters Creek, History of Usage.) This usage was followed by Vestal (Vestal, 1952, pp. 17-25) in his Webster County report and later, in 1954 (Vestal, 1954, pp. 22-26).

Foster (Foster, 1940, pp. 23-30) was the first in Mississippi to recognize the Naheola formation as a discrete lithologic unit and thus give it formation rank. Of this he says, (p. 25)

"Since the Naheola of east-central Mississippi is a mappable unit ranging up to 75 or 100 feet thick in some places, although varying greatly in thickness and locally absent due to the unconformable contact between the Midway and Wilcox, and since it has a lithology different from other parts of the Midway, it is proposed that the Naheola of central and east central Mississippi be given formational rank."

Foster included in his Naheola at the base a green, sandy, glauconitic, calcareous, highly limonitic marl. The marl is the Matthews Landing marl member and is placed in the Porters Creek.

MacNeil's (MacNeil, 1946b, pp. 12-14) Naheola formation in Alabama consists of an unnamed basal laminated sand and shale member with a lignite bed at the top. This is overlain by the Coal Bluff marl member.

Original usage of Coal Bluff series or Coal Bluff beds was as part of Nanafalia formation of Wilcox group by E. A. Smith, first in 1886, and later in 1892. Coal Bluff fell into disuse until 1920 when Brantly (Brantly, 1920) revived the term, applying "Coal Bluff beds" to 40 to 70 feet of strata forming the basal member of the Nanafalia formation in Alabama. For the rest of the Nanafalia formation he used "Gullette Bluff beds." Cooke (Cooke, 1933) in 1933 extended the Ackerman formation from Mississippi into Alabama to replace the Coal Bluff beds and restricted the Nanafalia formation to beds above the Coal Bluff or equivalent to the Gullette Bluff beds of Brantly. MacNeil (MacNeil, 1946b, p. 13) in 1946 restricted the Coal Bluff marl member of the Naheola formation to the lower glauconitic sandy marls and shales of the Coal Bluff beds of Brantly. This will be further discussed in the Wilcox section.

Toulmin, LaMoreaux and Lanphere (Toulmin, LaMoreaux, Lanphere, 1951) subdivide the Naheola formation into two members. The lower member they call the Oak Hill (previously used by Smith in 1887) from the type locality near Oak Hill, Wilcox County, Alabama. This unit is overlain disconformably by the Coal Bluff marl member.

Areal extent: The Naheola formation enters Kemper County from the extreme northeastern corner of Lauderdale County. The strike of the formation through the County is essentially northwest-southeast. The width of outcrop is as much as 4 miles in the southeastern part of the County, but diminishes to a mile in the northern part (Plate 1). The narrowness of the outcrop is in all probability due to overlap along strike by basal units of the Wilcox group.

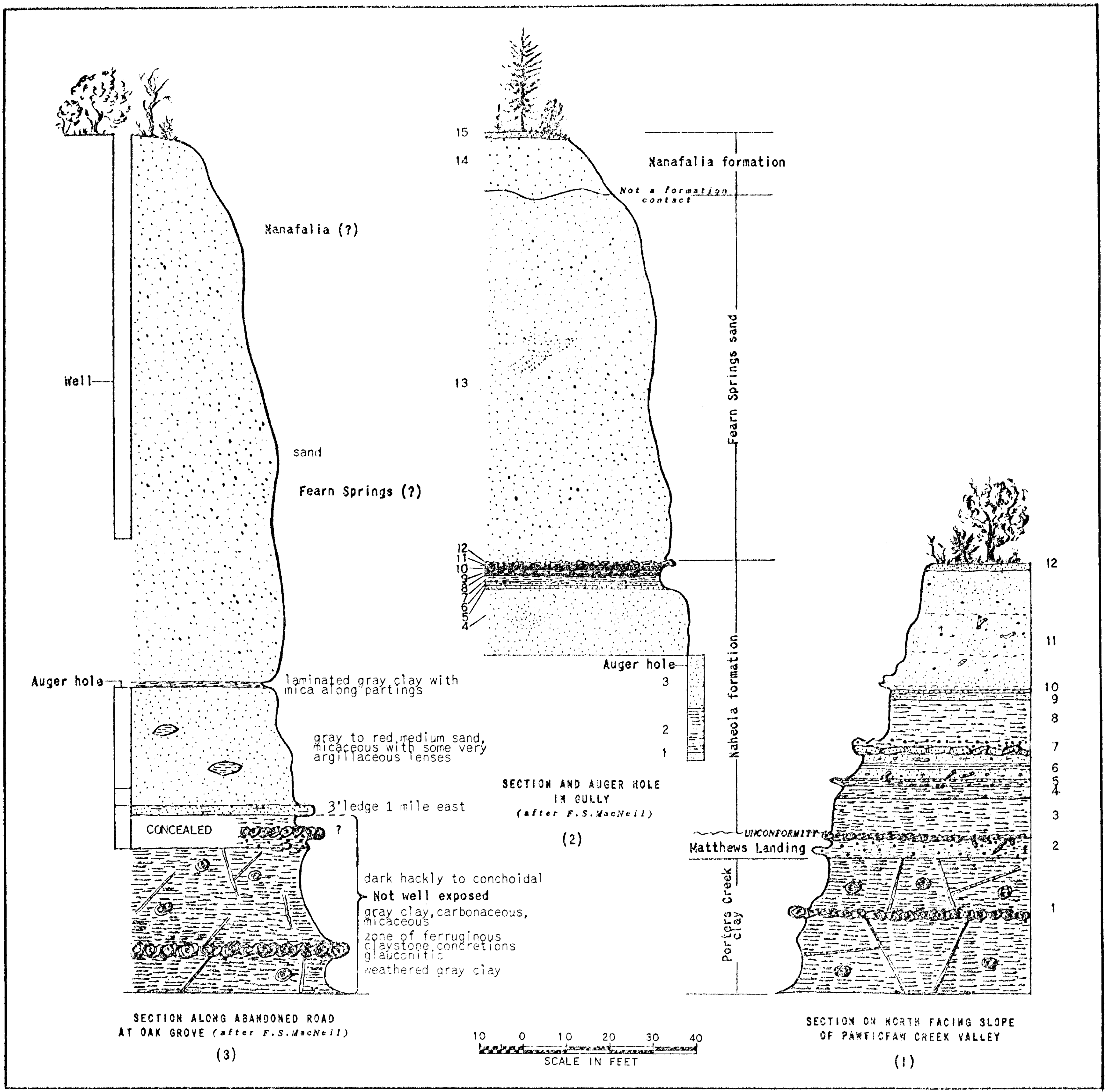
Thickness: The Naheola formation has its maximum thickness, between 100 and 115 feet, in the southeastern part of the county (Secs. 27, 28, 29, 30, 31, 32, 33, and 34, T.9 N., R.18 E.). It gradually thins to the north. In the vicinity of Oak Grove (Secs.33-34, T.10 N., R.17 E.), its thickness is about 90 feet. About one mile north of DeKalb (Sec.21, T.11 N., R.16 E.) the writer measured 84 feet of Naheola. From northern Kemper County the Naheola formation begins to thin rapidly due to overlap by the basal units of the Wilcox group.

Lithological character: The Naheola formation consists of dark gray to black carbonaceous, silty, muscovitic clay shale, interlaminated gray and yellow gray argillaceous silt and muscovitic, fine sand. The section contains beds of massive to cross-bedded red to yellow, highly muscovitic, fine to medium grained sand, sparsely glauconitic, and containing the marine boring *Halymenites major* Lesquereux.

Figure 32.—Red sand and basal clay contact (hammer) of Naheola formation with the underlying Matthews Landing marl member of Porters Creek clay. Road cut on Enondale Road, (SE.¼, Sec.8, T.9 N., R.18 E.). Oct. 12, 1957.

Figure 33.—Section of Naheola formation showing carbonaceous clay shales and overlying laminated sands and gray clays. Road cut, U. S. Highway 45, (NW. ¼, Sec.19, T.9 N., R.18 E.). Oct. 12, 1957.

The contact of the Naheola with the underlying Matthews Landing marl member of the Porters Creek clay is not everywhere the same. In several localities throughout the county the gray clays of the Naheola are in contact with the glauconitic sandy clays of the Matthews Landing marl (Figure 32). In other places laminated clays, clay shales and sands are in contact with



NAHEOLA, FEARN SPRINGS — NANAFALIA SECTIONS — OAK GROVE the marl beneath. In the NE.¼, Sec.4, T.11 N., R.16 E., the muscovitic red and yellow sands of the Naheola rest directly on the Matthews Landing marl.

The carbonaceous and laminated gray clays, clay shales and silts are beautifully exposed on U. S. Highway 45 approximately 2.6 and 2.9 miles respectively north of the Kemper-Lauderdale County line (Figure 33). Along an east-west road from the junction with U. S. Highway 45 through Tamola east to a junction with a northeast road in Sec.34, T.9 N., R.18 E. the complete section of Naheola may be examined. The soft yellow sands, fissile shales, red cross-bedded muscovitic sands and gray clays are well exposed along this road. A section near the top of the Naheola is as follows:

SECTION (SW.¼, NE.¼, SEC.31, T.9 N., R.18 E.) ON TAMOLA ROAD 100 YARDS WEST OF OLD MISSISSIPPI HIGHWAY 45.

	Feet	Feet
Top Soil		2.0
5. Weathered or colluviated	2.0	
Naheola formation		30.5
4. Brown to gray laminated fine silty muscovitic clay having conchoidal fracture. Fine white sand and muscovite along partings	15.5	
3. Ash bed	0.5	
2. Gray to red brown and buff irregularly laminated fine silty muscovitic clay shale with carbonaceous specks	2.5	
1. Gray-blue to gray to brown to yellow soft fine muscovitic sand with thin gray to brown clay partings. *Halymenites major* Lesquereux in soft sand. Basal 6 inches somewhat ferruginized. Top part with limonite plates and tubes. Spring zone several feet from bottom	12.0	
Total section		32.5

Red, muscovitic fine sands containing *Halymenites major* Lesquereux are beautifully displayed in cuts on the Enondale Road (Figure 34) and on U. S. Highway 45 (Figure 35). An excellent exposure of Naheola lying unconformably on the Matthews Landing marl member of the Porters Creek clay may be seen on a north-facing slope overlooking Pawticfaw Creek valley (Plate 7-1).

Figure 34.—Section of fine red Halymenites-bearing sands of Naheola formation on Enondale Road, (SE.¼, Sec.7, T.9 N., R.18 E.). Oct. 12, 1957.

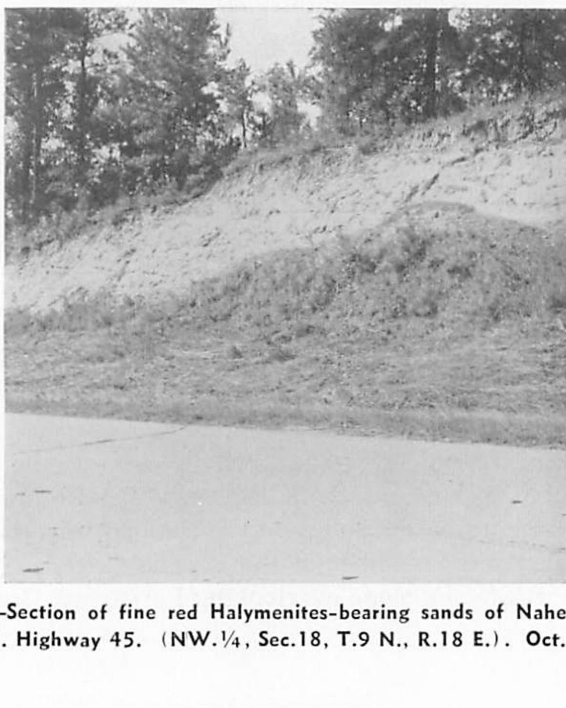


Figure 35.—Section of fine red Halymenites-bearing sands of Naheola formation on U. S. Highway 45. (NW.¼, Sec.18, T.9 N., R.18 E.). Oct. 12, 1957.

Section (SE.¼, NE.¼, Sec.34, T.10 N., R.17 E.). on north-facing slope of Pawticfaw Creek Valley.

	Feet	Feet
Top Soil		1.0
12. Buff to brown sandy, silty top soil	1.0	
Naheola formation		61.3
11. Red-brown, cross-bedded medium to coarse, muscovitic sand, and stringers of gray clay, containing the marine boring *Halymenites major* Lesquereux in lower 5 feet	27.4	
10. Yellow-brown, hard muscovitic ferruginous sandstone ledge	0.2	
9. Dark blue-gray muscovitic argillaceous silt	1.8	
8. Yellow-brown to gray mottled plastic, muscovitic clay; silty in places. Basal few feet blocky, hackly, containing pale gray-green soft, spongy capsule-shaped glauconite in lower 2 feet	10.7	
7. Brown, irregular, discontinuous ferruginous sand zone	2.1	
6. Brown to red, slightly cross-bedded, very muscovitic (large flakes) coarse sand, with blebs and stringers of gray clay and containing *Halymenites major* Lesquereux	6.0	
5. Yellow to gray somewhat mottled plastic clay. Thin ferruginous sand at top	1.1	
4. Light gray silty muscovitic clay	2.8	
3. Dark gray, hackly, slightly conchoidal, silty muscovitic clay, sparsely glauconitic in lower foot or so	9.2	
Unconformity		
Porters Creek clay		36.1
Matthews Landing marl member		
2. Yellow-brown highly glauconitic clay with sandy limonite concretions (0.5 ft.-1.0 ft.) and numerous marine borings at top	5.0	
Porters Creek clay, typical		
1. Dark to light gray, hackly, conchoidal, muscovitic, silty clay; joints filled with platy limonite; contains limonite concretions and laminated zones of fine muscovitic sand	31.1	
Total section		98.4

Just north of DeKalb on State Highway 39 on a north-facing slope overlooking Sucarnoochee Creek Valley the writer measured 84.0 feet of Naheola, the section of which is described below (Figure 36):

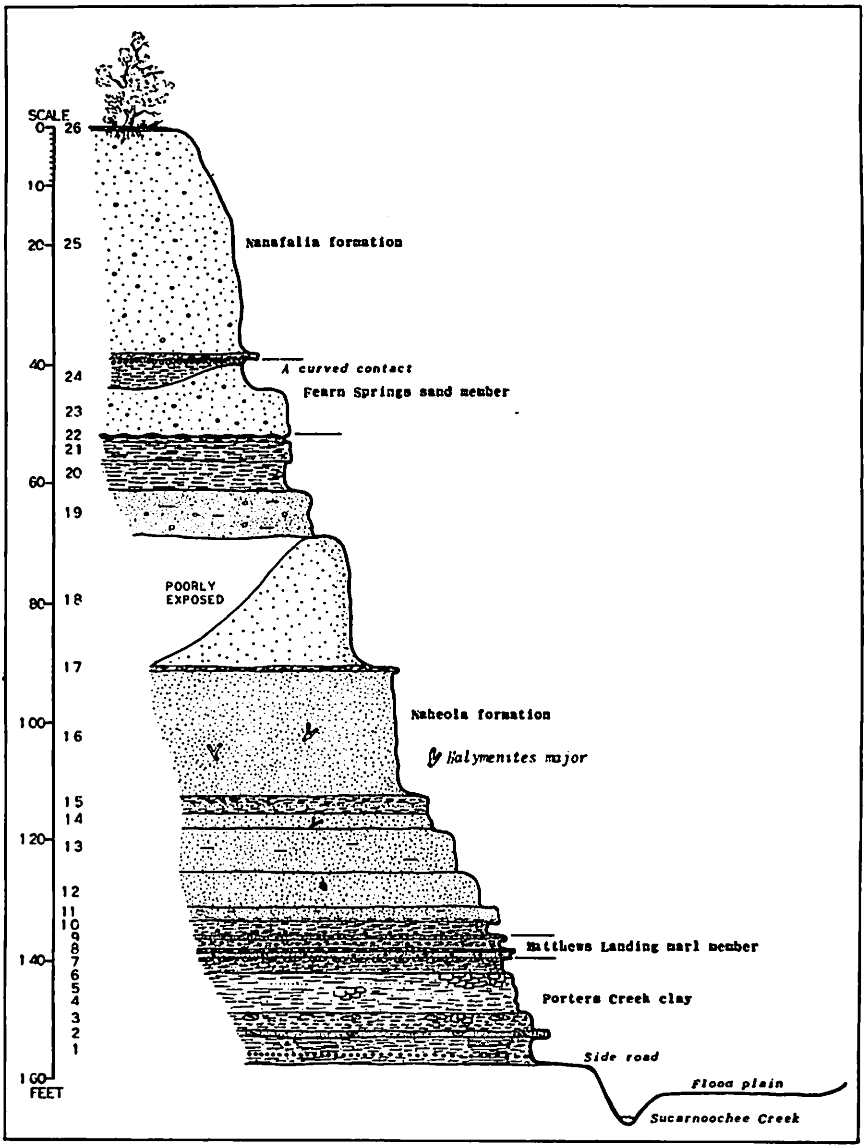


Figure 36.—Section of Naheola formation on State Highway 39, north facing slope of Sucarnoochee Creek Valley (Sec.21, T.11 N., R.16 E.).

SECTION (SEC.21, T.11 N., R.16 E.) ON STATE HIGHWAY 39. NORTH-FACING SLOPE OVERLOOKING SUCARNOOCHEE CREEK VALLEY.

	Feet	Feet
Top Soil		0.5
26. Brown sandy, silty top soil	0.5	
Nanafalia formation		51.5
25. Tan to brown coarse sand with pea gravel and ferruginous bed at base	38.5	
Fearn Springs sand member		
24. Light gray, sandy, silty muscovitic clay with clay balls at top	5.0	
23. Tan, very coarse, muscovitic sand with pea gravel	8.0	
Unconformity		
Naheola formation		84.0
22. Black lignitic clay and lignite	1.0	
21. Gray to black carbonaceous clay	3.4	
20. Light gray sandy, silty clay	5.0	
19. Brown to tan, argillaceous sand containing clay balls	7.7	
18. Poor exposure—coarse sand and top soil?	22.0	
17. Red-brown, hard, continuous limonitic layer	0.5	
16. Yellow to brown to pink fine, soft, muscovitic sand containing *Halymenites major* Lesquereux	21.5	
15. Gray interlaminated muscovitic, silty clay and tan fine sand	2.7	
14. Red brown, very muscovitic coarse sand containing *Halymenites major* Lesquereux	2.3	
13. Tan laminated slightly argillaceous, very muscovitic fine sand	7.5	
12. Light gray, muscovitic fine sand	5.5	
11. Bluish-gray to light brown argillaceous sand, basal part very argillaceous	2.3	
10. Dark bluish-gray muscovitic slightly silty clay—lower part glauconitic	2.6	
Unconformity		
Porters Creek clay		21.6
Matthews Landing marl member		
9. Rust brown to green highly glauconitic sand with fossil prints	0.7	
8. Dark green to black, glauconitic sandy clay	1.7	
7. Brown limonitic concretion zone	0.5	
6. Dark green, argillaceous, glauconitic medium sand	1.0	
Porters Creek clay, typical		
5. Gray sandy, silty, muscovitic clay with a zone of flat siderite concretions 0.4 foot thick at top	2.7	
4. Dark gray, silty, muscovitic blocky clay, laminated	7.0	

3. Gray silty muscovitic blocky, hackly clay with siderite concretions at top and containing platy limonite zones	3.0	
2. Rusty brown, soft ferruginous sand with siderite concretions	1.0	
1. Dark gray, carbonaceous, very sandy, silty muscovitic clay with medium fine glauconitic sand partings	4.0	
Total section		157.6

To the north in the county the Naheola becomes much thinner and is apparently overlapped in part by units of the Wilcox group. On State Highway 39, approximately 4.6 miles north of DeKalb (NE¼, Sec.4, T.11 N., R.16 E.) the Naheola is only 16.4 feet in thickness. On an east-west road near the county line (SW.¼, NW.¼, Sec.4, T.12 N., R.16 E.) only 3.8 feet of Naheola are exposed. The section here is somewhat thinner than normal for this locality. Just over the county line in Noxubee County on State Highway 39 the thickness of Naheola measured by the writer is 13.9 feet. Here it is overlain with sharp contact by the very coarse sands of basal Fearn Springs.

Stratigraphic relations: In Kemper County the Naheola formation lies unconformably on the Matthews Landing marl member of the Porters Creek clay and is overlain unconformably by the Fearn Springs member of the Nanafalia formation.

Physiographic expression: The topographic surface on which the Naheola formation crops out is the typical sand hills physiography. Road cuts show the fine yellow to red sands which are so characteristic of the Naheola formation in Kemper County. The topographic expression is very similar to that manifested by the laminated sands and clays of the upper Porters Creek clay. The rolling topography is in marked contrast with the Flatwoods to the east that results from the weathering and erosion of the massive black clays of that belt. Elevations of 400 feet above mean sea level are not uncommon, with relief of as much as 100 feet.

Paleontology: The Naheola formation in Kemper County is considered unfossiliferous. Only the marine boring *Halymenites major* Lesquereux has been found. Borings of other animals are present in the upper contact at several places.

Age and Correlation: The Naheola formation is the upper formation of the Paleocene series of the Gulf Coast region. The

Kemper County exposures are correlated with the Wills Point formation and the Soloman Creek member of the Seguin formation of Texas. The Naheola is the equivalent of three units in Louisiana, the Naborton, Logansport, and Hall Summit formations. To the east in Alabama it is the time equivalent of the Coal Bluff member of the Naheola formation. The Naheola formation correlates in part with the lower Landenian stage or Thanetian sub-stage of the European section.

MIDWAY-WILCOX CONTACT

Along the Midway (Paleocene) and the Wilcox (Eocene) contact in an arc passing through northeastern Mississippi, southern Alabama and southeastern Georgia, ball clays, stoneware clays, kaolin and bauxite are present. The deposits roughly parallel the early Tertiary strand lines. The contact of the Midway and Wilcox groups is one of unconformity and the hiatus is of considerable magnitude. The rocks of Midway age, and older, which are manifested in updip surface exposures, were deeply weathered, eroded to base level, and locally buried by transported sediments. The exact nature and age of this zone of weathered and transported materials have been the subject of much investigation and controversy, and the zone has been placed in one group or the other or in both, depending on the ideas of different workers. The concept is tenable that the untransported weathered material is Midway in age or older, depending on what formation it happens to be a part of, whereas the transported material which was deposited during the interval between the Midway and Wilcox, may be either of late Midway or early Wilcox age or of both ages. The bauxite deposits are commonly found in the transported sediments that form the base of the Wilcox group, but may be also of Midway age. Thus the defining of the Midway-Wilcox contact within the weathered zone is controversial. To illustrate the evidence bearing on the problem, the writer will quote passages from several of the more important papers.

The units involved are the Betheden formation of Mellen, the Fearn Springs formation of Mellen, and the "Ackerman" formation. In his original description of the Betheden formation (Mellen and McCutcheon, 1939) Mellen says, "The Betheden residuum or formation includes all residual material at the top of the Midway and below the Midway-Wilcox unconformity. It includes the deposits of bauxite, kaolin, bauxitic and kaolinitic clays, and the overlying lignite. When fully preserved, the entire thickness of the formation is approximately 25.0 feet. The lower contact is gradational into the Porters Creek formation. The upper contact is unconformable with the Fearn Springs, or with the Ackerman where the Fearn Springs was eroded. In many places the Betheden itself was eroded and the Wilcox beds were deposited directly upon the unweathered Midway."

Thus, the Betheden of Mellen is of definite Midway age, lying conformably on the Porters Creek clay. Of the Betheden (MacNeil, 1946b) MacNeil says,

"Examination of many other sections of the Betheden indicates, however, that although some of its constituents may have been reworked from Midway deposits, it is not a residue, but a transported non-marine sedimentary deposit lying between the top of the marine clays of the Midway and the lowest coarse non-marine sands of the Wilcox . . . It is difficult to give a typical section for the Betheden formation because of the great variation in its composition. Sand, massive kaolin beds, and clay-ball conglomerates are common constituents of the lower and middle part, and laminated leaf-bearing clay and shale are common in the upper part. Locally, however, any one of these constituents may make up the greater part of the formation.

"In general, two types of lithologic sequences exist, one showing probably the *normal sequence* of beds, the other, a *channel deposit.*

"Where present, the *normal sequence* everywhere overlies leached, laminated, marine Porters Creek clay. Gray to white kaolin, at many places, showing plant inclusions and bedded or irregular bodies of fine white sand, commonly rest directly on the leached Porters Creek clay, but rarely a thin sand bed occurs at the base of the kaolin. Granular siderite is common in the kaolin. In much of the kaolin there is an intricate system of cracks, which suggests that it had been dried and cracked by the sun many times. In most sections the kaolin grades upward to silty, carbonaceous, clay-shale or lignite, at places carrying excellent fossil leaves. Locally, however, a bed of fine, white sand lies between the kaolin and the carbonaceous shale, and in some sections this sand makes up the main body of the formation. Clay balls commonly occur scattered throughout the sand and frequently form a conglomerate at the top.

"The *channel sequence* always rests on dark, unleached Porters Creek clay, showing that if a leached zone ever were present, it was scoured away. The base of the channel deposit is everywhere made up of conglomeratic material consisting of clay balls, lignite lumps, and pieces of Porters Creek clay. The deposit is always sandy, ranging from scattered sand between conglomeratic particles to mostly sand with only scattered conglomeratic material. The basal conglomerate or sand grades up into white kaolin and the kaolin into carbonaceous shale. In two holes drilled by the Bureau of Mines in southwestern Union County, Mississippi, bentonite was found to take the place of kaolin, suggesting that secondary channels filled with volcanic ash cut the kaolin. The carbonaceous shale appears to form the top of both the normal and channel sequences. This and the fact that the leached Porters Creek clay and the kaolin that immediately overlies it in the normal sequence are never found below a channel indicates that the relative position of the channel is at the base of or within the sand and conglomeratic clay zone that is locally present in the middle part of the normal section.

"The writer's picture of the sequence of events that produced the above deposits is about as follows: The laminated beds at the top of the Porters Creek clay were elevated above sea-level and subjected to subaerial leaching, and the clays were partly kaolinized. Locally these clays were reworked, with little transportation of material, to form massive bodies of clay with some of the fine sand from the Porters Creek clay redeposited in beds and pockets. Plant material was either incorporated in the clay during transportation, or penetrated it later as roots. Following the redistribution of the clays, they were subjected to wetting and drying as indicated by the intricate system of cracks. Locally they are bauxitic, though rarely entirely bauxite. Following the period of wetting and drying, fine to medium white sand containing scattered clay balls was deposited locally from a new source; the large amount of the sand practically precludes the possibility of its having been reworked from the Porters Creek clay. Near the top of the sand, concentrations of the clay balls are abundant and commonly some massive kaolin is present overlying the beds containing the clay balls. The greater part of the bauxite of northern Mississippi was found in the conglomeratic and massive clay just mentioned.

"At about the time the beds of sand and clay balls were being deposited, scouring took place locally and channels were cut through the underlying beds down into unweathered Porters Creek clay. The clay-ball conglomerates in the channels, which are thus taken to be stratigraphically equivalent to the conglomerates in the normal section, are, like them, commonly bauxitic. As indicated above, bentonite is known to have been deposited in a late stage of the formation of the channel deposits.

"Following the cutting and filling of the channels, gray, silty, carbonaceous shales, grading upward into less silty, leaf-bearing clays, were deposited over wide areas. Locally these clays pass laterally into lignite.

"Since this paper was written the writer has had occasion to restudy notes on several sections observed in northern Kemper County, Mississippi, where the Naheola section is complete. These sections indicate that deep channels are cut into the lower beds of the Naheola formation and filled by the sand of the base of the Coal Bluff marl member, which, as has been stated, was not recognized this far north as a separate unit. This relationship might provide a clue to the perplexing problems arising in sections of the Betheden formation. It is suggested that the normal Betheden section represents the normal Naheola-Coal Bluff sequence, but that the channel-type section of the Betheden represents the scouring away of the lower member of the Naheola prior to deposition of the Coal Bluff marl member. If this interpretation is correct, the Midway-Wilcox contact might be located at any one of three possible horizons as follows:

"1. The base of the Naheola formation. This is the horizon commonly picked in the subsurface. There is some justification for its acceptance at the surface for in northern Mississippi this horizon separates marine from non-marine beds.

"2. The base of the Coal Bluff marl member of the Naheola. Several micropaleontologists who studied the fauna of the Coal Bluff marl regarded it as basal Wilcox. This interpretation would find justification at the surface, if the above interpretation of the channels in the Betheden is correct, in which case the Coal Bluff marl member would fill deep channels in beds below it.

"3. The base of the Fearn Springs sand member of the Nanafalia formation. The molluscan faunas commonly regarded as lower Wilcox all lie above this horizon. The stratigraphically lowest occurence of *Ostrea thirsae*, a commonly accepted guide to the lower Wilcox is in this member. This interpretation finds justification in the surface outcrops of the Fearn Springs sand which fills deep channels in bed below and consists partly of coarse sand and gravel that are commonly interpreted as the indicators of a break of importance."

MacNeil further states that the channel type section of the Betheden is remarkably similar to the sequence in the Arkansas bauxite mines and that his opinion is that the "Midway-Wilcox contact, as interpreted by the bauxite parties working in Arkansas, is horizon 2 stated above."

In this report MacNeil considered the Betheden formation as an upper formation of the Midway group and considered it as the non-marine lateral equivalent of the Naheola formation, but recognized that it might possibly be a swamp or lagoonal deposit of early Wilcox age.

"In the columnar diagram (column 31 and northward) and in the small correlation chart, the Betheden formation is plotted as an upper formation of the Midway group, suggesting a correlation with the Naheola formation, but it is possible that the Betheden is a swamp or lagoonal deposit of lower Wilcox age. It is impossible to trace the formation continuously at the surface, as it is absent in many places along the strike. The equivalence of the Betheden and the Naheola is suggested by the following: (1) the Betheden is found only to the north of the area where the Naheola is definitely recognized; (2) the Naheola carries some beds of comminuted plants and lignites such as are common in the Betheden; (3) at the southernmost exposure of beds assigned to the Betheden it rests directly on the Matthews Landing marl member of the Porters Creek, the normal position for the Naheola; and (4) in Winston County, Mississippi, where beds assigned to the Betheden outcrop, drilling down the dip shows that a section comparable in lithologic composition and thickness to the Naheola formation of Alabama intervenes between the Matthews Landing marl member of the Porters Creek clay and the basal sands of the Fearn Springs sand member of the Wilcox formation. If this correlation is correct, the comparatively thin exposures and disconnected occurrences of the Betheden formation at the outcrop indicate overlap by beds of Wilcox age."

In a later paper, MacNeil (MacNeil, 1951) considers the "Betheden type deposits" to be early Wilcox in age. He states (op. cit., pp. 1068 et seq.):

"Conant also agrees that much of what he had earlier identified as Fearn Springs and 'Betheden' actually belongs to the same stratigraphic unit.

"Largely through the later work of Conant in northern Mississippi, it was found that the middle beds of the 'Betheden' and Fearn Springs sequence locally occupy channels which cut through the lower beds of the interval as well as part of the underlying Porters Creek clay."

The "Betheden" formation of Mellen is an example of the extremely variable "normal type" section of Conant, deposited in low coastal swamps resting directly on a pan of Porters Creek clay; and the typical Fearn Springs represents the "channel-type" section in which Fearn Springs type sediments were deposited in channels locally cut into the "Betheden" type sediments. The normal and channel-type sections are apparently continuous from northern Mississippi across the state and extend into Alabama. They have been recognized in the Fearn Springs member of the Nanafalia formation of Alabama where both the channels and the beds channeled are marine in contrast to the non-marine character of the deposits in northern Mississippi. "In both areas, however, the beds are strikingly similar, consisting normally of fine sand or clay at the base, grading into coarser sand or even gravel above. In both areas the coarser material is locally concentrated into channels that cut through part or all of the finer material below. In both areas both the channel deposits and the non-channeled beds grade upwards into what appear to be identical clays." (MacNeil, 1951.) Both normal and channel type deposits are stratigraphically lower than the widespread silty, leaf-bearing clays and lignites of the upper Fearn Springs.

Thus the Betheden and Fearn Springs were deposited contemporaneously and are considered by MacNeil as being intraformational and belonging to the same lithologic unit. Two formal stratigraphic names are apparently in use for one unit. MacNeil favors the retention of the name Fearn Springs either as a formation or member and recommends that the name Betheden be abandoned.

Much controversy based on the type locality of the Fearn Springs in Winston County has a definite bearing on the problem in which the writer is presently engaged. At the type locality, 0.25 mile west of the village of Fearn Springs (NE.¼, Sec.3, T.13 N., R.14 E.) Mellen mistakenly considered the basal coarse sand of the Fearn Springs as colluvium. Inasmuch as the section exposed here includes a basal coarse sand of the Fearn Springs, and at the top of the section the basal coarse sand of the Nanafalia (Mellen's basal "Ackerman") which is lithologically identical, confusion resulted. The names Fearn Springs and "Ackerman," were applied fallaciously, and the Midway-Wilcox boundary was further obscured in the literature. More discussion of this, including the "Ackerman," will be found under the heading "Fearn Springs Sand Member."

The very nature of the complex Midway-Wilcox problem has been a challenge to Gulf Coast geologists for over a hundred years. The writer would like to see initiated studies involving single lithologic units carefully traced along the line of outcrop through the entire State of Mississippi. Thus a single unit could be concentrated on, and its facies changes, changes in thickness, and other features could be correlated and mapped along strike. This was the general plan followed by MacNeil in his "Midway-Wilcox Stratigraphy of Alabama and Mississippi," which in the opinion of the present writer, represents the greatest single contribution to date. This was also the approach used by Lowe (Lowe, 1933); by Grim in his "Eocene Sediments of Mississippi," (Grim, 1936); and by Stephenson and Monroe in their "Upper Cretaceous Deposits" (Stephenson and Monroe, 1940). Isolated county reports are not the solution to the problem.

To try to "pin down" the geology in Kemper County the writer carefully traced all formations in that county from their classical exposures in western Alabama to a latitude north of Kemper County where he still felt certain of the units involved. A considerable amount of time was spent in Alabama, and in Lauderdale, Neshoba, Winston, Noxubee, and Choctaw Counties in Mississippi.

EOCENE SERIES

WILCOX GROUP

In Kemper County the Eocene series contains sediments of the Wilcox group. The name Wilcox was first used by E. A. Smith, State Geologist of Alabama, in an unpublished manuscript, for the formations of this group which are typically exposed in Wilcox County, Alabama. The name Wilcox was formally adopted by the U. S. Geological Survey, March 23, 1905. However, Wilcox was first used in the literature as a formation name in 1906 (Crider, 1906; Crider and Johnson, 1906). Of the first use and type locality, the writer wishes to quote from Crider and Johnson (Crider and Johnson, 1906) who say, "The present name, Wilcox, was first given in some unpublished work by Eugene A. Smith, State Geologist of Alabama, for the reason that typical strata of the former Lignitic of Hilgard are exposed at Wilcox, Alabama." Wilcox is a geographic name which replaced the descriptive term Lignitic (first used by Safford of Tennessee), and the earlier geographic name, LaGrange of Safford, which incorporated the Lafayette and portions of the Cretaceous.

There is disagreement over use of Wilcox versus Sabine, which hinges on nomenclatural decisions dating back to 1906, that in time proved unfortunate. Two names, Wilcox and Sabine, were accepted practically simultaneously by the U. S. Geological Survey for the same unit — Wilcox, east of the Mississippi; and Sabine, west of the Mississippi.

Priority: Wilcox. Wilmarth (Wilmarth, 1938) states: "March 23, 1905 . . . This name (Wilcox) was selected after correspondence (by E. C. Eckel) with the State Geologist of Ala. (E. A. Smith), and type loc. was specifically stated in the records to be Wilcox Co., Ala., 'which affords good exposures of the entire 'Lignitic' section.' " Wilmarth implies that the "records" referred to here are inter-departmental correspondence concerning manuscripts for U. S. Geological Survey Bulletin 283, "Geology and Mineral Resources of Mississippi," by A. F. Crider; and U. S. Geological Survey Water Supply Paper 159, "Underground Water Resources of Mississippi," by A. F. Crider and L. C. Johnson (both of which reports contain geologic maps by Eckel and Crider). These two publications appeared in 1906.

There is some dispute over the type locality chosen for the Wilcox. The name "Wilcox," in the U. S. Geological Survey "records" of which Wilmarth wrote, was applied to units exposed typically and "specifically" in Wilcox *County,* Alabama. The question has arisen in the literature as to the intention of using a county for the type locality. It has been noted that the original formal description stated only "Wilcox, Alabama," and Howe (Howe, 1933) also called attention to the fact that there is no suitable village or geographic point called "Wilcox, Alabama." Wilmarth also discounted the existence of a suitable post office so named; although this hardly seems necessary, when she had already positively identified the intention of the U. S. Geological Survey to select Wilcox *County,* as the type locality. The only pertinent fact today is that there is not a known suitable geographic place for a type locality, other than Wilcox *County,* Alabama.

Sabine: Wilmarth (op. cit., p. 1862) states that the staff of the U. S. Geological Survey accepted for west of the Mississippi, practically simultaneously, the admittedly synonymous name "Sabine," as proposed by A. C. Veatch, who was engaged in a study of the geology and underground water resources of northern Louisiana and southern Arkansas. "Sabine" was originally used in 1905 in "The Underground Waters of Northern Louisiana and Southern Arkansas," (Veatch, 1905) by Veatch. In 1906, a later report by Veatch (Veatch, 1906) gave a detailed description of the Sabine. Actually, which of the names, Wilcox or Sabine, possesses unassailable priority seems irrelevant. The U. S. Geological Survey accepted Wilcox for units east of the Mississippi; and Sabine for the same units west of the Mississippi.

The type locality of the Sabine was selected by Veatch (Veatch, 1906) who stated, "the name Sabine has been suggested and adopted from the typical development of the formation along Sabine River in Sabine County, Texas, and Sabine Parish, Louisiana and from noteworthy exposures at Sabinetown Bluff." This is an area along Sabine River, between Sabine County, Texas, and Sabine Parish, Louisiana, approximately 30 miles in length.

Subsequent usage: In 1910 the U. S. Geological Survey decided to abandon the term "Sabine formation" in favor of "Wilcox formation" in a report by Alexander Deussen (Deussen, 1914; from Wilmarth, op. cit., p. 1863). In 1932 Plummer (Plummer, 1932) named the "Sabinetown formation" and chose as the type locality "Sabinetown, or Sabine River, Sabine County." Plummer's Sabinetown is the top formation in his division of the Wilcox group in east Texas, and is correlatable with the Bashi of Alabama.

In 1933, Howe (op. cit. p. 619) wrote "the name 'Wilcox' is both inappropriate and lacks priority," but he concluded that the "Wilcox section" of Alabama represents only the upper portion of the Sabine group present in Sabine County, Texas, and Sabine Parish, Louisiana, demonstrated by drilling to be at least 3,000 feet thick. Howe and Garrett (Howe and Garrett, 1934) in 1934 divided the Sabine group of Louisiana into the Wilcox and Mansfield (older) subgroups. "Mansfield" is a name first used by Hilgard for a portion of the "Lignitic," which he thought was equal to the materials in the lower portion of the Vicksburg bluff; and characteristically developed near Mansfield, Louisiana (Wilmarth, op. cit. p. 1287).

The U. S. Geological Survey, in cooperation with the Mississippi Geological Society, in 1945, and MacNeil in 1946 (Miss. Geol. Society Map of Mississippi, prepared in cooperation with the U. S. Geol. Survey, 1945; MacNeil, 1946b) employed Wilcox formation rather than Wilcox group.

Murray in 1953 (Murray, 1953) who gives a detailed history of the nomenclature, proposed using Wilcox group as a rock unit term only, including "The great mass of complexly interbedded, continental to deltaic deposits of Midway and Sabine ages," and accepted "exposures in Wilcox County, Alabama" as typical of the group. He proposed to use Midway stage, as a "provincial subdivision of series, a time-rock classification, to embrace all the time involved in the deposition of the Clayton, Porters Creek, and Naheola formations." He proposed to use Sabine stage, as a time-rock term for all the time involved in the deposition of post-Midwayan and pre-Claibornian rock units. Thus Sabine and Midway, were made time-stratigraphic terms; and all the Sabine stage, and the part of the Midway stage from the top of the Porters Creek to the base of the Nanafalia (*Ostrea multilirata- Ostrea thirsae* zone) are included in an enlarged Wilcox group, used as a rock unit term only (transgressing time-stratigraphic divisions).

In 1955, Murray (Murray, 1955) noted that the names Midway and Wilcox used as he had proposed in 1953 had been extended into all areas of the Coastal Plain where these strata crop out; and that drilling had permitted the extension of nomenclature of certain surface units into the subsurface, especially the Matthews Landing, Nanafalia-Marthaville, and Bashi-Sabinetown units. Murray continued to recommend use of Sabine stage, Midway stage, and Wilcox group.

The dispute between users of Wilcox and users of Wilcox and Sabine seems to rest basically on whether or not there is a distinction that belongs in the nomenclature between Midway and Wilcox-Sabine time which coincides with the bio-stratigraphic and litho-stratigraphic divisions. The reader is referred to the opinion of some geologists that the Midwayan sediments represent pro-delta clays of the Wilcox down dip. Electrical properties, such as the fact that the Porters Creek is easily picked on electric logs, has an important bearing on subsurface nomenclature problems in the Gulf Coast area. On the surface, in Kemper County, close to the classic Alabama section, the writer found that the use of

Wilcox in both a time-stratigraphic sense, and a litho-stratigraphic sense, is expedient; and it seems only to add to the confusion to attempt to use a time-stratigraphic unit name, different from the rock unit name for these same deposits, or any parts of the same deposits.

Formation names used in Kemper County are those in general use in Alabama. The lithologic units within Kemper County at the surface are much more closely related to those in western Alabama than they are to units to the north in Mississippi, and the writer feels justified in using Alabama nomenclature.

Formations comprising the Wilcox group in Kemper County are in ascending order: Nanafalia formation and Fearn Springs sand member at the base, Tuscahoma formation, and the Hatchetigbee formation with the Bashi marl member at the base.

The Mississippi Geological Society Map (Op. cit., 1945) shows the Wilcox as a formation, being the equivalent of the Wilcox group in Alabama. The Wilcox formation of the Mississippi Geological Society is used as Wilcox group in Kemper County, because the above-mentioned formations can be delimited.

The Wilcox group in Mississippi is composed of formations mainly of fresh-water origin, which consist predominantly of fine, gray, olive colored sands, dark clays and clay shales, and lignite. The formations are strongly cross-bedded and contain channels at different stratigraphic positions. In east central Mississippi, in Kemper County, these formations contain, in addition to lignites, fossiliferous print beds of marine origin, which are extensions of more prominent and widespread units in the outcrop in Alabama. The fossil print beds in Kemper County are excellent horizon markers for mapping and stratigraphic determinations.

The Wilcox occupies approximately half of the surface of Kemper County (Plate 1). The strike of the units of the group is northwest. The Wilcox group overlies the Midway and underlies the Claiborne groups, and is separated from each by an unconformity.

The "Ackerman" formation was previously considered as the correlative of the Nanafalia formation in Alabama, and is still considered as the basal formation of the Wilcox by the

Mississippi Geological Survey. The writer discussed nomenclature and stratigraphic problems with F. S. MacNeil and Louis C. Conant, both of the U. S. Geological Survey. It is the opinion of MacNeil that the "Ackerman" formation at the type locality,

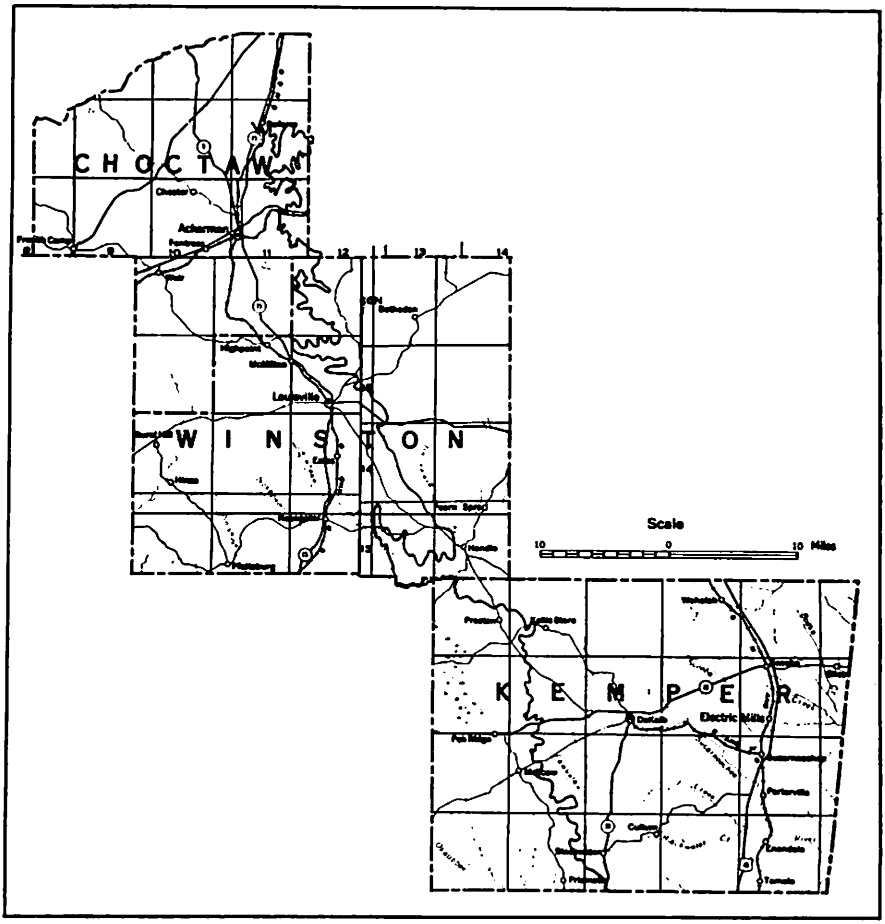


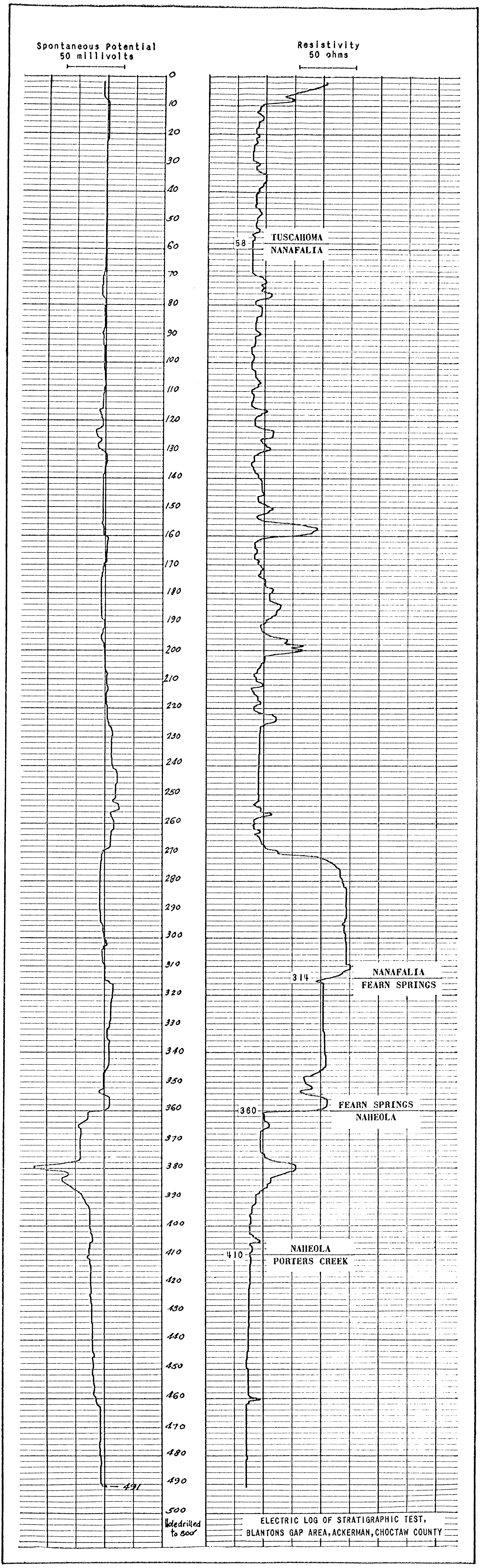
Figure 37.—Nanafalia-Tuscahoma contact in Kemper, Winston, and Choctaw counties. "Ackerman" at its type locality, Blantons gap, is Tuscahoma in age.

Blanton's Gap, approximately 1.5 miles east of Ackerman in Choctaw County, correlates with beds well up in the Tuscahoma sand of Alabama. The persistent gray clay-shale and silts which mark the top of the Nanafalia formation, and have been traced as far north as the village of Reform, in Choctaw County, are well displayed in and around Legion State Park in Winston County. Thus, the Nanafalia-Tuscahoma contact is approximately four miles east of the Ackerman type locality (Figure 37). The writer drilled a 500-foot stratigraphic test on the C. E. Blanton property (SE.¼, NW.¼, Sec.28, T.17 N., R.11 E.), approximately half a mile south of the south end of the railroad cut, Blanton's Gap, to determine the thickness and sequence of the units in that area. The electric log is shown in Plate 8, and has been interpreted as follows: Tuscahoma-Nanafalia contact at 58 feet below the surface; Nanafalia-Fearn Springs sand contact at 314 feet; Fearn Springs sand-Naheola contact at 360 feet; Naheola-Porters Creek clay contact at 410 feet. It is the opinion of the writer that the "Ackerman" formation should be redefined if the name is to be used further. If the "Ackerman" is redefined, it should include equivalents of Nanafalia and Tuscahoma age combined.

Another perplexing stratigraphic problem is the question of the age of the red and brown coarse sands and gravels, lignites, bauxites, and petrified wood which have been mapped as Wilcox and Claiborne in north central Mississippi. It was a theory of E. H. Rainwater (personal communication) of Shell Oil Company in Houston, Texas, that some of these deposits are surficial and are Pleistocene in age.

It is the opinion of the writer that the sands, lignites, gravels, boulders, and petrified wood of Kemper County in question are merely the weathered phase of the outcropping formations in updip exposures. Several key marker beds in Kemper County have been identified as Wilcox on the basis of contained fossil prints (MacNeil, 1955; personal communication).

An interesting technique that may in time prove to be widely useful in such stratigraphic problems is the application of palynology to geology. Palynologic investigations already add to the body of knowledge of Tertiary and Quaternary vegetation. For example, information derived by pollen analysis about the flora represented in a lignite can be helpful in ascertaining the botanic origin of anthraxylon and attritus, the two primary microstructural constituents of lignite. It is true that many of the Cenozoic fossils can be definitely identified with extant groups of plants. Others can be assigned to artificial groups and serve as satisfactory stratigraphic indices, but many forms cannot be classified



ELECTRIC LOG OF STRATIGRAPHIC TEST, BLANTONS GAP AREA, ACKERMAN, CHOCTAW COUNTY to either family or order. The whole nomenclatural system in the field of palynology is still in a state of flux due primarily to incomplete knowledge of modern spore and pollen morphology and of numerous extinct groups of plants. A brief examination of the works of Wodehouse, Erdtman, Bertsch, Faegri and Iversen, and Iversen and Troels-Smith (Wodehouse, 1935; Erdtman, 1943; Bertsch, 1942; Faegri and Iversen, 1950; Iversen and Troels-Smith, 1950) shows the considerable variation in morphological terminology and classification that exists today. The lignite of Kemper County is rich in spores and pollen. Recently, the writer has been informed that the age sequence of plants has been established to some extent by palynologists with the Standard and Shell groups of companies (Rainwater, E. H., Letter, Sept. 10, 1957), but this information is not published and of course is not available to the writer or the general public. Palynology is a field that is rapidly inviting investigation, and which should prove of much benefit in definitely establishing the age and sequence of the thick, complex continental to deltaic deposits of the Gulf Coast geosyncline. The writer is interested to learn along this line that in the opinion of oil company palynologists, lignites and coals usually have a specialized and local flora, and are not as good for age determination as carbonaceous clays and silts.

NANAFALIA FORMATION

First reference: E. A. Smith, 1886 (Smith, 1886). Although this is the first reference to the lithology, the name Nanafalia Bluff appeared on fossil lists and outcrop notations as early as 1850 to 1860.

Nomenclator: E. A. Smith and L. C. Johnson, 1887 (Smith and Johnson, 1887). In this publication the names Hatchetigbee, Nanafalia, Matthews Landing, Naheola, and Midway were introduced for the first time as formal names.

Type locality: Nanafalia Landing on the Tombigbee River in the SE.¼, Sec.31, T.14 N., R.1 E., Marengo County, Alabama.

Original description: (Smith, 1886, pp. 12-13.)

"The strata of this section are 200 feet in thickness, and consist of about 50 feet of gray, sandy clays at top, which show a great tendency to indurate into tolerably firm rocks, resembling very closely some of the strata of the Buhrstone. Below this, about 80 feet of sandy beds, often strongly glauconitic, characterized throughout by the presence of small oysters, *Gryphaea thirsae.*

"Near the base of this sandy division there is a bed about 20 feet thick, literally packed with these shells.

"Below the *Gryphaea thirsae* beds follow some 70 feet of cross-bedded sands, glauconitic, and apparently devoid of fossils, including, about 10 feet from the base of the section, a bed of lignite which varies in thickness from four to seven feet.

"The greatest variety in the shells of this group is seen in the strata which immediately underlie the lowest of the beds containing *Gryphaea thirsae,* and following section of the type locality is therefore given:

"Section at Nanafalia Landing

1. Greensand marl, highly fossiliferous, the main form being *Gryphaea thirsae,* with a few other shells, such as *Turritella Mortoni,* a *Flabellum,* etc. This is the lowermost of the Gryphaea beds, and is here about 20 feet thick.
2. Dark-blue, almost black, laminated clay, devoid of fossils, but passing below gradually into a bluish marl..........3 to 4 ft.
3. Bluish, green-sand marl, containing a few shells in the upper three or four feet, but becoming much more fossiliferous below. This bed contains a great variety of beautifully preserved and easily detached fossils, which can, however, be seen only at a low stage of water. Thickness ....8 to 10 feet."

Other descriptions: E. A. Smith and L. C. Johnson (Smith and Johnson, 1887, p. 51) described the Nanafalia:

"The Nanafalia Series, Including the Coal Bluff Lignite

"The series of strata to which the Nanafalia marl has given the name, broadly considered, is susceptible of three-fold division upon the basis of lithological and paleontological characters, viz:

"First. Forty feet or more of indurated, gray clays and sandy clays, in part glauconitic and rather closely resembling some of the materials of the Buhrstone. Near the base of this first division there are hard, sandy clays filled with shell casts, chief among which are Turritellas and Cythereas.

"Second. Seventy-five to eighty feet of yellow and reddish and whitish sands, alternating with greensand beds, highly fossiliferous. The characteristic shell in both the sands and the greensands is *Gryphaea thirsae* Gabb. In the upper fifty or sixty feet of this division this shell is found either in thin greensand beds or sparingly distributed through the other sands. In the lower twenty feet there are thick greensand beds literally packed with these shells. The greater part of the exposure at Nanafalia Landing consists of greensand beds filled with Gryphaea thirsae and other forms, the first named making perhaps 90 percent of the whole.

"Third. Below the *Gryphaea thirsae* beds follow some eighty feet or more of sandy clays and sands, variously interstratified, cross bedded sands passing near the base of the division into greensands which overlie a bed of lignite varying from four to seven feet in thickness."

Brantly (Brantly, 1920) in his description of the Nanafalia shows its thickness to be 250 feet made up of sections from three areas, Black's Bluff, Alabama River, Wilcox County; Grampian Hills, 2 miles southeast of Camden; and section above Gullette Bluff on Gravel Creek and Alabama River. His description of the Nanafalia formation is as follows:

"The Nanafalia formation, the lower-most of the Wilcox Group, consists of from 125 to 150 feet in ascending order of lignite, massive and laminated sands and clays, cross-bedded sands, highly fossiliferous greensand marl and kaolin-like laminated to thick-bedded clays, with thin, highly fossiliferous indurated beds. The formation is readily subdivided into three lesser divisions based on both lithology and fossil content. In order to assist in the description of certain features concerning the formation, the lower of the three phases will be referred to as the Coal Bluff beds while the upper two phases will be referred to as the Gullette Bluff beds, where their entire thickness is exposed. Smith has used the term 'Coal Bluff' to apply to the lignite at the base of the Nanafalia. In this paper the name is extended to include all the strata below the Gullette Bluff fossiliferous marl.

"The Coal Bluff beds consist of 2 to 7 feet of lignite at the base overlain by 40 to 70 feet of cross-bedded sands, laminated clays and sandy clays with sand lenses and at the top a 20-foot bed of yellow to clean white cross-bedded sands with a few tough blue clay streaks and lenses of flattened pebbles. The best development of these beds is in Wilcox County. Westward in Marengo County they have a 60-foot thickness while on the Chattachooche River according to Langdon's Section they are entirely absent."

Cooke (Cooke, 1926a) in his description of the Nanafalia formation used essentially the description of Smith and Johnson above but adds,

"The present writer suspects that the lower division more logically forms part of the Naheola formation than of the Nanafalia, but he has done so little field work in this area that he prefers to suspend judgment.

"There are two principal means of recognizing the Nanafalia formation—first, the presence of abundant shells of *Ostrea thirsae;* and second, the "pseudo-buhrstone." Both of these criteria should be used with caution. *Ostrea thirsae* is not confined to the Nanafalia formation, although beds composed chiefly of shells of that species have not been seen except in the Nanafalia. The "pseudobuhrstone" so closely resembles certain facies of the Tallahatta formation that it might readily be mistaken for the Tallahatta by one not thoroughly familiar with both formations. Both contain hard, brittle rock, generally rough on the surface, which caps high, steep hills.

"The most characteristic and easily recognized lithologic facies of the Nanafalia, the "pseudobuhrstone," is most extensively devolped in Wilcox and Butler counties. East and west of these counties the formation contains fewer hard rocks, and the topography of its outcrop does not differ materially from that of the softer, laminated sands of the adjacent Tuscahoma formation."

Toulmin, LaMoreaux and Lanphere (Toulmin, LaMoreaux, and Lanphere, 1951) subdivide the Nanafalia into three principal parts. A basal medium- to coarse-grained cross-bedded channel sand with fine gravel and clay balls is present in some areas.

The middle part, the *"Ostrea thirsae* beds," contain firm to loose olive-gray to yellow glauconitic sand and clayey sand with layers of concretions composed of calcareous fossiliferous sandstone. The upper part consists primarily of tough dark-gray clay.

"The basal cross-bedded sand does not have a uniform thickness, but appears to be lenticular and to vary in thickness from a feather edge to 40 feet in Choctaw County. The sand for the most part is fairly well sorted and medium-grained, although in places coarse sand, gravel, and clay balls appear along cross-bedding planes. This basal sand of the Nanafalia has been called the Fearn Springs sand member by MacNeil, the type locality of which is in Winston County, Miss.

"The beds of the middle division can be traced from north-central Choctaw County eastward across the State. At the type locality of the formation at Nanafalia Landing, on the Tombigbee River, about 36 feet of the *Ostrea thirsae* beds" are exposed, which consist of blue-gray clayey silt, marl, glauconitic sand, and indurated ledges of calcareous sandstone, fossiliferous throughout. The total thickness of these beds in the county ranges from 30 to 60 feet.

"The upper clay unit of the Nanafalia formation in Choctaw County attains a maximum thickness of 30 feet. This clay appears to thicken westward from the Tombigbee River. In the section just south of Tuckabum Creek, on the Pennington-Lavaca road in the eastern part of the county it is about 13 feet thick, is predominantly dark gray, and contains some streaks of fine glauconitic sand. The upper 5 feet of the clay unit is non-fossiliferous. The thickness of the clay was not measured in the north-central part of the county, but its surface is exposed in the bottom of Tuckabum Creek on Alabama Highway 29 and in places northwest to the Sumter County line. Westward the clay becomes less fossiferous."

History of usage: Present usage has followed Smith and Johnson's description with modifications. The Nanafalia formation of Smith (1886), Smith and Johnson (1887), and Smith, Johnson and Langdon (1894) consisted of three divisions: a lower or basal division of about 80 feet of sandy clay and cross-bedded glauconitic sand; a middle division, consisting of about 80 feet of yellow, reddish and whitish sands containing *Ostrea thirsae* Gabb; and an upper division consisting of 20 to 40 feet of gray to black clay and glauconitic sandy clay.

Brantly in 1920 (Brantly, 1920) subdivided the Nanafalia into three different phases, the lower being referred to as the Coal Bluff beds (now the upper member of the Naheola formation of Alabama), and the upper two phases were referred to as the Gullette Bluff beds.

Cooke (Cooke, 1933) in 1933 extended the Ackerman formation of Mississippi into Alabama to replace the Coal Bluff beds of Brantly, and restricted the Nanafalia formation to beds above the Coal Bluff.

MacNeil in 1946 (MacNeil, 1946b) reduced the Wilcox group in Mississippi to formational rank and made the Fearn Springs formation of Mellen its basal member. The Fearn Springs sand member was extended into Alabama and made the basal member of the Nanafalia formation of the Wilcox group in that State. Thus, he included in the base of the Nanafalia in Alabama (as the Fearn Springs sand member) the upper coarse sand of the Coal Bluff beds of Brantly. MacNeil divided the Nanafalia of western Alabama into two zones: a lower part consisting of loose to tough sand with ledges or concretionary zones of sandstone, commonly known as the *Ostrea thirsae* beds; and an upper zone which is predominantly sandstone, sandy claystone, and laminated clay, the Grampian Hills rock or "pseudobuhrstone" of Smith, Johnson, and Langdon. In a later paper in 1951, MacNeil (MacNeil, 1951) included in the Fearn Springs sand member in Mississippi the Betheden formation of Mellen because he was inclined to believe it to be early Wilcox in age rather than Midway. Earlier he had tentatively considered the Betheden-type sediments as the non-marine lateral equivalent of the Naheola formation of Midway age, but he stated even then, "it is possible that the Betheden is a swamp or lagoonal deposit of lower Wilcox age." (MacNeil, op. cit., p. 17.)

Areal extent: The Nanafalia formation crops out in a northwest to north trending belt through Kemper County (Plate 1). It extends in a southeasterly direction through northeastern Lauderdale County, Mississippi, thence into Sumter County, Alabama. Its width of outcrop varies along its strike from approximately 3.5 miles to as much as 10 miles or more. In Kemper County, as in western Alabama, the top of the Nanafalia formation is marked by a persistent silty clay shale which extends through the county and which the writer has seen in Legion State Park, Winston County, and has observed as far north as Reform in Choctaw County, Mississippi. In addition, a fossil print bed, in fine light olive gray sand, serves as an excellent horizon marker in southern Kemper County. No prints have been seen by the writer farther north than Sec.2, T.9 N., R.15 E., but on the basis of lithology the bed can be traced through the county. It extends in a southeasterly direction through northeastern Lauderdale County, where, in the northeast corner of Sec.14, T.7 N., R.18 E., it merges into a lower marl containing

Ostrea thirsae, and extends thence into Alabama where it is recognized as the *Ostrea thirsae* bearing sand. The Lauderdale County outcrop mentioned above is the farthest northern *Ostrea thirsae* bearing beds in Mississippi.

Thickness: The thickness of the Nanafalia formation in Kemper County, including the Fearn Springs member is approximately 230 feet. Above the Fearn Springs its thickness varies

Figure 38.—Irregular to coarsely cross-bedded sand and argillaceous silts with ferruginous layers of Nanafalia formation. State Highway 16, 1.8 miles west of junction of State Highway 397 (SE.¼, Sec.26, T.11 N., R.15 E.) Aug. 5, 1954.

from about 20 feet to about 130 feet. The Fearn Springs member at the base thickens and thins greatly along strike, its greatest thickness being about 85 feet in southern Kemper County.

Lithologic character: The Nanafalia formation in Kemper County consists in the main of silty clay and clay shale, fine olive colored sands and argillaceous fine sands containing clay blebs and stringers. The formation is strongly cross-bedded (Figure 38). The Fearn Springs sand member consists of two phases, a basal white to red, graveliferous coarse sand and an upper phase consisting of gray, laminated fine sand and silty clay. Clay-ball conglomerates composed of kaolin with coarse quartz grains scattered throughout the matrix are common in the Fearn Springs member. Locally bauxitic conglomerates are also found in the Fearn Springs. The only known deposit of bauxite in Kemper County is on the Pete Flora property, NW.¼, NW.¼, Sec.10, T.12 N., R.16 E. The laminated fine sands and clays at the top of the member are lens-like and many of these lenses pinch out in a single exposure. Thus it is difficult to map the contact of the Fearn Springs member with the Nanafalia proper above.

Fearn Springs sand member: The name Fearn Springs was assigned by Mellen (Mellen and McCutcheon, 1939) in 1939 to the laminated silty clays and sands which are exposed in a road cut west of the village of Fearn Springs.

Type locality: Road cut 0.25 mile west of the village of Fearn Springs, Winston County, Mississippi, NE.¼, Sec.3, T.13 N., R.14 E. As mentioned in the discussion of the Midway-Wilcox contact, the type section of the Fearn Springs has been the subject of much controversy and several papers appear in the literature, to which the reader is referred for details. It is not the intention of the present writer to criticize the work of others, but merely to set forth the opinions of others as interpreted by him. What is actually included in the Fearn Springs at the type locality has a definite bearing on the Midway- Wilcox contact throughout the state, as well as in Kemper County. A brief review of the disagreement is here presented.

The main controversy concerning stratigraphic relationships at the Fearn Springs type locality centered around two sands, one at the bottom of the hill, the other at the top. In his original description of the Fearn Springs, Mellen considered the sand at the base of the hill to be colluvium and not in place. The sand at the top of the hill he called "basal Ackerman sand." The sand at the bottom of the hill, beneath the laminated silty clay, is actually in place. As a result of Mellen's misconception that the lower sand was not in place there was an erroneous application of names. The basal sand of the Fearn Springs was called "basal Ackerman sand" elsewhere. MacNeil in 1951 (MacNeil, 1951) contended that the two sands are in place. He said,

"There are, therefore, two coarse sands, one below the silty clay phase of the Fearn Springs and the other above it. Mellen believes only one sand exists. This erroneous interpretation apparently led to the following misapplication of names.

"1. The sand in the lower part of the type exposure of the Fearn Springs, which Mellen believed to be colluvium, is in reality in place. In other exposures Mellen has termed this unit 'basal Ackerman sand.'

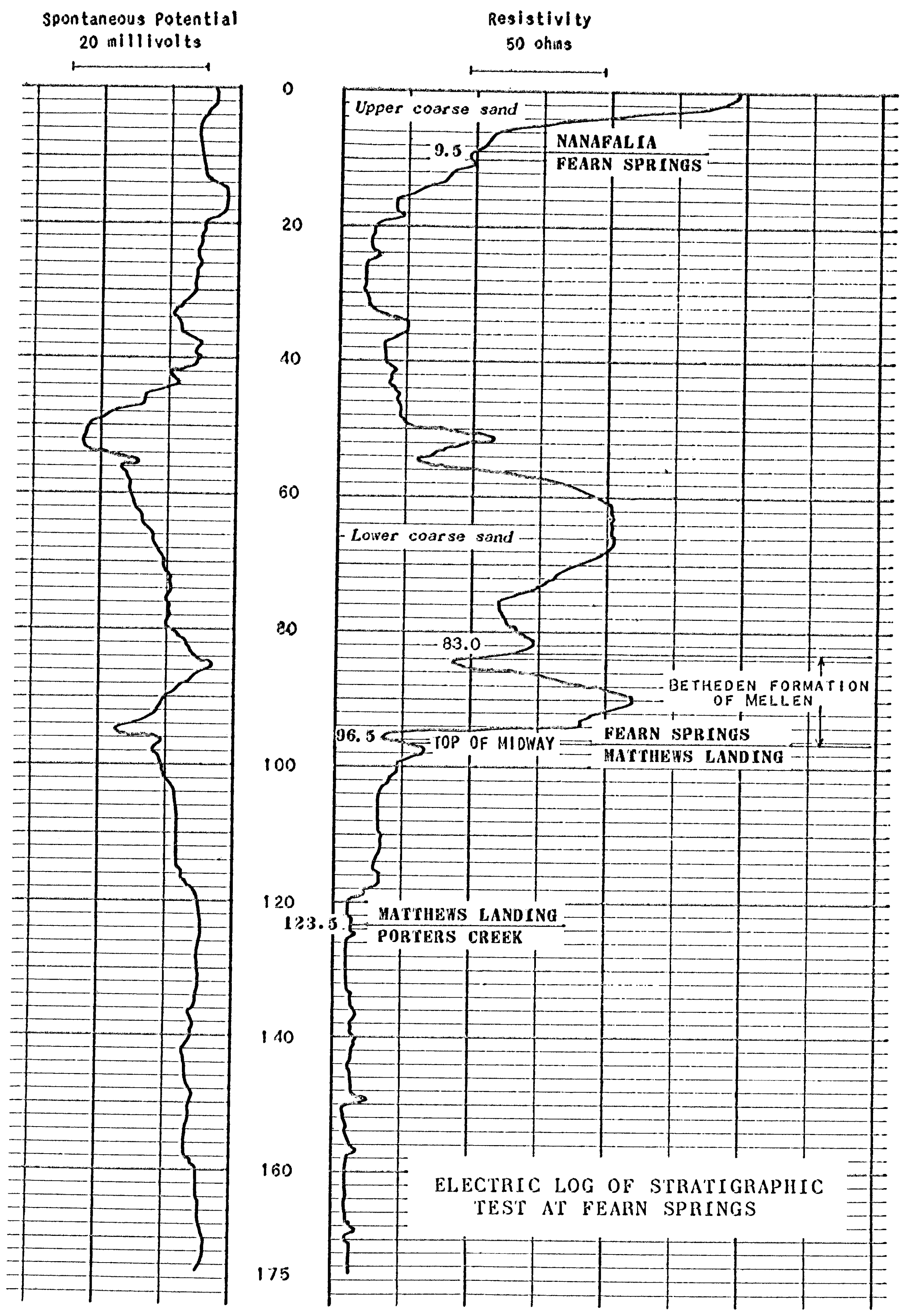
"2. The name Fearn Springs was applied to a part of the Naheola formation at the surface in Lauderdale and Kemper Counties, Mississippi (Foster, Bull. 41), and to the entire Naheola formation in the subsurface in both Alabama and Mississippi (Mellen, Bull. 69).

"3. The Naheola formation as used by Mellen in his subsurface diagrams (Bull. 69) includes mainly the 'Matthews Landing marl bed' of Smith and Johnson, a zone of fossiliferous greensand and clay that is now designated the Matthews Landing marl member of the Porters Creek clay by the United States Geological Survey. Mellen's Naheola may also include a few feet of marly or silty beds of the underlying clay member."

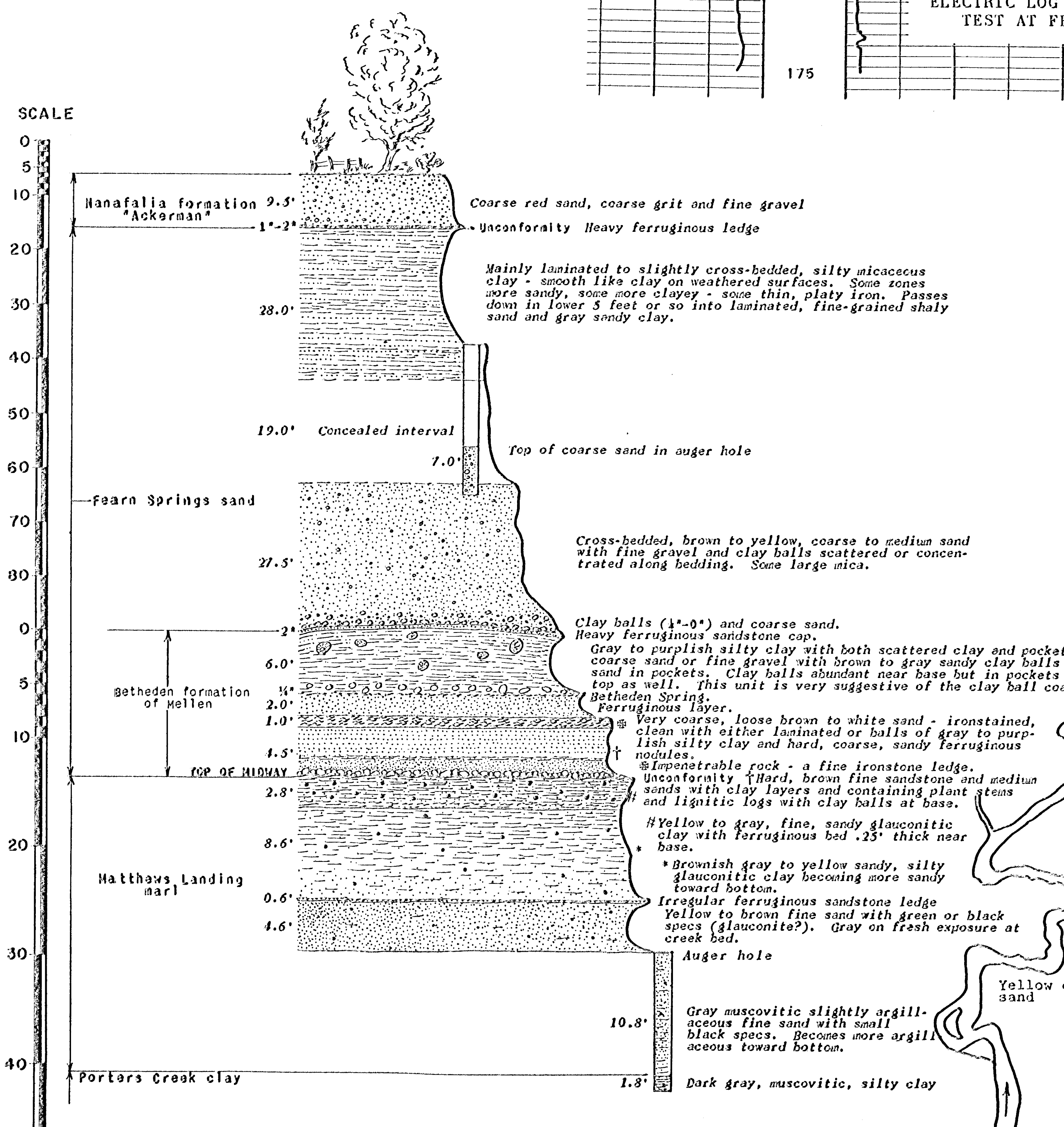
Figure 39.—Glauconitic clays and sands of Matthews Landing marl exposed on north wall of creek some 225 yards downstream from bridge at foot of hill at Fearn Springs, Winston County, Miss. (NE.¼, Sec.3, T.13 N., R.14 E.) Mar. 15, 1958.

The writer of the present report drilled a stratigraphic test just north of the road at the type locality, spudding in in the upper coarse sand at the top of the hill, and drilling to a depth of 175 feet, well into the Porters Creek clay. A second sand was encountered below the laminated clays and was found to be fresh, unweathered, and in place. The electric log shows that there is no doubt as to the existence of the lower sand.

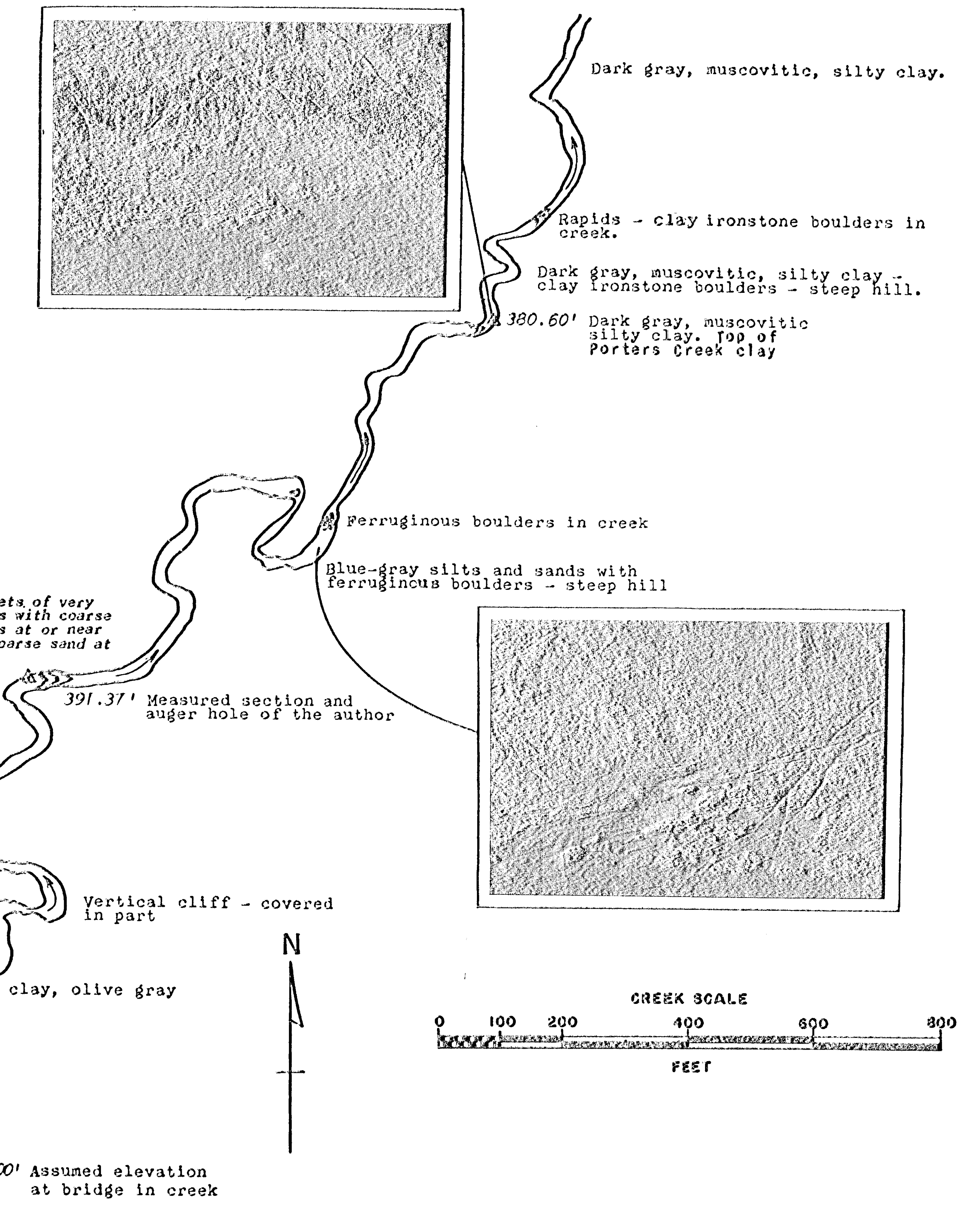
Poor exposures of glauconitic clays at about creek level at the bridge necessitated further investigation in an attempt to get a



ELECTRIC LOG OF STRATIGRAPHIC TEST AT FEARN SPRINGS



Section of Nanafalia, Fearn Springs sand, Matthews Landing marl and Porters Creek clay approximately 0.3 mile west of Fearn Springs, Winston County (NE.¼, Sec. 3, T.13 N., R.14 E.). *(After F. S. MacNeil to top of Midway. Remaining section is that of the author).*



more complete section below the lower sand. Two hundred yards or so downstream from the bridge the creek in its sinuous winding has cut into the side of a hill exposing an excellent section of fine glauconitic sands and clays (Figure 39). Further downstream were more exposures and an almost complete section to the top of the Porters Creek clay can be seen. A plane table survey of the creek was made and outcrops noted. The complete section at Fearn Springs, the creek survey and the electric log of the drilled hole appear as Plate 9.

The writer then carefully traced the Fearn Springs and "Ackerman" south from the Fearn Springs type locality into Kemper County, through that county into Lauderdale County, and into western Alabama, where it had been mapped as the Fearn Springs sand member of the Nanafalia formation by some geologists.

The Fearn Springs sand member of the Nanafalia formation is well developed south of the type locality in Winston, Noxubee, and Kemper Counties where it thickens and thins greatly along strike.

In southern Noxubee County, near the Hubbard bauxite, east of Center of Sec.8, T.13 N., R.15 E., there is an excellent section of Fearn Springs and the overlying Nanafalia formation. Here the Fearn Springs is 83.2 feet thick. It lies disconformably on the glauconitic clays of the Midway group.

SECTION (EAST OF CENTER, SEC.8, T.13 N., R.15 E.) OF ROAD CUTS, AUGER HOLES AND EXPOSURES ALONG CREEK SOUTH OF ROAD NEAR W. H. HUBBARD SR. BAUXITE. (AFTER F. S. MACNEIL)

	Feet	Feet
Nanafalia formation		50.0+
14. Medium red and yellow sand, forming deep gullies	50.0+	
Fearn Springs sand member		83.2
13. Tough fine grained mottled brown to gray and purple clayey sand	26.0+	
12. Red micaceous medium fine sand with thin ferruginous sandstone at top and bottom	2.0	
11. Tough gray, iron-stained sandy clay, slightly pisolitic in lower part, sublaminated above	10.0±	
Auger hole		
10. Hard bauxite	8.0	
9. Tough gray clay	2.0	

8. Gray to iron-stained mealy clay, pisolitic, not apparent in cuttings. Some scattered coarse white sand grading to dry, tough micaceous gray looking sand with a small black mineral	10.0	
7. Becoming fine sandy at 10.0 feet (slightly tough clayey, very micaceous fine gray sand)	2.0	
6. Hard rock, ferruginous sandstone	0.5	
5. Hard fine ferruginous sandstone ledge	0.5	
4. Coarse grained sand	20.0	
Exposures in creek		
3. Coarse brown gravelly sand	2.0	
2. Heavy ferruginous sandstone ledge with pea or larger gravel in it	0.2±	
Midway (Naheola ?)		10.0
1. Dark gray micaceous sand and glauconitic clay	10.0	
Total section		143.2

In northern Kemper County the Fearn Springs varies in thickness from approximately 25 feet in the Flora bauxite area to 60 feet elsewhere. In the southeastern part of the county the basal sands of the member reach their greatest thickness as channel deposits. Thicknesses of as much as 85 feet were measured in gullies and road cuts in and around the village of Oak Grove, Sec.33, T.10 N., R.17 E.

The Fearn Springs-Nanafalia contact is exposed about 2 miles south of Kellis Store, NE.¼, Sec.34, T.12 N., R.15 E. Here the coarse red sands of the basal Nanafalia overlie the gray laminated clays of the upper Fearn Springs. Pisolitic clays (Figure 40) with large quartz grains in the matrix can be seen at this locality. The clays here are approximately 145 feet lower than those at the Flora bauxite mine.

SECTION (NE.¼, SEC.34, T.12 N., R.15 E.) ON ROAD 1.75 MILES SOUTHEAST OF KELLIS STORE.

	Feet	Feet
Top soil		1.0
8. Buff, fine sandy, silty top soil	1.0	
Nanafalia formation		62.9
7. Red brown coarse sand containing platy limonite	23.0	
6. Brown soft coarse sand with platy zone at bottom	3.0	
Unconformity		
Fearn Springs sand member		
5. Gray slightly silty plastic muscovitic clay	9.5	
4. Light gray clay, pisolitic toward bottom and having much sand (large quartz grains) in matrix	7.2	

3. White pisolitic clay (kaolinitic), very sandy at base	7.0	
2. Hard brown ferruginous sandstone with clay balls in upper part	2.2	
1. Brown to tan (weathered in places) coarse, muscovitic sand	11.0	
Total section		63.9

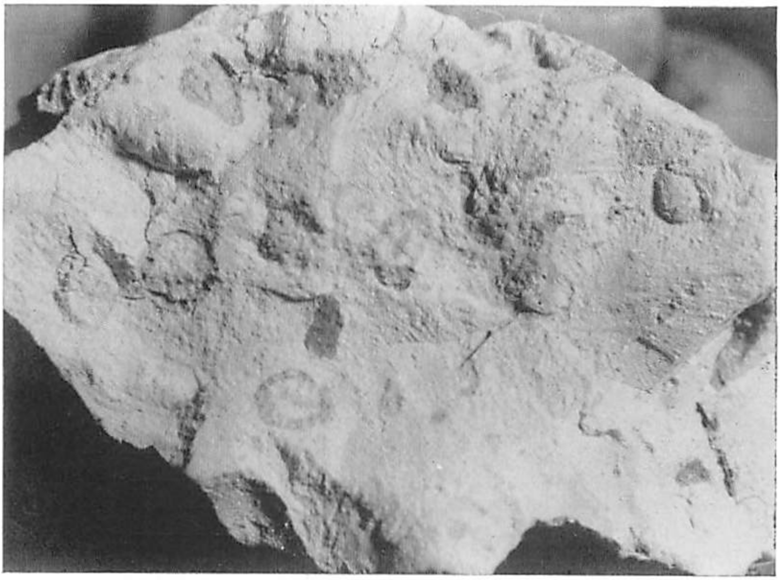


Figure 40.—Pisolitic clay of Fearn Springs sand. Kaolinitic matrix contains coarse quartz sand. Two miles south of Kellis Store, (NE.¼, Sec.34, T.12 N., R. 15 E.)

On State Highway 39 about a mile north of DeKalb the Fearn Springs is again exposed. The basal sand rests on the Naheola formation and the upper silty clay phase is overlain disconformably by the basal sand of the Nanafalia formation. The section has been described under the heading Naheola formation.

Southwest of the city limits of DeKalb on a road to Moscow the Fearn Springs-Nanafalia contact is well exposed. The basal sands of the Fearn Springs sand member here are 33.6 feet thick and are overlain by 14.7 feet of gray laminated silty clays and sands. The contact with the overlying Nanafalia is sharp and marked by a zone of clay pebble conglomerate admixed with sand, the thickness of which varies from 0.5 foot to 2.0 feet.

In the Oak Grove locality is a very thick sand section in a deep gully. The section consists of two sands, and the contact between the two is not sharp (Plate 7-2). It is the writer's opinion that the greater part of the section is Fearn Springs, approximately 15 feet of the upper sand being Nanafalia. The Midway-Wilcox contact is well exposed here.

SECTION (NE.¼, SEC.33, T.10 N., R.17 E.) IN A LARGE GULLY 0.2 MILE EAST OF OAK GROVE.

	Feet	Feet
Top soil		2.0±
15. Buff to tan top soil		2.0±
Nanafalia formation		101.8
14. Brown, very coarse sand with pea gravel	15.4	
Fearn Springs sand member		
13. White to yellow to brown slightly cross-bedded muscovitic (large flakes) medium to coarse sand	85.0	
12. Brown, hard platy limonite ledge	1.0	
11. Brown plastic clay with streaks of lignite	0.4	
Unconformity		
Naheola formation		43.0
10. Lignite; dips 3° SW.	1.0	
9. Dark gray lignitic clay	0.3	
8. Lignite	0.4	
7. Dark gray lignitic clay	1.1	
6. Light brown sandy silty muscovitic clay	0.7	
5. Brown soft, muscovitic, ferruginous sand	0.5	
4. White to yellow to light brown, muscovitic slightly cross-bedded fine to medium sand with gray and pinkish streaks along cross-laminations	15.0	
3. Yellow muscovitic fine sand with some purplish zones (auger hole)	12.0	
2. Dark, silty plastic clay with coarse sand streaks (auger hole)	10.0	
1. Yellow-brown iron-stained, muscovitic, fine to medium sand (auger hole)	2.0	
Total section		146.8

A third section (Plate 7-3) in the Oak Grove area is along an abandoned road approximately 0.1 mile east of Oak Grove (NE.¼, Sec.33, T.10 N., R.17 E., and SE.¼, Sec.27, T.10 N., R.17 E.). The large sand section is probably Fearn Springs and Nanafalia. Doubtful contacts were not shown.

The Midway-Wilcox contact may also be seen on U. S. Highway 45 approximately 2.0 miles north of the Kemper-Lauderdale County line. Here the laminated silty clays above the grit and

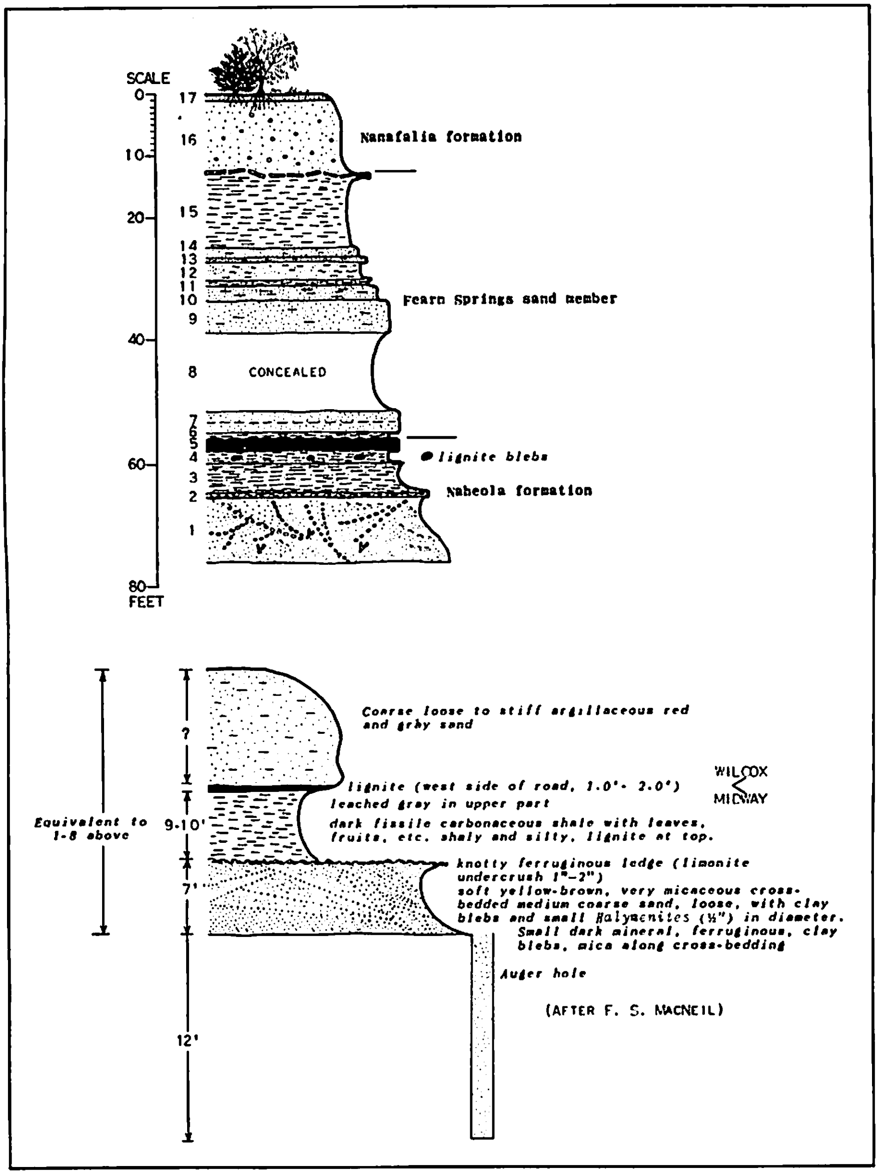


Figure 41.—Midway-Wilcox contact. U. S. Highway 45, 2.0 to 2.3 miles north of Kemper-Lauderdale County line (W. ½, Sec.19, T.9 N., R.18 E.).

pea gravel of the basal Fearn Springs are represented (Figure 41). The coarse sands of the Fearn Springs lie with sharp contact on the Naheola formation, the two being separated by a lignite seam approximately 2.0 feet in thickness. The lignite grades down to a dark gray lignitic plastic clay which can be examined just across the highway. The clay contains leaf impressions, fruits and seeds. The collection made here was taken to Washington, D. C., to the U. S. National Museum for possible identification. Roland W. Brown showed the writer much better specimens of the same leaves, and it is Brown's opinion that they are of Midway age.

The complete section including road cut to the north on the east side of the road, just north of an east-west road, is as follows:

SECTION (W.½, SEC.19, T.9 N., R.18 E.) ON U. S. HIGHWAY 45, 2.0 TO 2.3 MILES NORTH OF KEMPER-LAUDERDALE COUNTY LINE.

	Feet	Feet
Top soil		1.0
17. Buff fine sandy, silty top soil	1.0	
Nanafalia formation (?)		54.7
16. Light to red brown coarse-grained sand containing pea gravel and with a wavy limonitic layer 0.2 foot in thickness at base	12.0	
Unconformity		
Fearn Springs sand member		
15. Gray massive slightly muscovitic clay-shale fissile	12.0	
14. Light gray very muscovitic silt and interbedded yellow brown muscovitic medium sand	1.6	
13. Light gray muscovitic fine sand and yellow brown clay with thin limonite partings	0.6	
12. Light yellow indistinctly cross-bedded medium sand and light brown plastic clay with numerous thin limonite partings	3.0	
11. Yellow gray slightly silty muscovitic clay	0.9	
10. Light to dark gray argillaceous muscovitic silt	2.5	
9. Light gray to yellowish brown muscovitic fine- to medium-grained sand, slightly argillaceous	5.4	
8. Covered interval	12.7	
7. Interbedded yellow to brown muscovitic medium sand and gray plastic clay	3.3	
6. Light, gray-brown plastic clay	0.7	
Unconformity		
Naheola formation		20.4
5. Lignite seam	2.2	

4. Dark gray carbonaceous clay, shaly and silty containing seeds, fruit and leaf impressions	2.0	
3. Gray silty clay containing plant stems and leaf impressions	5.0	
2. Irregular ferruginous bed with hard platy limonite beneath	0.2	
1. Yellow brown highly muscovitic (large flakes) cross bedded fine to coarse sand with muscovite, clay blebs and soft platy limonite concentrated along cross laminations and containing *Halymenites major* Lesquereux	11.0	
Total section		76.1

On an east-west road approximately 0.25 mile west of U. S. Highway 45 (SE.¼, NE.¼, Sec.36, T.9 N., R.17 E.) the writer measured 55.0 feet of brown coarse, cross-bedded graveliferous sand lying unconformably on the yellowish-gray massive clays of the Naheola formation. Beneath the massive clays is a lignite seam as in the section on U. S. Highway 45 described above.

The lignite bed is generally persistent at the Midway-Wilcox contact, and the differentiation of formations belonging to these two groups is not too difficult where it is present. The laminated silty clays of the upper part of the Fearn Springs are not everywhere present, however, and where they are absent it is impossible to separate the basal sand of the Nanafalia from the basal sand of the Fearn Springs member.

Nanafalia formation: The Nanafalia formation in Kemper County has a tri-part division. The lower division, the Fearn Springs sand member, discussed above, consists primarily of coarse, cross-bedded sand containing fine gravel and clay balls, and laminated silty micaceous clay and fine sand. The middle division of the Nanafalia, correlated with the *Ostrea thirsae* beds of western Alabama, is characterized by coarse red and white sands, gray shaly clays and firm olive gray to yellow sand containing numerous fossil prints. The upper division, consists of gray massive blocky silt and clay.

The coarse red sands forming the basal part of the middle division are well exposed in several localities. Approximately two miles south of Kellis Store, in the NE.¼, Sec.34, T.12 N., R.15 E., the sands are prominent. Just north of DeKalb on State Highway 39 they may be seen resting on the Fearn Springs clays. Also, southeast of DeKalb near the village of Oak Grove they are well exposed.

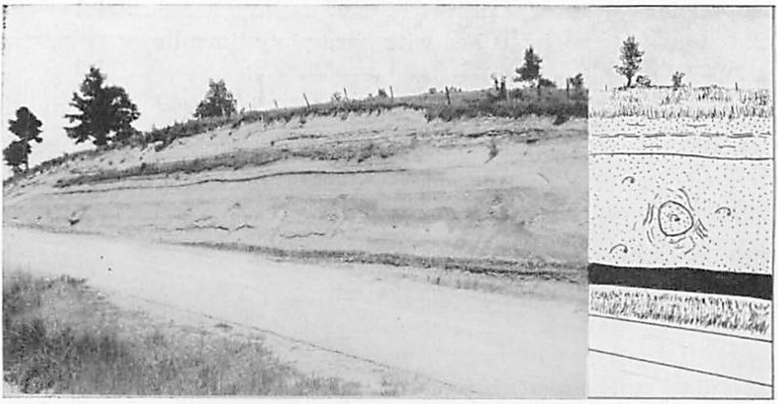


Figure 42.—Fossil print bed of middle Nanafalia age in light olive-gray fine sands. Four-tenths mile north of Kemper-Lauderdale County line on State Highway 39. (SE.¼, Sec.32, T.9 N., R.16 E.) Aug. 23, 1955.

Figure 43.—Close-up of ferruginous boulder in bed of light olive-gray fine sand on State Highway 39. (SE.¼, Sec.32, T.9 N., R.16 E.) June 21, 1955.

The light olive gray sands containing fossil prints are beautifully exposed in a road cut on State Highway 39 approximately half a mile north of the Kemper-Lauderdale County line (Figure 42). The sands contain ferruginous boulders which also are fossiliferous (Figure 43). Approximately 0.6 mile north of this locality, on the same highway one of the ferruginous concretions was found to be 12 feet in its longest dimension (Figure 44).

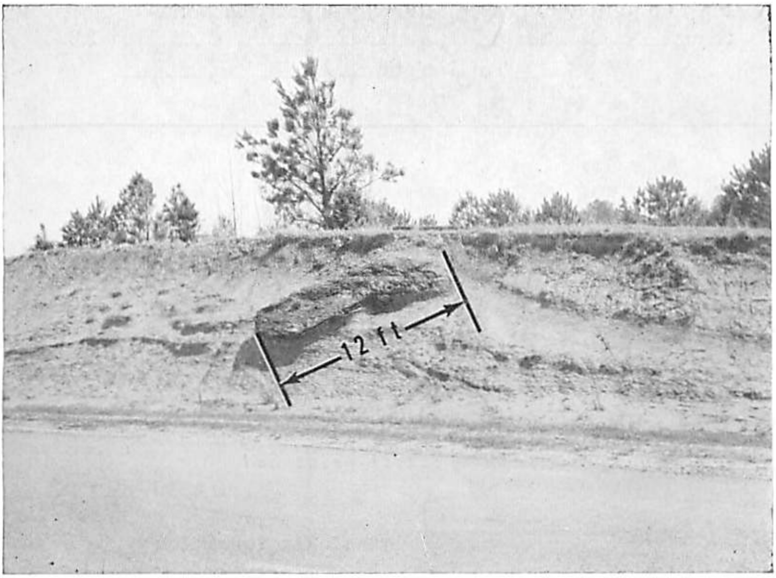


Figure 44.—Ferruginous boulder containing fossil prints of Middle Nanafalia age. State Highway 39. (SE.¼, Sec.29, T.9 N., R.16 E.) Apr. 6, 1958.

SECTION (SE.¼, SEC.32, T.9 N., R.16 E.) ON STATE HIGHWAY 39, 0.4 MILE NORTH OF KEMPER-LAUDERDALE COUNTY LINE.

	Feet	Feet
Top soil		2.7
10. Buff, fine silty top soil	2.7	
Nanafalia formation		32.2
9. Tan to brown fine to medium muscovitic sand with thin platy limonite partings in lower foot and containing *Halymenites major* Lesquereux	7.4	
8. Light brown and yellow mottled argillaceous muscovitic sand. Dark gray carbonaceous clay at base	2.3	
7. Massive olive gray fine sand containing fossil prints of the genus *Venericardia* and ferruginous boulders with fossil prints	12.8	
6. Lignite	1.4	
5. Dark gray carbonaceous silty clay	0.8	
4. Gray massive firm muscovitic (large flakes) argillaceous fine sand containing limonite tubes and veinlets	3.7	
3. Thin lignite	0.5	
2. Dark-gray carbonaceous plastic, stiff, slightly muscovitic clay	0.7	

1. Mottled yellow to gray plastic clay slightly carbonaceous	2.6	
Total section		34.9

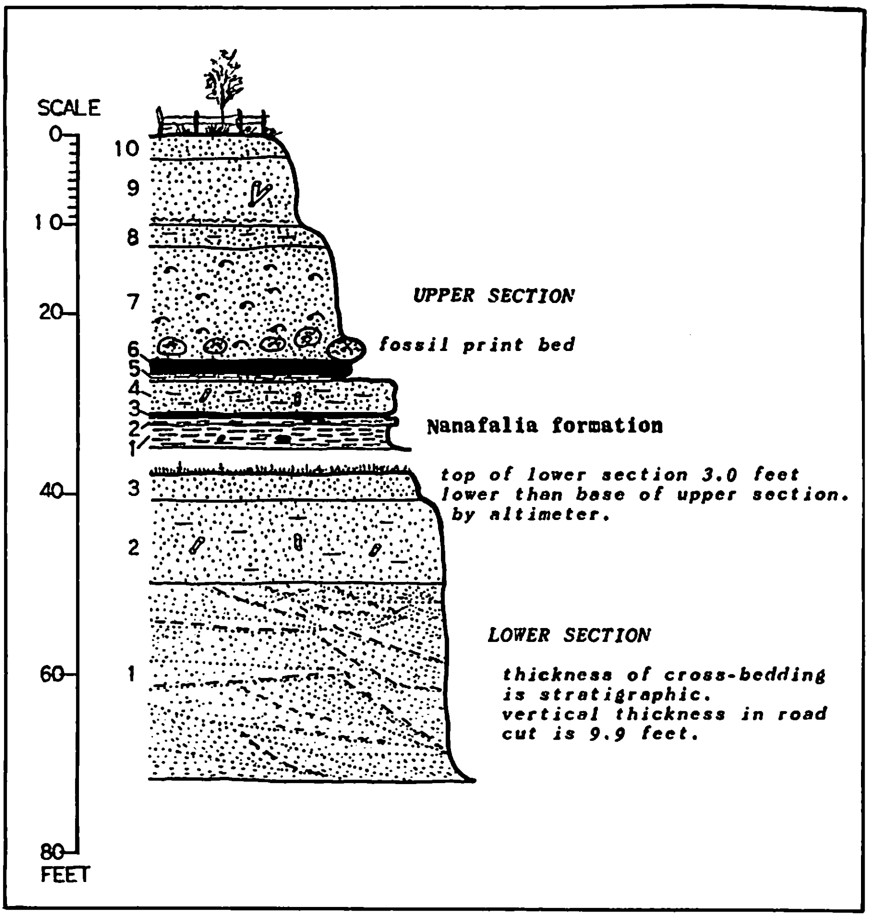


Figure 45.—Section of Middle Nanafalia formation on State Highway 39, 0.2 to 0.4 mile north of Kemper-Lauderdale County line (SE.¼, Sec.32, T.9 N., R.16 E.).

Approximately 0.2 mile south of the above section are coarsely cross-bedded sands and clays. The top of the section here is approximately 3 feet lower by altimeter than the section just north. The complete section is shown in Figure 45.

SECTION ON STATE HIGHWAY 39, 0.2 MILE NORTH OF KEMPER-LAUDERDALE COUNTY LINE.

	Feet	Feet
Nanafalia formation		34.1
3. Fine brown muscovitic sand—colluvium	3.0±	
2. Fine brown muscovitic sand containing flaky gray clay inclusions and ferruginous tubes	9.1	
1. Coarsely cross-bedded gray to brown muscovitic sand and gray muscovitic argillaceous fine sand containing limonite partings and nodules. Dip 4° to 6° S. Upper 10 to 15 feet more thinly laminated. Limonite tubes and irregular masses in upper 5 feet	22.0	
Total section		34.1

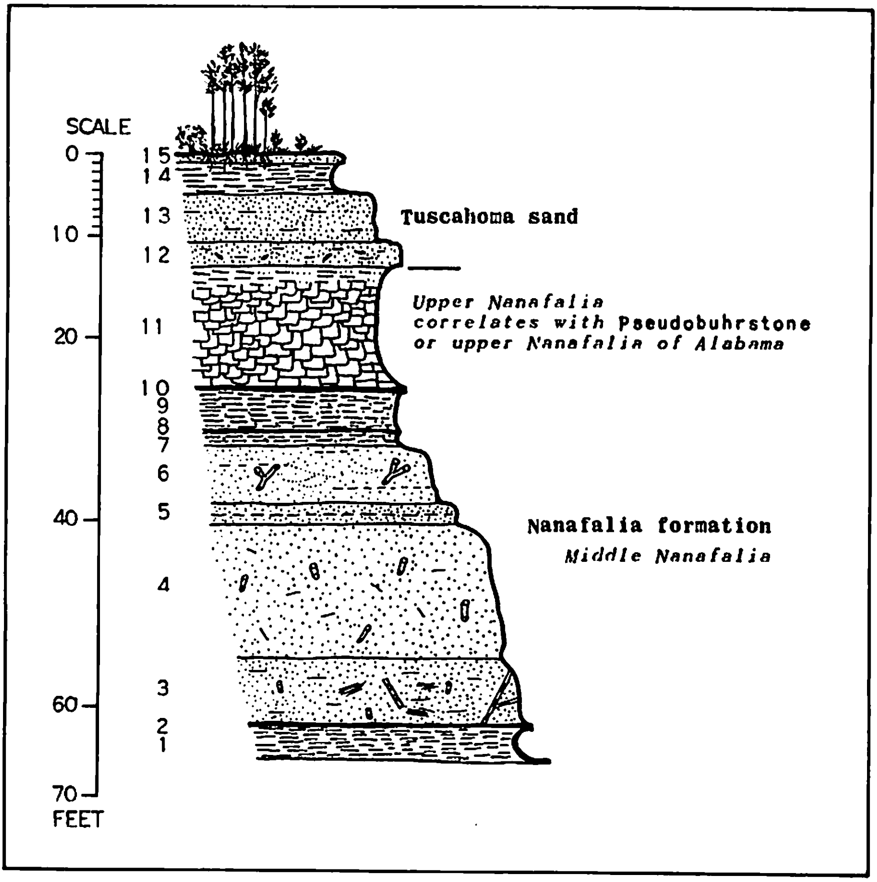


Figure 46.—Section of Middle and Upper Nanafalia formation on an east-west road just east of village of Liberty (NW.¼, NW.¼, Sec.2, T.9 N., R.15 E.).

Massive to slightly cross-bedded olive-gray fine sands containing limonite tubes can be easily traced through the county. In most exposures they are overlain by the gray massive blocky silts and clays which mark the top of the Nanafalia in Kemper County.

The gray blocky silts or silty clays are very well exposed (NW.¼, NW.¼, Sec.2, T.9 N., R.15 E.) on an east-west road, just east of the village of Liberty (Figure 46).

SECTION (NW.¼, NW.¼, SEC.2, T.9 N., R.15 E.) ON EAST-WEST ROAD 1.0 MILE EAST OF LIBERTY.

	Feet	Feet
Top soil		1.0
15. Buff, silty top soil	1.0	
Tuscahoma sand		11.5
14. Red brown clay, weathered	3.2	
13. Interlaminated yellow to brown fine sand and gray muscovitic argillaceous silt	5.4	
12. Yellow to brown slightly argillaceous finely muscovitic fine sand with carbonaceous specks	2.9	
Nanafalia formation		53.3
11. Light to dark gray blocky argillaceous silt or silty clay slightly laminated in upper part	13.0	
10. Lignite bed	0.1	
9. Yellow brown to gray silty clay	4.4	
8. Lignite bed	0.1	
7. Yellow-brown to gray silty clay	1.5	
6. Variegated yellow to brown to red slightly cross-bedded muscovitic fine sand with streaks of gray clay, and containing *Halymenites major* Lesquereux throughout	6.4	
5. Laminated light brown to olive gray muscovitic sand and gray clay	2.6	
4. Massive olive-gray and yellow fine sand with irregular gray clay inclusions and limonite tubes (better exposed east of creek)	14.2	
3. Slightly laminated olive-gray argillaceous muscovitic (large flakes) fine sand with shaly to irregular carbonaceous clay inclusions and limonite veinlets and tubes	7.3	
2. Lignite streak	0.3	
1. Mottled red-brown and gray finely muscovitic, slightly silty plastic clay	3.4	
Total section		65.8

The dark clays which commonly mark the top of the Nanafalia formation are exposed at an intersection of a north-south road with State Highway 16, approximately 4.3 miles west of the junction of State Highway 16 with State Highway 397 (Figure 47).

About 2 miles north of this outcrop, the massive olive-gray sands are also well exposed (south of Center, Sec.20, T.11 N., R.15 E.)

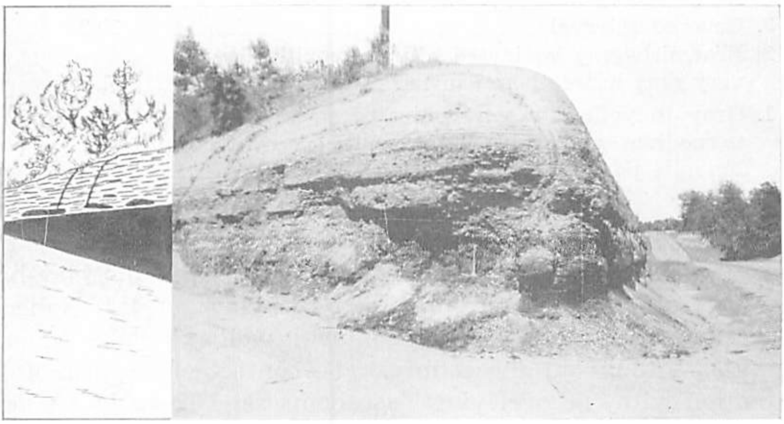


Figure 47.—Gray clays and lignite marking top of Nanafalia formation. State Highway 16, 4.3 miles west of junction with State Highway 397. (SE.¼, NW.¼, Sec.33, T.11 N., R.15 E.) Aug. 5, 1954.

SECTION (SOUTH OF CENTER, SEC.20, T.11 N., R.15 E.) ON EAST-WEST ROAD 3 MILES WEST OF MISSISSIPPI STATE HIGHWAY 397 AT BLOOMFIELD.

	Feet	Feet
Tuscahoma formation (?)		8.9
15. Olive-gray to mottled yellowish-brown massive to slightly laminated finely muscovitic, slightly argillaceous fine sand containing limonite tubes and platy limonite	8.9	
Nanafalia formation		55.0
14. Thin lignite streak	0.2	
13. Gray to yellow muscovitic silty clay with thin platy limonite partings	1.2	
12. Gray to yellow slightly argillaceous finely muscovitic very fine sand	0.6	
11. Thin, platy limonite parting, botryoidal on surface ½ inch		
10. Yellowish-brown massive, muscovitic fine sand	1.1	
9. Gray to brown laminated muscovitic argillaceous fine sand, including several platy limonite partings at top. Small *Halymenites*-like tubes at base	2.5	

8. Thin platy limonite parting ½ inch		
7. Brownish-gray to gray slightly silty finely muscovitic fissile shale, flaky on surface	6.9	
6. Thin limonite parting ½ inch		
5. Olive-gray mottled yellow very finely muscovitic argillaceous fine sand	2.8	
4. Buff to reddish fissile shale (may be slumped from above)	3.0	
Nos. 3 to 1 continue around curve to bottom of hill		
3. Covered interval	10.9	
2. Brownish-gray laminated silty muscovitic clay; silvery gray in weathered surface	11.9	
1. Gray to yellow-brown laminated muscovitic fine to medium sand and gray muscovitic clay with thin limonite partings	13.9	
Total section		63.9

Stratigraphic relations: The coarse, gravelly sands of the Fearn Springs sand member containing clay balls and clay-ball conglomerate lie disconformably on the clays of the Naheola formation. The Midway-Wilcox contact is well exposed at several localities throughout the county. The contact of the Nanafalia formation with the overlying Tuscahoma sand is distinct where unweathered. The contact is picked at the top of the persistent gray clay-shales and silts which are overlain by olive-gray fine sands of the Tuscahoma ranging in thickness from 2.9 feet to 8.9 feet or more.

Physiographic expression. Some of the most rugged topography in Kemper County is that underlain by the sands of the Nanafalia formation and the basal Fearn Springs sand member. The physiographic province to which the formations of the Wilcox group belong is the North Central Hills, the Red Hills phase. It is in the eastern part of this physiographic province that the topography becomes very hilly and rough, forming the Wilcox cuesta. The highland or hill area is continuous and rugged to the west through the county, interrupted only by the broad flats of the major streams. Streams have cut valleys into these sediments to depths of 100 to 200 feet below the tops of the ridges.

Paleontology. The Nanafalia formation is unfossiliferous in Kemper County with the exception of a fossil-print bed which is correlated with the *Ostrea thirsae* Gabb beds (middle Nanafalia) of Alabama. The bed is well exposed in the southern part of the county and maintains its lithologic identity through the county and is unfossiliferous north of Sec.2, T.9 N., R.15 E. Prints from this bed are pelecypods, in the main of the heterodent genus *Venericardia,* but lack of morphological characteristics makes identification somewhat uncertain. The species probably

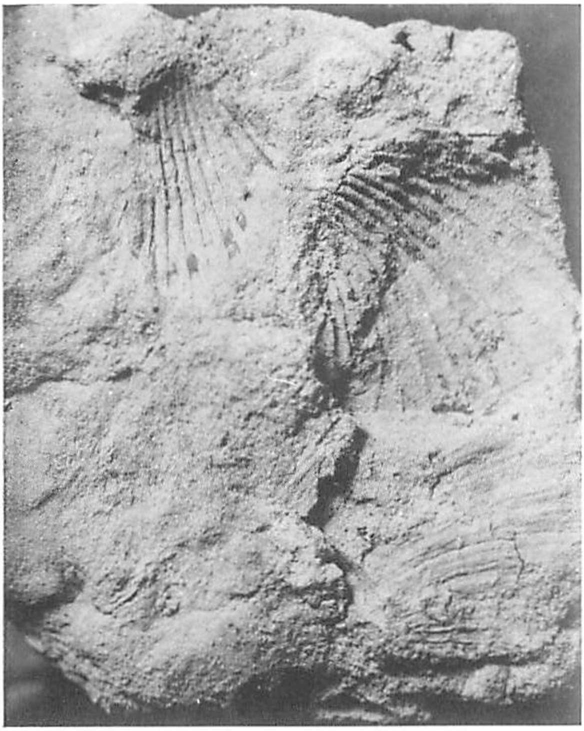


Figure 48.—Pelecypod prints of the genus Venericardia. Fossil print bed, Middle Nanafalia. State Highway 39. (SE. 1/4, Sec.32, T.9 N., R.16 E.) Apr. 6, 1958.

is *planicosta. Venericardia planicosta* (Lamarck) is considered a world-wide index fossil of the Eocene. In addition to this well known fossil the writer has questionably identified an inequivalved desmodont of the genus *Corbula.* Identification as to species is uncertain. Figure 48 is a photograph of the olive-gray glauconitic fine sand showing fossil prints. *Halymenites major* Lesquereux is also found in the sands of the Nanafalia formation. Figure 49 shows the marine borer.

Age and correlation. The Nanafalia formation and its Fearn Springs sand member in Kemper County are early Wilcox in age and correlate with the Nanafalia of Alabama. The threefold subdivision is essentially the same as that in Alabama. It is correlated with the Marthaville formation of Louisiana and the Caldwell Knob member of the Seguin formation in Texas. The Nanafalia is the equivalent of part of the Ypresian substage of the European classification. Exact correlation with European stages is merely suggested.

Figure 49.—Halymenites major Lesquereux in road cut just east of Liberty. Nanafalia formation. (NW.¼, NW.¼, Sec.2, T.9 N., R.15 E.) April 6, 1958.

TUSCAHOMA SAND

First reference: E. A. Smith, 1888 (Smith, 1888)

Nomenclator: E. A. Smith, 1894 (Smith, Johnson, and Langdon, 1894)

Priority: Bells Landing series (also called Bells Landing formation) has one year's priority over Tuscahoma (Smith and Johnson, 1887). The Bells Landing series was replaced by Tuscahoma sand which was a better established name.

Type locality: Tuscahoma Landing, on the Tombigbee River in NE.¼, Sec.31, T.13 N., R.1 W., Choctaw County, Alabama.

Original description: The description quoted below from U. S. Geological Survey Bull. 43, pp. 46-47 and p. 50 as Bells Landing series is identical with that appearing as the Tuscahoma or Bells Landing series in Alabama Special Report 6, pp. 162-163 and p. 167. (Smith, Johnson, and Langdon, 1894.)

"This series includes two important fossiliferous beds, separated by about twenty-five feet of gray, sandy clays. Between the lignite, which forms the base of the preceding division, and the upper marl of this series there are some forty feet of reddish sands and laminated, gray, sandy clays, and below the lower marl about sixty feet of sandy clays of the prevailing gray color, rather massive in the lower part. About fifty feet below the lower of the two marl beds, and ten feet above the base of this series, there is a third small greensand bed one foot or less in thickness containing fossils. The entire series comprises about one hundred and forty feet of strata, which, as a whole, are gray, sandy clays, becoming more and more massive toward the base, while they are more thinly laminated and more mixed with sands near the summit of the section. The strata which lie between the Wood's Bluff marl and the uppermost of this series are about sixty feet of sandy clays, containing several thin seams of lignite, all of which are exhibited in direct superposition at Yellow Bluff, and have been placed, as shown above, with the Wood's Bluff series. The upper marl bed, which is the Bell's Landing marl bed proper, is some ten feet thick, contains greensand, and indurates into bowlders, fine examples of which are to be seen at the base of the bluff at Bell's Landing. This marl is characterized above all others in the Tertiary of Alabama by containing gigantic specimens of shells which at other localities are of moderate size. The lower bed, known as the Gregg's Landing marl from its occurrence at the landing of that name, is four or five feet in thickness and is of clayey material. It has a peculiar group of fossils.

The fossil bearing beds of this series are best exposed along the banks of the Alabama River at Bell's Landing, Gregg's Landing, Peeble's Landing, Lower Peach Tree, and Yellow Bluff; and on the Tombigbee at Tuscahoma, Turner's Ferry, near the mouth of Shuquabowa Creek, and at Barney's Upper Landing. The exposures on the Alabama are much more satisfactory.

"Unlike the Wood's Bluff marl, the marls of this series make comparatively little show inland from the rivers and exercise little, if any, influence upon either the soils or the topography of the country in which they come to the surface. I am not certain that either the Bell's Landing marl or the Gregg's Landing marl has been identified at any distance from the rivers, while the Wood's Bluff marl can be followed with ease from the Mississippi line as far eastward as we have been."

"Section at Tuscahoma, Tombigbee River

"1. Indurated sand with a line of bowlders at the base. This stratum is eight to ten feet thick at the warehouse, but down the river it thickens to twenty feet or more, and a second line of ferruginous, indurated bowlders appears about ten feet above the first. The strata above this upper string of bowlders are more distinctly laminated and inter-bedded with thin sheets of clay. This is most clearly shown about six to eight feet above the upper line of bowlders. Taken all together there are .... about 30 feet

2. Light bluish gray, sandy clays, which are somewhat striped with harder projecting seams......35 to 40 feet
3. Sandy marl, containing the Bell's Landing fossils, but in badly preserved condition......2 feet
4. Dark blue, massive clay......3 to 4 feet
5. Thin streak of greensand, with *Venericardia planicosta* and other Bell's Landing fossils to water level......6 inches or more."

Other descriptions: Brantly (Brantly, 1920) refers to the Tuscahoma as the Tuscahoma or Bell's Landing formation as consisting of 150 to 200 feet of sands, sandy clays, laminated clays and fossiliferous greensand marls. On page 153 he mentions the contact of the Tuscahoma with the underlying Nanafalia formation in which he says, "On Geneva Hill, 8 miles southeast of Rembert on the Rembert-Nanafalia road, the Nanafalia is overlain for (by) 20 feet of unconsolidated massive to cross-bedded white to banded yellow sands with a few streaks of black sand. Above this are 18 feet of massive greenish argillaceous sand which is in turn overlain by Lafayette sand and gravel."

Cooke in 1926 (Cooke, 1926a) describes the Tuscahoma formation as "chiefly very fine, soft, laminated sand in which the clay appears as thin partings." He mentions the two marl beds, the upper, "herein designated as the Bells Landing marl member, tends to harden into large nodular masses of sandstone or marlstone, but the lower, or Greggs Landing marl member, more commonly contains an indurated ledge. At several places in the lower part of the formation large angular masses of laminated gray sand and massive gray clay are tilted in all directions and embedded in fine glauconitic orange sand."

MacNeil (op. cit., pp. 20-21) describes the Tuscahoma sand as being non-fossiliferous, fine, firm gray to olive sand and dark shale, with loose, white to yellow sands, and some lignite locally. He mentions the Bells Landing and Greggs Landing marl members. Of the basal beds he writes, "The basal beds of the Tuscahoma sand vary greatly. At many places in eastern Alabama they are coarse, gravelly, and glauconitic, and locally they carry a few Greggs Landing fossils. To the west they are finer-grained, sometimes thinly laminated and shaly, but more often massive and firm with more or less abundant shale. In central Marengo County, Ala., near Sweetwater, there is over 60 feet of loose white sand at the base of the Tuscahoma."

The Tuscahoma sand is described in the Guide Book, Tenth Field Trip of the Mississippi Geological Society, Midway and Wilcox Groups, West Central Alabama, September 24-26, 1953, as consisting mainly of about 350 feet of laminated fine sand, gray clay and fine-grained firm gray to olive-gray sand. Pillow-shaped sandstone concretions 3 to 5 feet in thickness are mentioned as being exposed at Tuscahoma Landing. The upper one third of the formation contains lignite beds up to 8 inches in thickness with the lower two thirds containing three or more greensand marl zones, ranging from 1 to 6 feet in thickness and very fossiliferous in places. The base of the formation locally contains as much as 60 feet of fine-grained olive-gray sand which weathers yellow to brown and encloses large angular blocks of bedded silty clay.

History of Usage: Use of the name Tuscahoma has followed Smith and Johnson's original description which appeared as Bell's Landing series. The Greggs Landing marl member was referred to by E. A. Smith in 1886 (Smith, 1886) and Smith and Johnson in 1887 (op. cit., pp. 46-51). The Bell's Landing marl member was mentioned by E. A. Smith in 1883 (Smith, 1883) and again in 1886 (Smith, op. cit., p. 12).

Areal extent: The outcrop of the Tuscahoma sand enters Kemper County in the southwest part. Towns in the outcrop belt are: Prismatic, Klondike, Liberty, Moscow, Pea Ridge, Bluff Spring, Preston, and Prince Chapel. The Tuscahoma sand thus occupies a belt approximately 9 miles wide trending north-northwest as indicated by its contact with the Nanafalia formation to the east and with the Hatchetigbee formation to the west in the southwestern part of the county. The width of outcrop was not measured where the contact with the Hatchetigbee formation extended into Neshoba County. In the extreme northwestern part of the county, in T.12 N., R.14 E., the strike of the Tuscahoma sand changes to west-northwest (Plate 1).

Thickness: The thickness of the Tuscahoma sand in its southernmost extent in Kemper County is about 300 feet. The stratigraphic thickness computed from trigonometric formulae is 260.6 feet. Due to extremely low dip (42 feet per mile, or 0°27′) the vertical thickness can be considered the same as the stratigraphic thickness.

Lithologic character: The Tuscahoma sand in Kemper County consists of fine, firm gray to olive-colored non-fossiliferous, in some places thinly laminated sands, and dark clays and fissile shales. Locally, at the base of the formation, are about 33 feet of tan to brown fine sands containing large angular to rounded blocks of bedded silty clay. This sand is not present everywhere. As MacNeil (MacNeil, 1946, pp. 21 and 22) pointed out in his paper on the Midway-Wilcox stratigraphy of Alabama and Mississippi, "The formation (speaking of the Hatchetigbee formation) consists of interlaminated and interbedded fine-grained gray to olive sands and shales, and some lighter colored loose sand, all of the same type as the beds of the underlying Tuscahoma sand. In fact, without the Bashi marl member to part the base of the Hatchetigbee formation, the writer knows of no way to differentiate the beds from the Bells Landing marl member of the Tuscahoma to the top of the Wilcox group." The two marine members so characteristic of the lower Tuscahoma in Alabama—the Greggs Landing marl and the Bells Landing marl—extend into Mississippi, into Lauderdale County, only a short distance. The Tuscahoma sand becomes non-fossiliferous and is such in its extent through Kemper County.

The basal olive sands of the Tuscahoma rest on the light-gray to dark-gray blocky argillaceous silts or silty gray clays of the upper divisions of the Nanafalia formation. The reader is referred to described sections elsewhere. (See described sections of Nanafalia.)

An excellent exposure of the basal olive to tan and brown firm muscovitic fine sands of the Tuscahoma containing the large angular to rounded blocks of bedded silty clay may be seen 0.45 mile west of Mississippi State Highway 39, in the SW.¼, Sec.32, T.9 N., R.16 E. (Figure 50). Approximately 0.3 mile east of these sands, and underlying them, on the same road, are 27.7 feet of olive to yellow and tan laminated glauconitic, muscovitic fine sands containing limonite pipes and tubes, and clays of the middle Nanafalia. These are overlain by a ferruginous bed about 1.5 feet in thickness which is capped by a knotty iron bed some 6 inches in thickness.

Lignites are common in the Tuscahoma section and may be found at all intervals from the base to the top. Black shales grading upward into sands, sands with tubular iron and breccia,

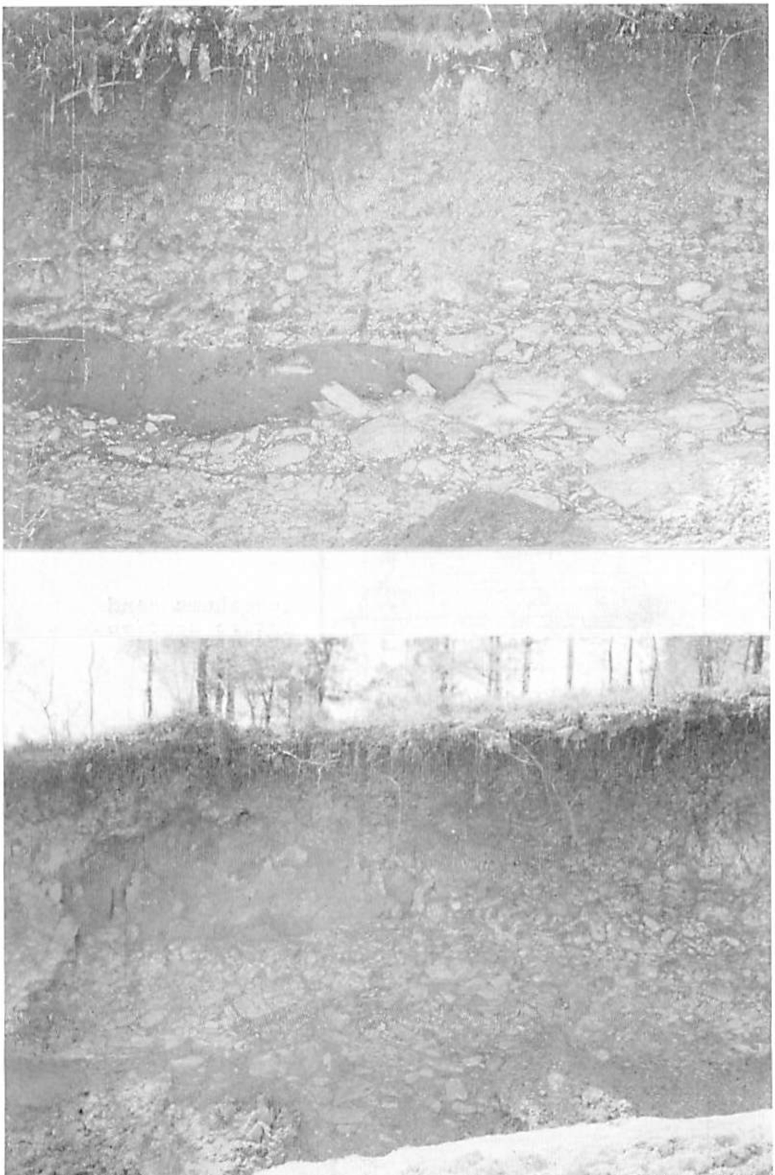


Figure 50-A and 50-B.—Silty clay blocks of basal Tuscahoma sand, 0.45 mile west of State Highway 39. (SW.¼, Sec.32, T.9 N., R.16 E.) Apr. 6, 1958.

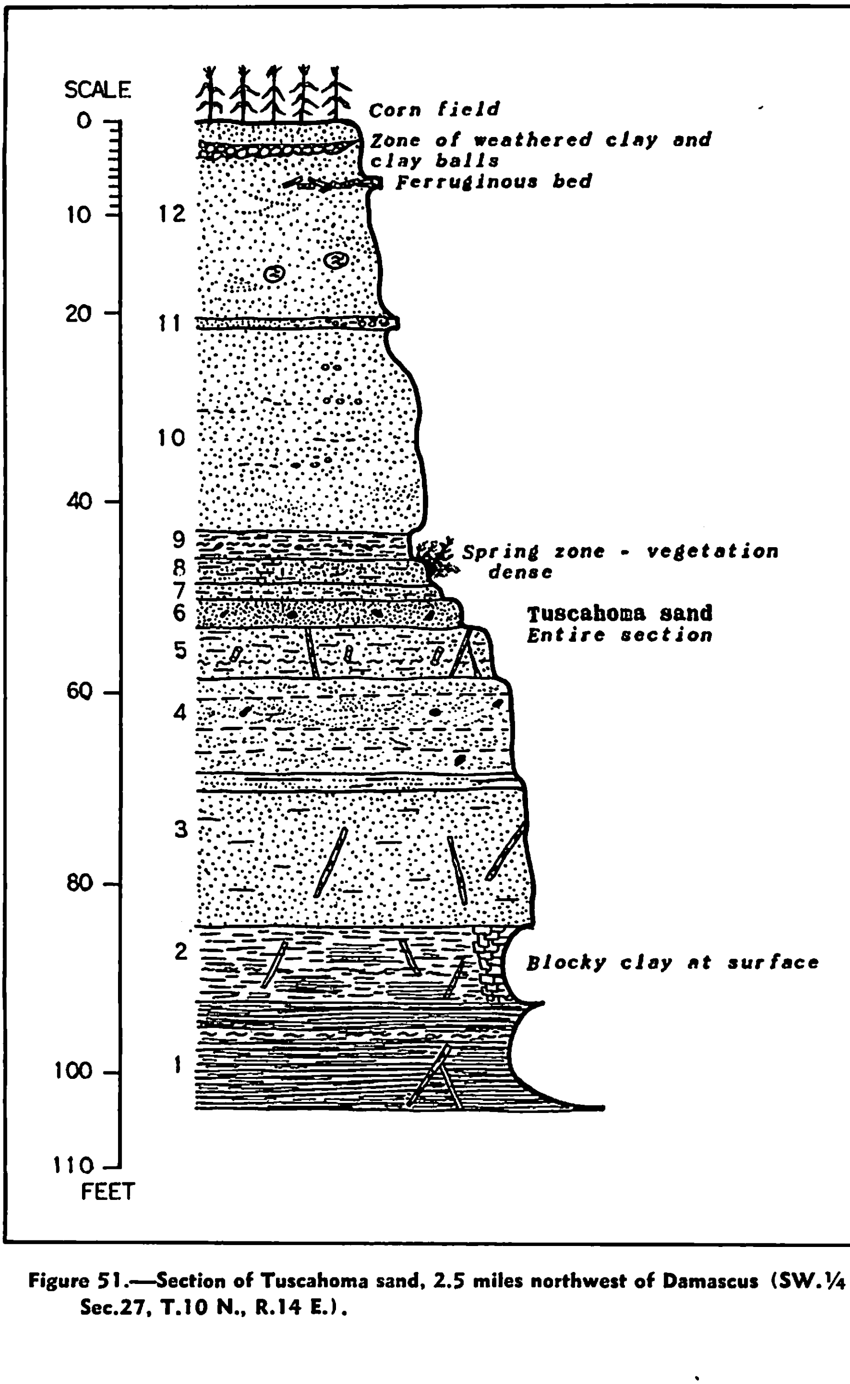


Figure 51.—Section of Tuscahoma sand, 2.5 miles northwest of Damascus (SW.¼, Sec.27, T.10 N., R.14 E.).

coarse red cross-bedded sands containing clay balls, cross-bedded olive sands, and lignites, fine red sands, olive sands and fissile shales—all make up the Tuscahoma section.

An excellent section showing the clay shales and sands of the Tuscahoma is on a southwest road, SW.¼, Sec.27, T.10 N., R.14 E. (Figure 51).

SECTION OF TUSCAHOMA SAND (SW.¼, SEC.27, T.10 N., R.14 E.) 2.5 MILES NORTHWEST OF DAMASCUS.

	Feet	Feet
Tuscahoma sand		104.3
12. Cross-bedded coarse to very coarse light-brown to red-brown sand containing an irregular clay zone 0-1.5 feet in thickness near top	20.8	
Note: The sand section is slumped and weathered. The description is general.		
11. Brown, muscovitic, medium sand; grades laterally into a weathered clay zone which thins to 0 feet	1.0	
10. Variegated red-brown to mottled yellow and pink muscovitic fine to medium sand with irregular clay stringers, blebs, and occasional clay balls. Basal red-brown sand slightly cross-bedded	21.8	
Note: Slumping in many places, and weathered.		
9. Yellow-brown laminated silty, muscovitic, plastic clay with lignite inclusions and several hard ferruginous partings; a few irregular lignite partings	2.8	
8. Blue-gray to gray argillaceous finely muscovitic silt having conchoidal to sub-conchoidal fracture	2.6	
7. Yellow-gray to blue muscovitic fine sand and gray muscovitic silty clay	1.5	
6. Dark-gray argillaceous finely muscovitic slightly sandy silt containing carbonized root stems and irregular inclusions of lignite	3.0	
5. Olive-gray muscovitic argillaceous fine sand, slightly laminated and containing thin partings, veinlets, and tubular limonite	5.1	
4. Olive-gray to yellow-brown finely cross-bedded slightly argillaceous muscovitic fine to medium sand containing irregular lignite inclusions and thin light-gray clay partings	10.1	
3. Laminated dark-gray and yellow-brown silty muscovitic slightly argillaceous fine sand, with veinlets of soft platy limonite; upper 2.4 feet slightly laminated silvery blue to blue fine sand containing fine muscovite and thin partings of lignite	16.0	

Figure 52.—Fine sands of Tuscahoma, 3.0 miles southwest of State Highway 39 at Blackwater. (SW.¼, Sec.24, T.9 N., R.15 E.) Apr. 5, 1958.

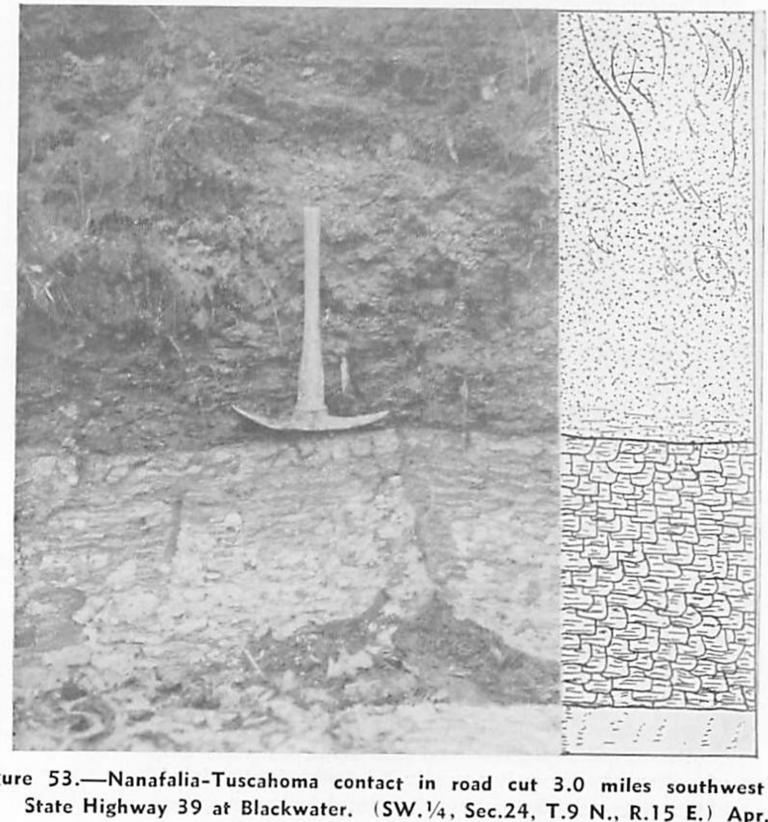


Figure 53.—Nanafalia-Tuscahoma contact in road cut 3.0 miles southwest of State Highway 39 at Blackwater. (SW.¼, Sec.24, T.9 N., R.15 E.) Apr. 5, 1958.

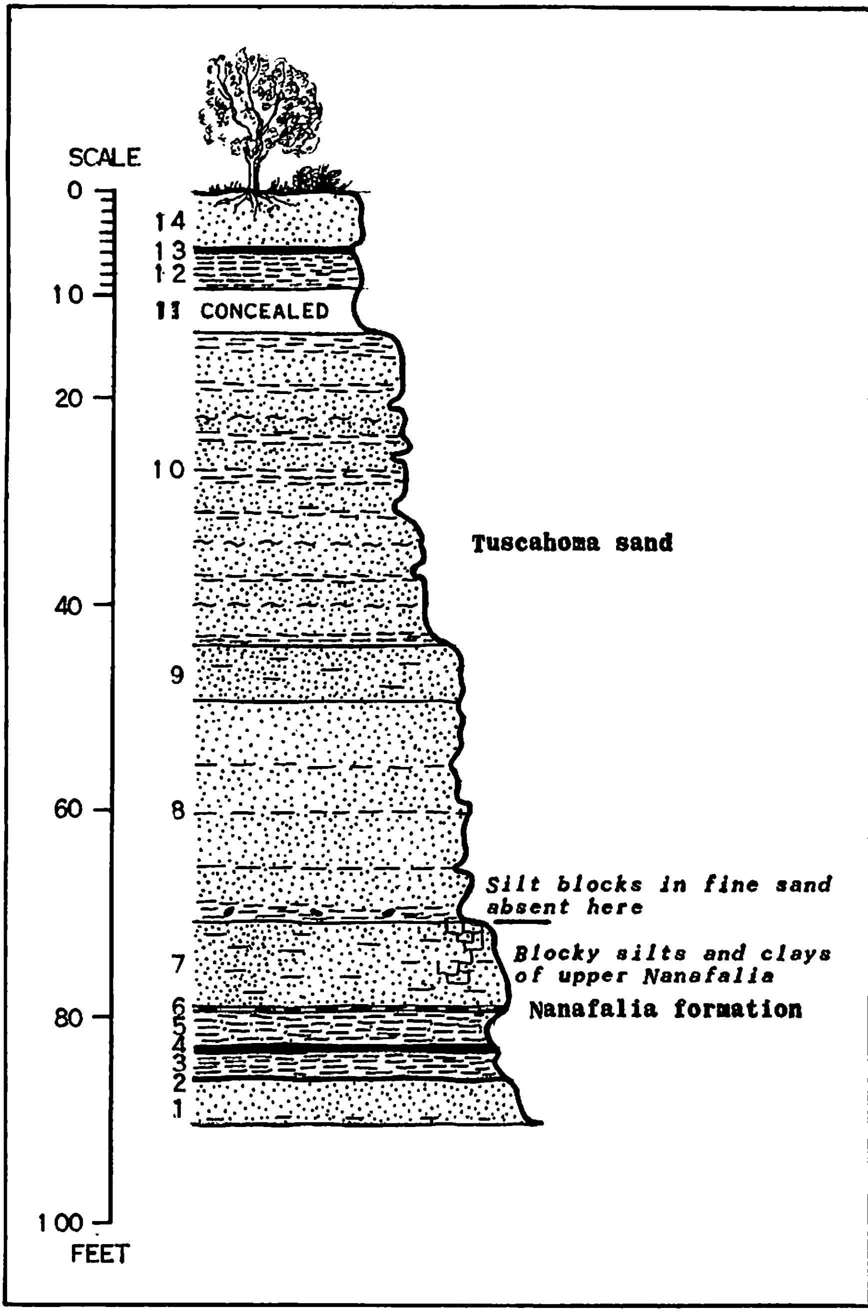


Figure 54.—Section of Tuscahoma sand 3.0 miles southwest of State Highway 39 at Blackwater (SW.¼, Sec.24, T.9 N., R.15 E., and SE.¼, Sec.23, T.9 N., R.15 E.).

	Feet	Feet
2. Light-gray finely muscovitic clay shale, blocky, hackly, and weathered surface, and containing veinlets and thin partings of soft platy limonite. Separated from (1) by a thin limonite parting	8.2	
1. Dark-gray laminated finely muscovitic clay shale containing veinlets of soft platy limonite; grades up into a light-gray blocky hackly clay. Basal foot or so weathered	11.4	
Total section		104.3

An excellent sand section of the Tuscahoma is well displayed on a north-south road (SW.¼, Sec.24, T.9 N., R.15 E. and SE.¼, Sec.23, T.9 N., R.15 E.). Approximately 71 feet of the fine sands (Figure 52) of the Tuscahoma are in contact with the blocky silts and silty clays so characteristic of the upper Nanafalia (pseudobuhrstone) of western Alabama. Figure 53 illustrates the contact between the blocky silts of the Nanafalia and the basal sands of the Tuscahoma.

SECTION OF TUSCAHOMA SAND (SW.¼, SEC.24, T.9 N., R.15 E. AND SE.¼, SEC.23, T.9 N., R.15 E.) 3 MILES SOUTHWEST OF MISSISSIPPI STATE HIGHWAY 39 AT BLACKWATER (FIGURE 54).

	Feet	Feet
Tuscahoma sand		71.2
14. Light tan-gray slightly argillaceous, muscovitic very fine sand; upper part weathered	5.4	
13. Lignite bed; soft brown lignite	0.6	
12. Light brown-gray plastic clay (underclay)	3.6	
11. Concealed interval	4.2	
10. Interbedded interlaminated yellowish-brown muscovitic fine sand and dark-gray clay with limonite partings	30.4	
9. Light tan-gray argillaceous muscovitic fine sand	5.4	
8. Interbedded yellowish-brown muscovitic fine sand and dark-gray silty clay; lower 1.5 feet carbonaceous silty clay or clay shale with gray medium sand above containing small blebs and stringers of lignite; grades up into a massive sand	21.6	
Nanafalia formation		19.2
7. Gray argillaceous silt, weathering to a light-gray and becoming blocky and hackly	8.2	
6. Dark-brown lignitic clay (carbonaceous) with thin streaks of soft lignite	0.6	
5. Gray-brown slightly silty clay, somewhat mottled in places	3.4	
4. Lignite bed	0.6	
3. Brown to gray clay (underclay)	2.3	

2. Lignite bed	0.2	
1. Tan through gray to buff medium to coarse loose sand; lower 0.5 foot slightly argillaceous	3.9	
Total section		90.4

The contact of the Tuscahoma sand with the overlying Bashi marl member of the Hatchetigbee formation is well shown in SW.¼, Sec.30, T.10 N., R.14 E., just north of the road V about on the Kemper-Neshoba county line. Worm borings in the interbedded gray carbonaceous clay shales are filled with the *Halymenites*-bearing glauconitic sands of the Bashi marl. This is the most northward extent of the contact within the county.

Stratigraphic relations: The contact between the Tuscahoma sand and the underlying Nanafalia formation is conformable and distinct where exposures are fresh. In areas where the contact is obscured by weathering it may be found by studying the firm olive sands in the basal part of the Tuscahoma sand and working down from there to the blocky hackly clays of the Nanafalia. The Tuscahoma sand is overlain disconformably by the Bashi marl member of the Hatchetigbee formation. The change from the gray non-marine clay shales of the Tuscahoma into the marine *Halymenites*-bearing glauconitic sands of the Bashi marl is sharp and is evidenced by numerous worm borings 1 to 3 inches in length filled with the glauconitic sands of the Bashi. The gray clay shales, cross-bedded sands, and lignite beds below the Bashi marl, previously included in the Bashi formation, are now considered a part of the Tuscahoma sand.

Physiographic expression: The topographic surface in the outcrop area of the Tuscohoma sand is rough. Relief is as much as 100 feet or more from stream valleys to tops of hills.

Paleontology: The Tuscahoma sand is barren of fossils in Kemper County.

Age and Correlation: The Tuscahoma sand belongs to the Wilcox group of the Eocene series in Kemper County, and it correlates with the Tuscahoma of Alabama. With the exception of the Greggs Landing and Bells Landing marl members, which are absent in Kemper County, the unit is very similar lithologically to that in western Alabama. It is correlated with the Pendleton formation in Louisiana and the Simsboro formation in Texas. The Tuscahoma sand is the correlative in part of the Cuisian of the European classification.

HATCHETIGBEE FORMATION

First reference: E. A. Smith, 1886 (Smith and Aldrich, 1886).

Nomenclator: E. A. Smith and L. C. Johnson, 1887 (Smith and Johnson, 1887).

Type locality: Hatchetigbee Bluff on the Tombigbee River, probably southwest corner of Sec.16, T.18 N., R.1 W., Washington County, Alabama.

Original description: Hatchetigbee was first introduced as a formal name by Smith and Johnson in 1887. It is referred to in their classic work as Hatchetigbee Series. It is essentially the same as that of Smith in 1886 who called it the Hatchetigbee Section. Smith's description is as follows:

"1. The Hatchetigbee Section. — 175 feet in thickness; made up of sandy clays of prevailing brown or purplish color containing three or four beds of marine fossils in the upper 75 feet, and of somewhat similar purplish-brown, sandy clays, nearly devoid of marine fossils in the lower 100 feet.

"All these brown, sandy clays become much lighter colored upon drying and exposure to the weather.

"The following is a more detailed description . . .

"Section at Hatchetigbee Bluff

"1.	Light-colored, aluminous rocks, lowermost of the Buhrstone	20 to 30 feet
2.	Sandy clays of brown, yellowish and reddish colors interstratified	15 to 20 feet
3.	Heavy-bedded, dark-brown clays (similar to 2), but of darker color when dry	10 feet
4.	Yellowish, glauconitic marl (marine shells)	2 to 3 feet
5.	Purplish-brown sandy clays, in the middle of which is a projecting ledge of dark-colored clays, which are harder, but which break up into small prismatic fragments upon weathering	15 feet
6.	Yellowish-gray sands, striped with thin streaks of brown, sandy clay, indurated in places	5 to 6 feet
7.	Bluish-brown, sandy-clay marl, containing many new forms of shells	5 to 6 feet
8.	Laminated, grayish sands, interstratified with thin beds of brown or black lignitic clay, indurated in places	4 feet
9.	Heavy-bedded, gray, sandy clays, with streaks of brown colored clays	8 feet
10.	Reddish, sandy marl, highly fossiliferous, forming concretionary bowlders. Remarkable for the great numbers of *Venercardia Plaincosta*, but containing also many other forms, such as *Athleta Tuomeyi*, *Fusus pagodiformis*, etc.	4 to 5 feet
11.	Dark-gray to brown, sandy clays to water's edge	15 feet"

Other descriptions: In 1887 Smith and Johnson (op. cit., pp. 39-40) used as a formal name Hatchetigbee. Of it they say, "Hatchetigbee Series, In this we would include all the strata intervening between the base of the Buhrstone and the uppermost of the Wood's Bluff fossiliferous beds, aggregating about 170 to 175 feet, as may be seen by consulting the engraved sections of Plate XV, especially Fig. 1, p. 155.

"By far the greater part of the beds here included are sandy clays or clayey sands of brownish gray colors, alternating with bands of dark brown or purple color, the whole forming a tolerably well marked and in most cases easily recognized group. Where these brown clays have been much exposed to the action of the atmosphere, and consequently thoroughly leached, as occurs whenever they lie high up on the hills, they exhibit very much lighter and less caracteristic colors. The best exposures of these beds are to be seen at the localities more particularly described below, and at one of them, White Bluff and vicinity, the whole series occurs in actual superposition, only about sixty-five feet of it being somewhat obscured by slides. The distinctively marine deposits of this series consist of three or four shell or marl beds, separated by non-fossiliferous sands and clays (Plate V)."

The described section at Hatchetigbee Bluff is essentially the same as that prepared by Smith a year earlier. The modifications are here listed.

"(a) Section at Hatchetigbee, Tombigbee River. (Plate XV, Fig. 2, p. 155.)

"1.	Light colored, aluminous sandstones and indurated clays, forming a vertical escarpment back of the main bluff	20 to 30 feet
	These light colored claystones we consider to be the lowermost of the Buhrstone formation, and all the underlying to be Lignitic.	
2.	Sandy clays of brown, yellowish, and reddish colors interstratified. These are dark blue when moist, but of lighter colors when dry	15 to 20 feet
3.	Heavy bedded, dark brown clays, somewhat like No. 2, but of darker color when dry	10 feet
4.	Yellowish, glauconitic marl	2 to 3 feet
	This bed shows a tendency to form at intervals hard concretionary ledges, which on weathering break off and roll down the bluff and are piled in great numbers at its base. Some of these bowlders have a nucleus of shells, which, however, are not usually very well preserved.	
5.	Purplish brown, sandy clays, in the middle of which is a projecting ledge of dark colored clays which are harder but break up into small prismatic fragments upon drying and on exposure to weather	15 feet
6.	Yellowish gray sands, striped with thin streaks of brown, sandy clay. These sands form, at intervals along the bluff, indurated, concretionary, rounded masses	5 to 6 feet
7.	Bluish brown, sandy, clay marl, containing many new forms of shells. The upper part more fossiliferous	5 to 6 feet
8.	Laminated, grayish sands, interstratified with thin beds of brown or black, lignitic clay. These sands form rounded, concretionary masses, which project from face of bluff	4 feet
9.	Heavy bedded, gray, sandy clays with streaks of brown clay	8 feet

10. Reddish, sandy marl, highly fossiliferous, forming concretionary bowlders. Remarkable for the great numbers of *Venericardia planicosta* Lam., but containing also many other forms, such as *Athleta Tuomeyi* Con., and *Fusus pagodiformis* Heilprin..............4 to 5 feet
11. Dark gray to brown sandy clays to water..............................15 feet"

Toulmin, LaMoreaux and Lanphere (Toulmin, LaMoreaux and Lanphere, 1951) describe the Hatchetigbee formation in Choctaw County, Alabama:

"about 250 feet thick and consists predominantly of fine- to medium-grained gray, brown, and olive-green firm sands and interlaminated carbonaceous and sparsely micaceous clay or shale. The sand beds exhibit cross bedding, and contain large irregular to rounded masses of sand with curved bedding resembling pot-hole deposition. The more sandy part of the formation weathers to a light-colored pink and gray loose sand. The massive and cross-bedded sand in the upper part of the formation is especially conspicuous in road cuts west of Butler. The interlaminated sands and clays of the Hatchetigbee formation are similar to those in the Tuscahoma.

"The Bashi marl member at the base of the Hatchetigbee remains fairly constant in thickness and lithology across Choctaw County. It is about 30 feet thick in exposures on the Tombigbee River. It thins slightly westward, and has an average thickness of about 20 feet in the Butler area and in creek cuts near Cyril at the Mississippi State Line. Where unweathered the Bashi marl consists for the most part of fossiliferous glauconitic calcareous sand with large rounded calcareous concretions. Where weathered it is a reddish-brown manganese-stained sand.

"The sand lying between the cross-bedded yellow and tan sand in the upper part of the Hatchetigbee and the claystone of the Tallahatta consists of light-colored and white cross-bedded medium- to coarse-grained quartz sand, which contains borings and weathers to loose light-colored sand. It is sharply defined by a lithologic break from the overlying buhrstone of the Tallahatta. The weathered sand presents a striking exposure of white or very light-colored gray, or greenish- to yellowish-gray, highly micaceous sand. This sand is absent in eastern Choctaw County or, if present, its thickness does not exceed 5 feet. In western Choctaw County it thickens to about 30 feet in places."

Lowe in 1933 (Lowe, 1933) says the Hatchetigbee formation in Mississippi "is composed chiefly of more or less laminated and lignitic brown, yellow, and gray clay, interbedded with thin and thick beds of white, gray, yellow, and brown sand. In places the clay becomes very dark brown to almost black. The formation was evidently laid down in very shallow waters and in part in swamps."

Foster in 1940 (Foster and McCutcheon, 1940) describes the Hatchetigbee formation in Lauderdale County as:

"composed of lignitic sands, sandy silts, and silty or sandy clays interbedded one with the other. In general, the basal part of the formation is more sandy than the upper part, and northwest of Meridian, extending to the county line north of Post (Sec.18, T.8 N., R.14 W.) it is easily separable into two members, an upper member composed of clay-shale, including one well developed lignite bed 1.0 to 2.5 feet thick, and a lower member composed of relatively fine or medium grained sand locally grading down into coarse grit-bearing sand.

"In Mississippi the Bashi-Hatchetigbee contact marks the conformable transition from marine to continental types of sediment and seems to represent a progressive withdrawal of the sea. Thus the contact is diagonal in nature — marine sediments recognized as Bashi in the southeastern part of the county being represented by continental sediments considered as Hatchetigbee toward the northwest. Although there is no recognizable unconformity between the two formations, the basal sands of the Hatchetigbee throughout the county contain local concentrations of large angular and, in many places, distorted blocks and fragments of Bashi material. Since the unconsolidated sediments of the Bashi could not withstand transportation over long distances, and since the fragments show no sign of rounding or corrosion, they probably represent local undercutting and consequent caving along an old shore line."

History of usage: The original use of Hatchetigbee in Alabama by Smith and Aldrich in 1886 was as the upper section (division) of the Lignitic; (oldest to youngest) Midway or Pine Barren Section, Black Bluff Section, Naheola and Matthews Landing Section, Nanafalia and Coal Bluff Section, Bells Landing Section, Woods Bluff or Bashi Section, and the Hatchetigbee Section.

In 1887 Smith and Johnson defined the Hatchetigbee as including all strata between the base of the "Buhrstone" and the uppermost of the Woods Bluff (Bashi) fossiliferous beds. Lowe in 1933 called Hatchetigbee the lignitic sands and clay shales lying conformably on the Bashi and being overlain unconformably by the thick red basal Claiborne sands. Foster's Hatchetigbee formation had a bi-part division, an upper clay-shale member with a lignite bed 1.0 to 2.5 feet thick, and a lower member made up of fine or medium sand grading downward into a coarse grit-bearing sand.

MacNeil in 1946 included in the Hatchetigbee formation the Bashi formation of previous usage, except the sands, shales, and lignites at the base which he assigned to the Tuscahoma. The Bashi was made the basal marl member. Toulmin, LaMoreaux, and Lanphere in 1951 included in the Hatchetigbee formation the marine fossiliferous greensand marl of the Bashi, making it the basal marl member.

In this present report on Kemper County, the writer uses Hatchetigbee formation, with Bashi marl member of MacNeil at the base.

Areal extent: The outcrop area of the Hatchetigbee formation lies west of the outcrop of the Tuscahoma sand. Its width of outcrop in Kemper County is approximately 2 to 4 miles in the extreme southwest part of the county and, having a northwest strike, it passes out of the county in Sec.30, T.10 N., R.14 E. (Plate 1).

Thickness: The exact thickness of the Hatchetigbee formation in Kemper County is not known. It is the writer's opinion that perhaps 100 feet is a fairly close figure, including the Bashi marl member. The thickness of the Bashi member varies in the county — a maximum of 41 feet and a minimum of 8.9 feet were measured.

Lithologic character: The Hatchetigbee formation consists of fine-grained gray and olive sands and brown or chocolate-colored carbonaceous clays more or less interbedded with one another and containing lignite seams. The Bashi marl member at the base in Kemper County is primarily a glauconitic sand containing fossil prints.

Bashi marl member: The name Bashi was first used by Angelo Heilprin in 1882 (Heilprin, 1882). The names Woods Bluff or Bashi were used by Smith and Aldrich in 1886 (Smith and Aldrich, 1886).

Type locality: The type locality of the Bashi is Bashi Creek, Clarke County, Alabama, but it is best known for its exposure at Woods Bluff on the Tombigbee River, Sec.10, T.11 N., R.1 E., Clarke County, Alabama.

The description by Smith and Aldrich appears below:

"2. The Woods Bluff or Bashi Section. — 80 to 85 feet in thickness. The uppermost 30 feet of this section consist of dark-brown clays passing into a green sand, which holds a great variety of finely-preserved marine shells. Below this green-sand marl are gray, sandy clays, with four or five thin beds of lignite within the first 25 feet, succeeded by about 30 feet of cross-bedded sands, with a two-feet seam of lignite at the base."

In 1887 Smith and Johnson introduced for the first time as a formal name Bashi. This description is below:

"(2) The Wood's Bluff or Bashi Series (Plates XV and XVI)

"The first beds of marine fossils of any consequence below the series of brown and purple clays above mentioned occur at Wood's Bluff, on the Tombigbee, and just below Johnson's Island, on the Alabama River; also, on Bashi Creek and its tributaries in Clarke County, and at numerous other localities to be given below. We have given to these beds the name of the Wood's Bluff or Bashi Marl. They are from 15 to 20 feet in thickness, are highly fossiliferous, hold a very considerable percentage of greensand, and the marl has a tendency to become indurated by carbonate of lime into rounded, bowlder-like masses of glauconitic, fossiliferous limestone. These bowlders may be formed in any part of the beds, but are more commonly seen in the upper half, and when this is the case the loose greensand marl below is easily washed out, giving rise to the formation of caves, sometimes of considerable dimensions. Immediately below this marl, and usually within 25 feet of it, are at least four or five thin seams of lignite, varying from a few inches up to 18 inches in thickness.

"All these characters render the Wood's Bluff marl easily recognized, and it has been traced by me from the western part of Choctaw across to the eastern part of Monroe County without any essential change in its quality. It has become one of our most important geologic landmarks.

"Some 35 to 40 feet below the lowermost of the thin, lignitic beds immediately underlying the Wood's Bluff marl, and separated from it by yellowish, cross bedded sands, is another lignite, about two feet in thickness, at the base of which we wish to draw the line between the Wood's Bluff and the Bell's Landing series. As thus defined, the Wood's Bluff series includes the strata intervening between the purplish-brown, sandy clays, above described, immediately overlying the Wood's Bluff marl, and the two feet of lignite. The thickness represented is about 80 feet. The most complete section of the whole series is at Yellow Bluff, on the Alabama River. (See Plate XVI, Fig. 1, p. 159)

"The best exposures of the marl bed are to be seen at Wood's Bluff, on the Tombigbee River, and on the tributaries of Bashi Creek in Clarke County, in the immediate vicinity of Wood's Bluff, although, as stated above the marl may be readily traced across Choctow, Clarke, and Monroe Counties, exhibiting at many places away from the rivers very fair sections. On the immediate banks of the Alabama River the marl does not make much show, though it may be seen below Johnson's wood yard.

"We give here only those sections, showing the details of the marl bed and of the strata underlying down to the top of the next, or Bell's Landing series.

"(a) Section at Wood's Bluff, Tombigbee River. (Plate XV, Fig. 1, p. 155, and Plate XVI, Fig. 7, p. 159.)

"Orange sand or stratified drift .... 20 feet or more

1. Dark brown or bluish black, laminated clays, breaking up into small fragments, 6 to 8 feet, at the upper end of the bluff, but rising to 10 feet or more farther down. These clays are identical with those at the base of the White Bluff section .... 8 to 10 feet or more
2. Dark bluish, sandy clay, turning red on exposed and weathered surfaces and capped with a hard ledge which may be easily traced down the river nearly to Davis's Bluff .... 3 feet"

   Footnote: "This bed is highly fossiliferous, containing *Laevibuccinum striatum* Heilpr., (which appears to be confined to this particular horizon), *Athleta Tuomeyi* Con., *Fusus pagodiformis* Heilpr., *Venericardia planicosta* Lam., *Actaeon pomilius,* Con., a small Natica, *Pleurotoma acuminata* Sow., Sharks' teeth, *Ancillaria staminea* Con., a small Cytherea, &c."
3. Bluish, laminated clay or sandy clay, very much like

No. 2 in color and texture, but containing no fossils, or very few, and not appearing red at the surface, of variable thickness	5 to 8 feet
4. Bluish or greenish, sandy clay, somewhat indurated, of decidedly reddish color on the surface, highly fossiliferous, characterized by *Turritella lineata* Lea and *Dentalium microstriatum* Heilpr., but containing also *Ancillaria staminea* Con., a small Natica *Pyrula multangulata* Heilpr., *Corbula oniscus Infundibulum trochiformis* Lea, a Phorus, and a small oyster. The lower part of this bed passes gradually into the greensand marl No. 5 and is the best collecting ground, as the material is less indurated and the shells are more easily removed	3 to 4 feet
5. Greensand marl to the water's edge	10 to 12 feet

"The upper part of this marl is quite soft and friable, but just above the water's edge it becomes indurated and shows a disposition to form rounded, bowlder-like masses, quite hard and firm and resembling a limestone. That this indurated part is of the same nature as the softer greensand above and below it, is seen from the circumstance that the indurated bowlders are sometimes near the top, sometimes near the bottom of the greensand stratum. The accompanying view (Plate VI) shows well the large, bowlder-like masses of the indurated greensand, No. 5. Passing through the central part of this marl bed is a layer of *Ostrea compressirostra* Say, with very thick and ponderous shells."

In 1946 MacNeil (MacNeil, 1946b, pp. 21-22) restricted the Bashi of Smith and Johnson and others to include only the fossiliferous glauconitic sands ranging in thickness from 2 to 25 feet. Approximately 70 feet of lignitic sandy clays, yellow cross-bedded sands with a basal lignite seam of some 2 feet in thickness were assigned to the Tuscahoma sand. The Bashi was made the basal member of the Hatchetigbee formation.

The Bashi sands are well exposed in Kemper County. An excellent exposure showing the glauconitic nature of the sands can be examined on a north-south road in the SW.¼, Sec.30, T.10 N., R.14 E. Here the glauconitic sands lie disconformably on the clay shales and sands of the Tuscahoma sand (Figure 55).

SECTION OF BASHI SAND (NW.¼, SW.¼, SEC.30, T.10 N., R.14 E.) 1.25 MILES NORTHWEST OF A ROAD INTERSECTION.

	Feet	Feet
Top soil		2.0
9. Buff, silty top soil	2.0±	
Hatchetigbee formation		40.8
Bashi marl member		
8. Olive to buff to yellow-brown glauconitic fine sand containing gray shaly streaks and irregular clay masses, also limonite tubes and *Halymenites major* Lesquereux	19.2	
7. Gray fissile clay-shale with thin limonite partings and fine sand	0.6	

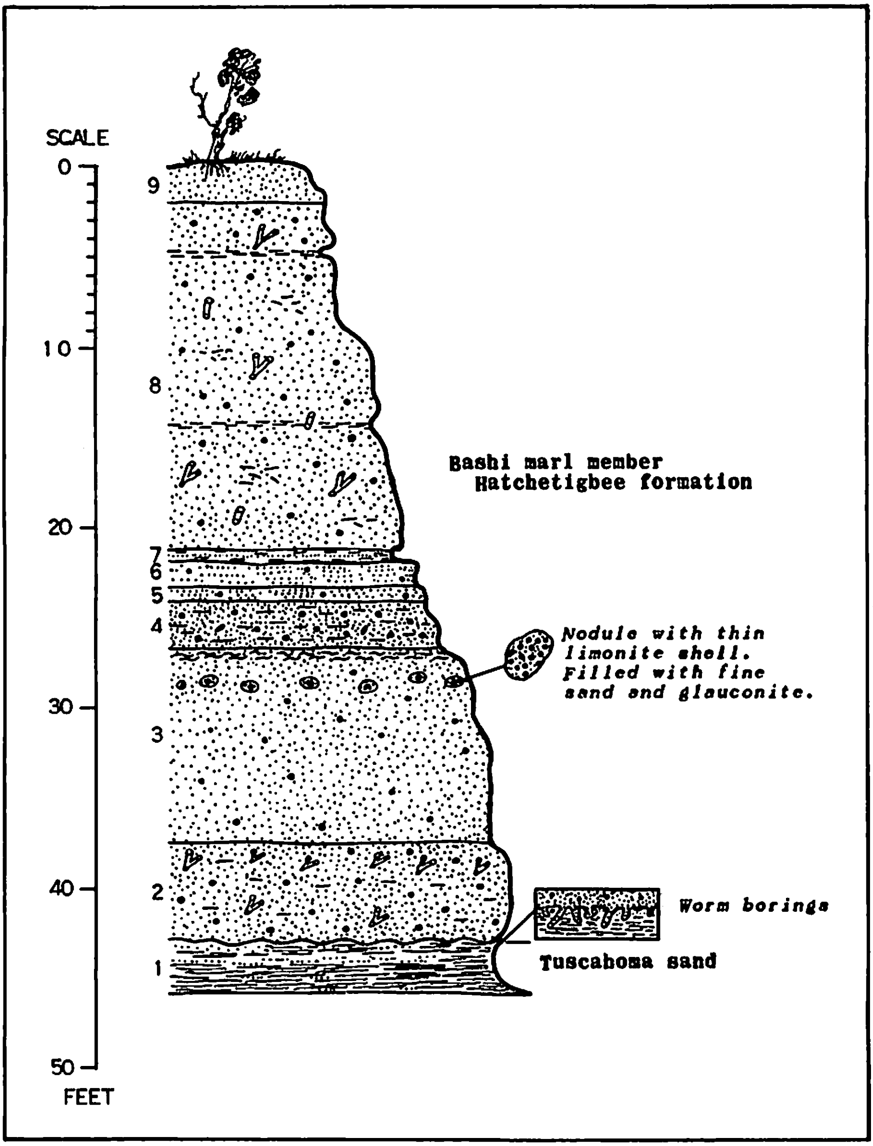


Figure 55.—Section of Bashi sand 1.25 miles northwest of a road intersection (NW.¼, SW.¼, Sec.30, T.10 N., R.14 E.).

6. Light-gray to yellow-brown laminated slightly glauconitic muscovitic fine sand	1.4	
5. Olive-gray to finely laminated orange and gray glauconitic muscovitic fine sand	0.8	
4. Olive-gray to gray muscovitic carbonaceous, argillaceous, glauconitic fine sand	2.6	
3. Yellow-brown to olive-brown glauconitic soft fine sand. Irregular limonite parting at top (0.7±). Sand in upper 3.1 feet very glauconitic, being in ferruginous sand nodules	10.8	
2. Olive-gray to mottled yellow-brown glauconitic muscovitic firm slightly argillaceous fine sand, containing *Halymenites major* Lesquereux (abundant toward top); more argillaceous toward top. Basal 2 feet a gray fine sand containing glauconitic capsules	5.4	
Tuscahoma sand		3.1
1. Interbedded, irregularly laminated dark-gray, carbonaceous clay-shale and gray fine sand perforated by borings filled with glauconitic sand from (2)	3.1	
Total section		45.9

A very glauconitic sand having a ferruginous concretionary zone at the top containing abundant fossil prints is exposed along an abandoned road just east of the road fork (NW.¼, SW.¼, Sec.7, T.9 N., R.14 E.). Figure 56 shows the sandstone concretionary zone containing prints.

SECTION (NW.¼, SW.¼, SEC.7, T.9 N., R.14 E.) OF BASHI SAND ALONG ABANDONED ROAD JUST EAST OF FORK.

	Feet	Feet
5. Brown weathered clay	2.0	
4. Thin, brown ferruginous medium sandstone parting - ½ inch		
3. Dark brown highly glauconitic medium sand	1.2	
2. Brown ferruginous sandstone somewhat concretionary, filled with gray sand containing glauconite; numerous fossil prints	0.3	
1. Brown, very glauconitic fine sand containing fossil prints and *Halymenites major* Lesquereux. Upper part contains gray clay blebs and stringers	5.4	
Total section		8.9

Fossil prints are common in the Bashi sand as far south as Section 28, T.7 N., R.15 E., Lauderdale County. Silicified shells are common from this locality in Lauderdale County and easily identify the member in its outcrop pattern into Alabama.

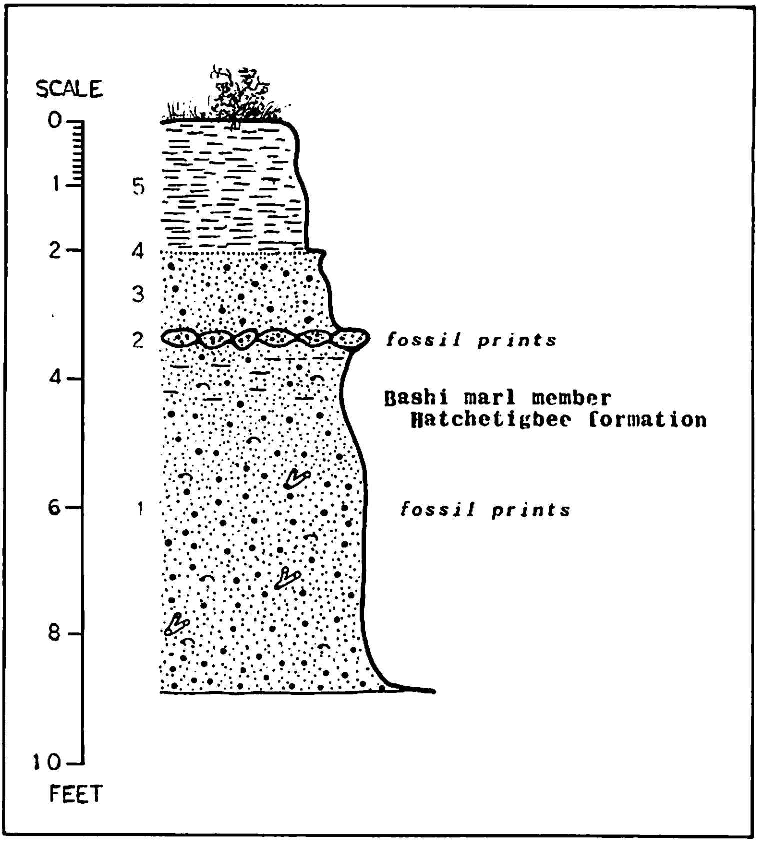


Figure 56.—Section of Bashi sand along an abandoned road just east of road fork NW.¼, SW.¼, Sec.7, T.9 N., R.14 E.).

Exposures of the Hatchetigbee in Kemper County lying above the Bashi marl member are very poor or lacking entirely and no described sections appear. Topographic relief in the extreme southwestern part of the County is great enough for a section of typical Hatchetigbee but the writer found no outcrops from which measured sections could be made.

Stratigraphic relations: The Hatchetigbee-Meridian sand or Wilcox-Claiborne contact is not exposed within Kemper County. The contact, however, is a major non-marine disconformity and can be examined in Lauderdale, Newton and Neshoba Counties. The Bashi marl member of the Hatchetigbee formation lies disconformably on the carbonaceous clay-shales of the Tuscahoma formation.

Physiographic expression: In the outcrop area of the Hatchetigbee formation the topographic surface is that of undulating hills of sand and clay. The topography is rough and characteristic of the Red Hills phase of the North Central Hills physiographic

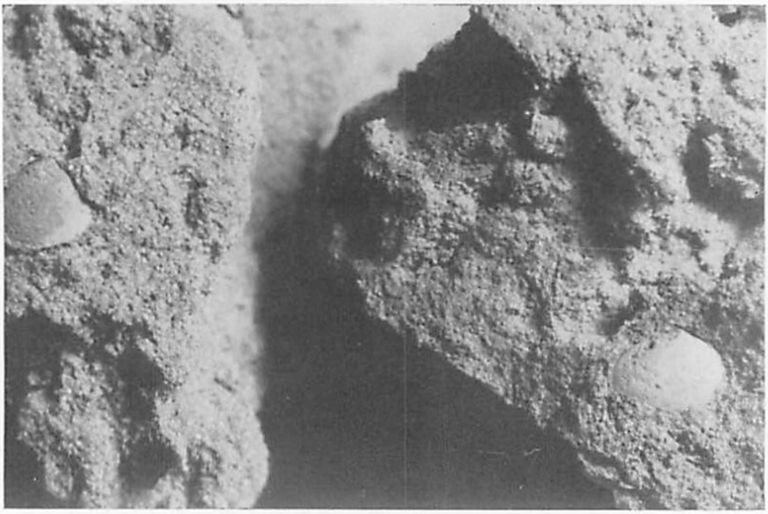


Figure 57.—Pelecypod prints in Bashi sand along an abandoned road just east of road fork. (NW.¼, SW.¼, Sec.7, T.9 N., R.14 E.).

province, as are other units of the Wilcox group. The area is well dissected in spite of abundant tree cover. The forests are mixed, being predominantly loblolly and short leaf pines, and hardwoods.

Paleontology: The Hatchetigbee formation in Kemper County is unfossiliferous. The Bashi marl member at the base contains only fossil prints probably *Ostrea, Venericardia,* and *Pseudoliva.* Figure 57 shows several pelecypod prints. These genera are present as silicified shells in Lauderdale County. *Halymenites major* Lesquereux is found in the sands of the Bashi.

Age and correlation: The Hatchetigbee formation, along with the Bashi marl member at the base in Kemper County, correlates with the Hatchetigbee formation of Alabama of recent reports. It correlates with the Sabinetown, Carrizo and Rockdale formations in Louisiana and Texas. It is the equivalent in part of the Ypresian stage of the European classification.

WILCOX-CLAIBORNE CONTACT

In the extreme southeastern corner of Kemper County (Secs. 30 and 31, T.9 N., R.14 E.) the Meridian sand member of the Tallahatta formation probably is present at the surface. This very small area, not more than a square mile, is almost inaccessible, and no exposures of definite importance were found by the writer. The contact is at the same stratigraphic position, however, as other outliers containing exposures of the Meridian sand only a few miles to the south in Lauderdale County and to the west in Neshoba County. There is no valid basis here, as there is in the adjoining counties, for a study of the controversial age of the Meridian sand. The Meridian sand might be included in either the Wilcox or the Claiborne group.

It is the opinion of Thomas (Thomas, 1942, p. 21) that the Meridian sand should be included in the Wilcox group. His reasons are stated here:

"1. It is lithologically much more similar to the underlying nonmarine Wilcox than to the overlying marine Tallahatta. It was deposited under conditions very similar to those which prevailed throughout most of the Wilcox time in eastern Mississippi.

"2. The marine Tallahatta section overlies the Meridian sand with distinct disconformity throughout eastern Mississippi and western Alabama.

"3. The lower Meridian contact changes over short distances along the strike from conformable to locally disconformable (local erosion channels)."

The Meridian sand could, then, be considered as being a sandy facies of the Hatchetigbee formation. In the sub-surface it is included in the Wilcox because its contact with the claystones of the Basic member of the Tallahatta is more discernible in well cuttings and on electrical logs than is its contact below with beds of unquestionable Wilcox.

The Mississippi Geological Society and others include the Meridian sand member of the Tallahatta formation in the Claiborne.

QUATERNARY SYSTEM

HOLOCENE SERIES

The Quaternary is represented in Kemper County by the Holocene Series, mainly flood-plain deposits.

FLOOD-PLAIN DEPOSITS

Alluvial sands, silts, clays, and gravels may be found along the larger streams in the county, lying unconformably on the older rocks. These deposits are mapped as "Qal" on the geologic map. Mapped belts of alluvium lie along Wahalak Creek, Bodka and Scooba Creeks, Sucarnoochee Creek, Pawticfaw Creek, Blackwater Creek, Okatibbee Creek, and Bogue Chitto Creek (Plate 1). The floodplains have their greatest extent on the weaker rock formations and are absent or narrow where the more resistant belts are crossed. The floodplains narrow or pinch out to the west and northwest in the high and rugged topography of the Sand Hills phase of the North Central Hills physiographic division.

Typical alluvial deposits are associated with present streams, subject to flooding during periods of high water, and present a rather flat upper surface, not highly dissected, containing twigs, branches, or bits of organic matter.

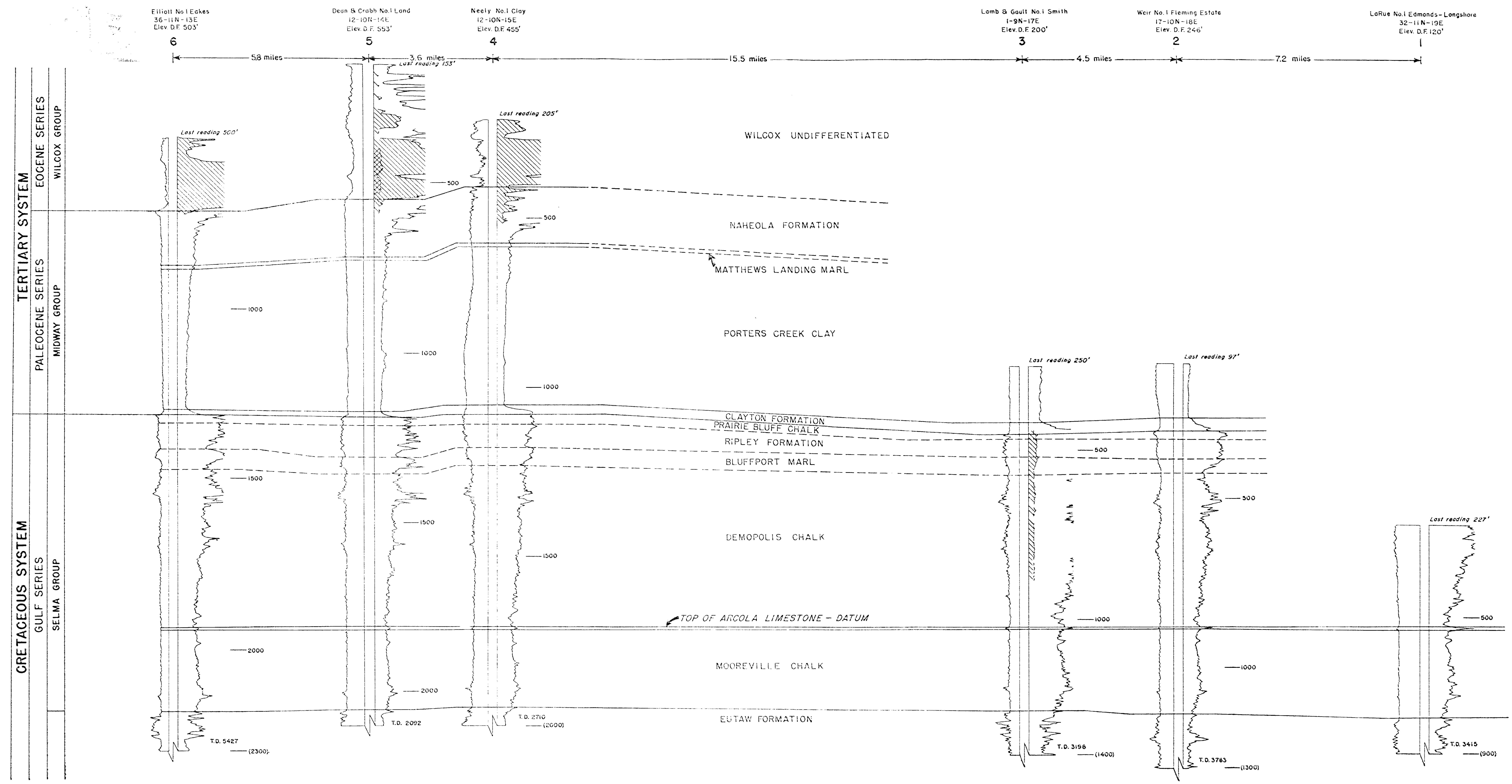
The thickness of the alluvial deposits is unknown.

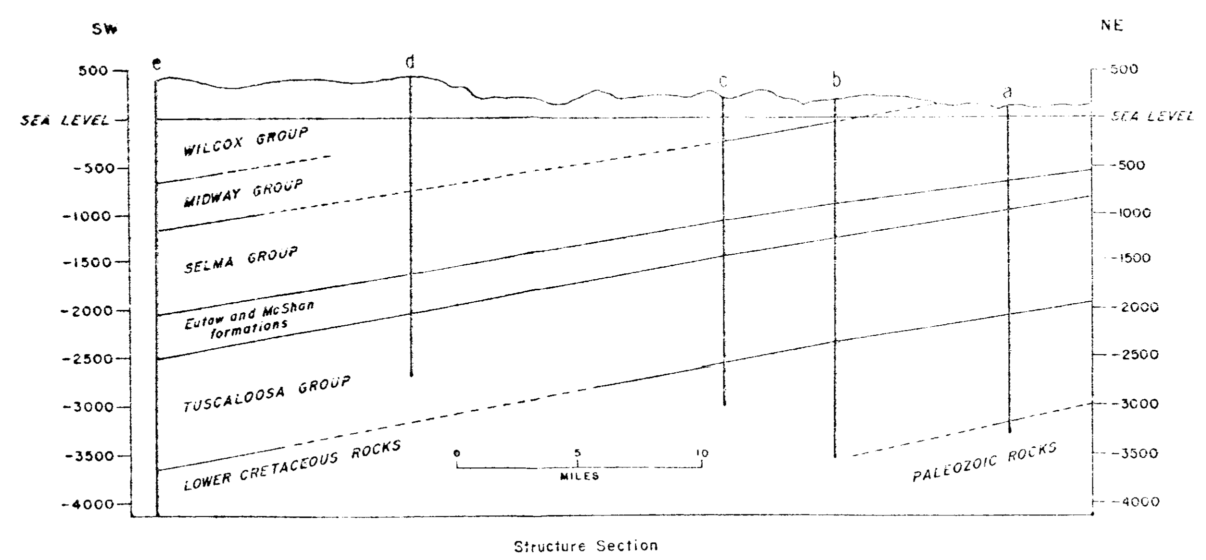
The present alluvial deposits vary greatly in composition, thickness, and distribution, but they consist of the following principal types:

(1) Definite deposits of sufficient thickness to mask the underlying strata nearly completely and to govern the development of the topography and the soils.

(2) Recent colluvial and alluvial material, which consists chiefly of soil, and much of which is still being actively shifted. Because of the difficulty of deciding where colluvium ends and alluvium begins, all such material is regarded as alluvium for the present purpose.

The writer estimates a thickness of about 25 feet for the floodplain of Blackwater Creek. Other creeks in the county may have thicknesses in excess of this figure, or perhaps less.

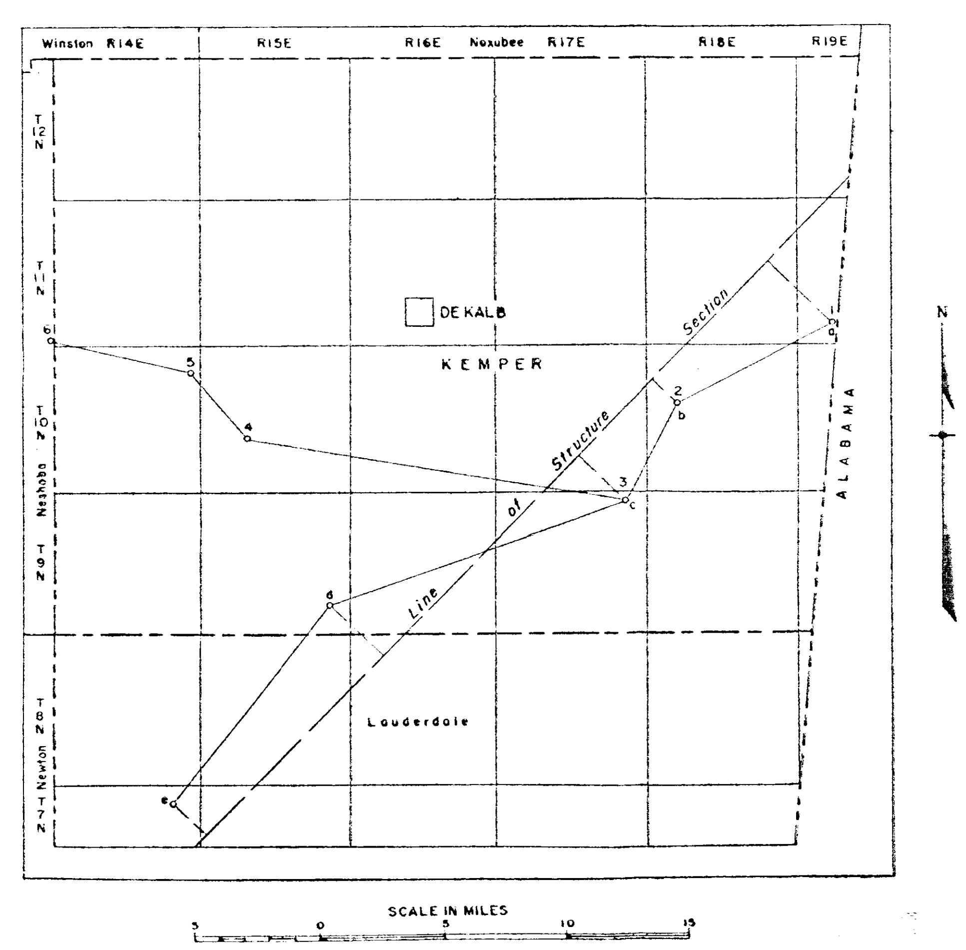




Structure Section

a LaRue No.1 Edmonds-Longshore 32-11N-14E Elev. D.F. 120'
b Weir No.1 Fleming Estate 17-10N-18E Elev. D.F. 246'
c Lamb & Gault No.1 Smith 1-9N-17E Elev. D.F. 200'
d Manning No.1 Coldwell 25-9N-15E Elev. D.F. 480'
e Stack & Johnson No.1 Miles 2-7N-14E Elev. D.F. 411'

STRATIGRAPHIC AND STRUCTURE SECTIONS



Index Map Showing Location of Stratigraphic and Structure Sections

SUBSURFACE STRATIGRAPHY

Fourteen wells for oil have been drilled in Kemper County. Well locations down dip were not ideal for projection onto the line of structure due to their location in the main in the extreme southeast part of the county. A stratigraphic section was, therefore, prepared with the Arcola limestone member of the Mooreville chalk as datum. A comparison of the lithologies and variation in thickness of the different formations can be seen in Plate 10. A structure section of wells in southeast Kemper County and in northern Lauderdale County appears at the bottom of the plate.

Below is a brief summary of the procedure and problems encountered in the preparation of the electric log stratigraphic and structural sections.

1. The Arcola limestone showed persistent kicks in wells used and was ideal for a datum.

2. Dip and strike were computed on several horizons on the electric logs and an average was taken.

3. The beds dip gently to the southwest throughout most of the county at about 40 feet per mile.

4. No detailed studies were made on differentiating the Wilcox. Long strings of surface casing prevent detailed studies. Projection into the subsurface is, therefore, of doubtful accuracy in the absence of complete electric log data. The 3 wells which show Wilcox are insufficient for differentiation.

5. Surface formation names are here used in the subsurface.

6. Bed thicknesses, in the main, generally increase down dip. A correction of about 0.99 foot per 100 feet (for dips of 40 feet per mile) of thickness must be deducted from well log thicknesses to arrive at the stratigraphic or true thickness of the formations.

7. Electric logs of wells drilled in Lauderdale and Neshoba Counties, near the Kemper County line, were used in subsurface studies to supply lacking information in the areas immediately adjacent to Kemper County.

The electric log structure section in the southeast part of the county is as close to the direction of regional dip of the beds as possible to show their attitude in the subsurface. Wells near-est the line showing the regional dip were projected at right angles onto that line. Wells selected for use in the electric log structure section are lettered alphabetically down dip. The wells were plotted in their correct positions on the index map at the bottom of the plate and were projected to their respective positions on the line of structure section. Projections of this nature are shown in the index map and structure section by a, b, c, d, e. Topographic expression was obtained from aerial photographs and contour maps.

STRUCTURE

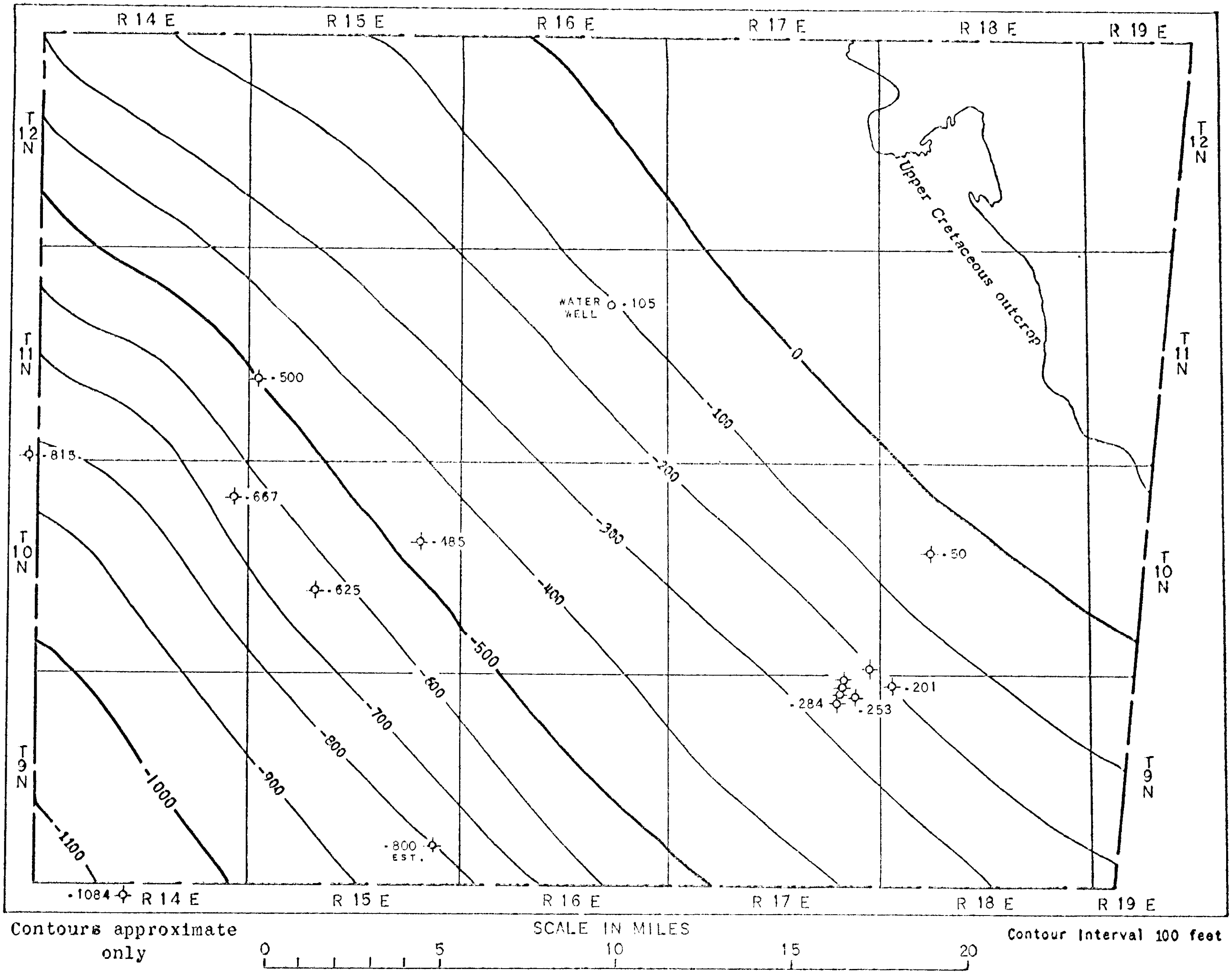
The strata which crop out in Kemper County are structurally homoclinal, in the main, and are part of the arcuate homocline composing the northern limb of the Gulf of Mexico Geosyncline. Plate 11 is a structure contour map on the top of the Cretaceous. The beds dip about 42 feet per mile to the southwest in the county. Dips were computed both graphically and by trigonometry.

No major surface faults were found by the writer in the county. However, the fact that numerous criss-cross faults (Plate 12) are present in the Central Gulf Coastal Plain to the west, south and north, and to the east in Alabama in Sumter and Greene counties on the extreme eastern flank of the Mississippi Embayment is indication enough that faulting is present in Kemper County. In western Alabama, just north of Livingston, at about the latitude of Kemper County, there is considerable faulting involving the Demopolis chalk, the Ripley formation and the Prairie Bluff chalk of the Cretaceous. These faults may be reflected in the subsurface in extreme northeastern Kemper County. It is the opinion of Boswell (Boswell, Ernest, 1958) that the Cretaceous in Kemper County is faulted.

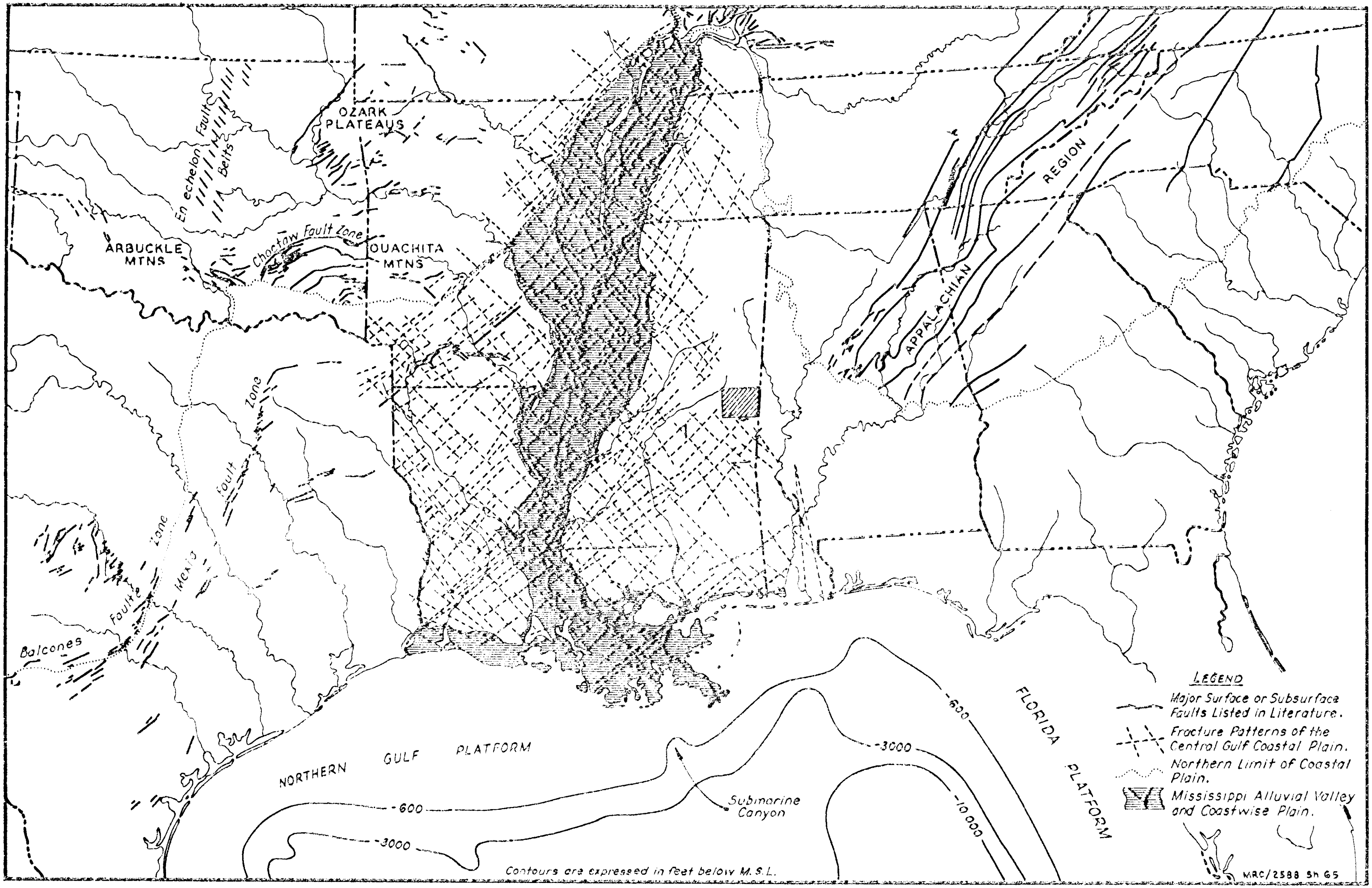
A letter from Lang, U. S. Geological Survey District Geologist, Water Resources Division, quotes Boswell's summary, as follows:

"The rapid increase in mineralization of water in the Eutaw and Tuscaloosa formations in Kemper County is partly due to the normal increase in mineralization associated with increasing depths. However, the increase is considerably greater in southeastern Noxubee and northeastern Kemper Counties than has been noted elsewhere.

"This may be due to several things. Incomplete flushing of marine sands by fresh water may result from faulting or other structural conditions. Leakage along fault planes from deeper formations may increase mineralization. Faulting may be present since this area is directly northwest of the Livingston fault zone as mapped by Watson Monroe.



STRUCTURE CONTOUR MAP ON TOP OF CRETACEOUS



RELATION OF FAULT ZONES WITHIN THE CENTRAL GULF COASTAL PLAIN (AFTER FISK)

"There is probably no structural significance associated with the high fluoride content of the water; this has been noted in almost all highly mineralized samples from the Eutaw formation.

"We have been able to obtain a few drillers' logs in Kemper County. These indicate the area east and southeast of Scooba is structurally disturbed but our records are too few to determine what type structure may be present. We have no logs that show anything abnormal southeast of Porterville, but the chemical quality of the water in the area is quite variable and the mineral content is extremely high at Enondale. Some of the indicated structural evidence from the wildcat wells in the area may be due in part to erroneous elevations."

In the drainage pattern, or map view of rivers as seen from the air, structural clues have been recognized, with interpretative usefulness depending chiefly on familiarity with regional probabilities. In Kemper County, at the intersection of the Gulf Coastal Plains with its extension, the Mississippi Embayment, primary regional expectations would be for trunk streams to flow generally south and southwest toward the Embayment, and for the first order tributaries to follow southeasterly, southerly and southwesterly courses. This regional expectation pattern is evident only in remnants in Kemper County, and the major portion of the drainage flows southeastwardly.

The run-off in Kemper County is partially controlled by the belted topography developed on the outcrops of different lithologic units. Modifications reflect variations in rock resistence; and moreover, strike and dip directions of the strata have exerted pronounced control on many stream segments. Downdip migration of obsequent slopes, called homoclinal shifting, accents this tendency, and many downdip tributaries are elongated in dip direction, as strike valleys are widened. Modifications in the drainage pattern of the county related to widespread warpings and fracturings seem indicated. Adjustment of coastal plain drainage to faulted zones, described as a roughly rectangular network made up largely of northeast-southwest and northwest-southeast lineations, has been noted by numerous workers.

The distinctly different drainage texture of three major run-off basins, parts of which are in Kemper County, is apparent in map view, and reflects geologic boundaries in a general way. Locally, within these basins in the county, are peculiar patterns of stream courses, which appear to be anomalous evidence of structural control of significant proportions.

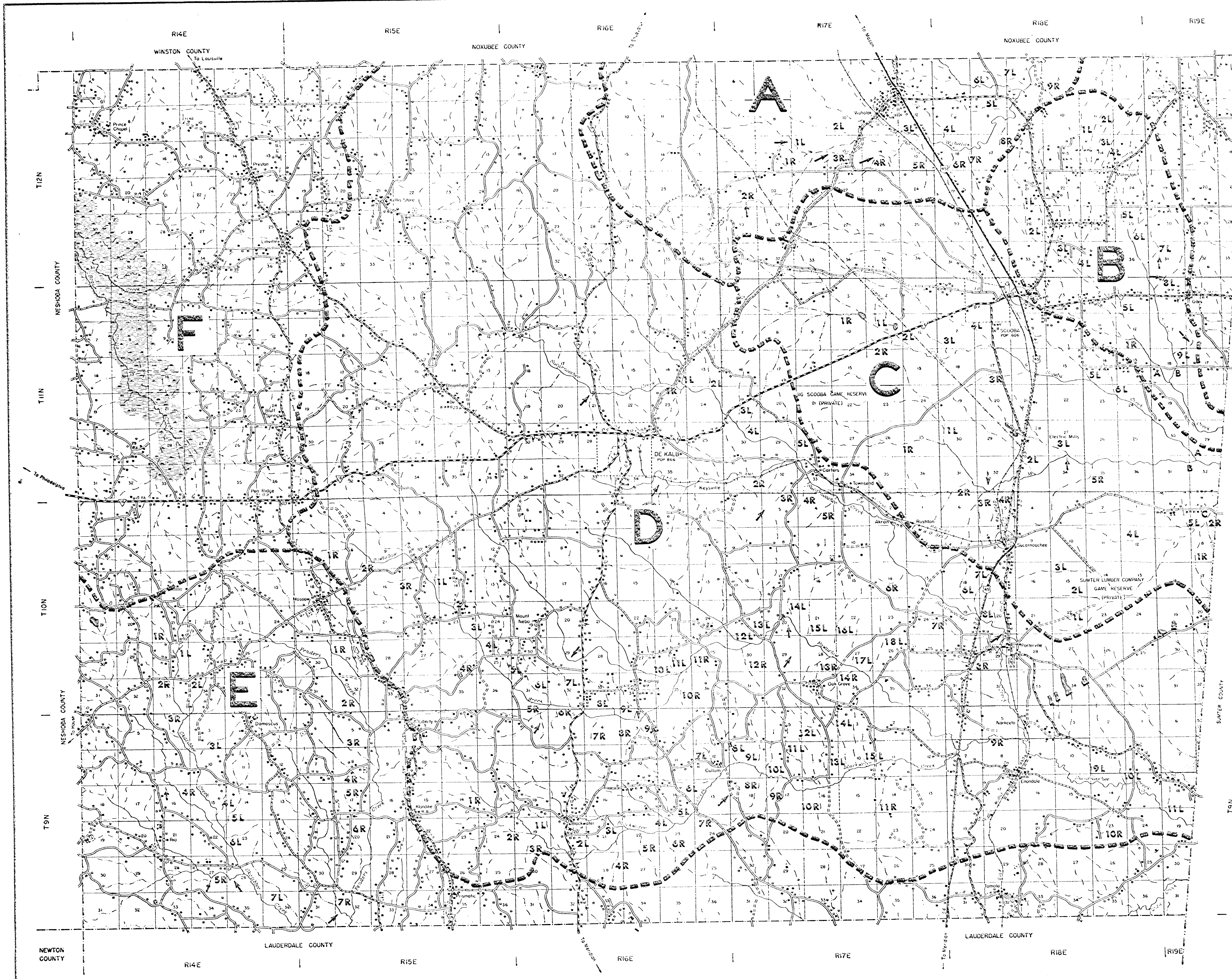
Tombigbee System: Adams in 1929 (Adams, 1929) suggested that downwarping in southwestern Alabama caused progressive diversion of through flowing streams. Although he was chiefly interested in proof of divergence of Tallapoosa and Coosa Rivers in western Alabama, he also considered the effect of this downwarping on the Tombigbee System in Mississippi. His explanation appears logical for the strong eastern and southeastern control exerted on the drainage of the Tombigbee River System in eastern Kemper County.

Wahalak Creek, part of the Tombigbee System, is the only drainage in Kemper County flowing northwardly out of the county, with the exception of Bogue Chitto drainage in the extreme northwestern corner of the county, and one rather long, intermittent tributary of Scooba Creek in east central Kemper County.

In the broad areal pattern, the northeastward curve of Wahalak Creek parallels the larger, similar curve of Bodka-Scooba Creeks in their course toward Noxubee River in Alabama. The course of Noxubee River appears offset to the northeast in the area of junction of Wahalak and Bodka-Scooba branches, and the rather angular offset is in striking alinement with the principal fault zones of the Central Gulf Coastal Plains (Plate 13-A). The course of Wahalak is also apparently influenced by the curved outcrop belt of more resistant beds in the northeastern part of the county, where some of the relief is about 200 to 250 feet (see Physiography).

However, Wahalak Creek flows through relatively flat farm and forest land in the Porters Creek clay (Flatwoods), and much of the course is intermittent, although the major channels are rather distinct.

On the accompanying drainage map (Scale 1:126,720; 1 inch= 2 miles), stream tributaries have been numbered downstream in numerical order, the letter R and the letter L denoting right hand and left hand, respectively. A study of the stream pattern at this scale (Plate 13-A), reveals 8 right-hand and 7 left-hand tributaries of Wahalak Creek. The left-hand tributaries are longer, and are elongated along strike, in which general direction they flow until intercepted by the eastward and northeastward flowing main body of the creek. Apparently there is notable angularity in the major bends of tributaries 2R, 3R, 4R and 1L (Plate 13-A). This reach of Wahalak Creek, flowing through



A Wahalak Creek, Tombigbee River System
B Bodka Creek, Tombigbee River System
C Scooba Creek, Tombigbee River System
D Sucarnoochee Creek, Tombigbee River System
E Okatibbee and Penders Creeks, Pascagoula River System
F Bogue Chitto Creek, Pearl River System

STREAM DERANGEMENT PATTERNS

farm and forest land in Sections 19 and 20, T.12 N., R.17 E., has a pattern suggestive of possible structural control. Stereoscopic study of aerial photos (Scale 1:20,000) of the portion of the channel affected by this angularity reveals an absence of the small meanders typical of adjoining segments of the creek course, which is also a suggestive factor.

Bodka Creek, part of the Tombigbee System, is formed by the confluence of two tributaries of almost equal length, and similar pattern, both of which head in northeastern Kemper County. One of the tributaries is largely intermittent. All the second order tributaries of Bodka Creek are left-hand tributaries, with the exception of one rather long intermittent second order tributary of the A channel (Plate 13-B). This dominance of left-hand tributaries, flowing in the direction of dip, generally southwest and south, indicates the down dip migration regionally commonplace.

There is remarkable angularity and similarity at certain sharp bends, in the patterns of tributaries and sub-tributaries (B7L, B8L, B9L, Plate 13-B), suggesting possible structural control. Most of the second order tributaries join the main tributaries at rather wide angles, and upstream there is perhaps less than normal decrease in the angle of junction.

Aerial photos (1:20,000) under the stereoscope, show that the reach of tributary B, including sub-tributaries 6L and 7L, has several pattern suggestions of structural control. For example, a linear, or opposite tributaries of a stream delineating a straight line, can be seen at B6L. Traces of similar straight lines in the tonal pattern of the aerial photos of the surrounding topography emphasize this suggestion. The portion of Tributary B, examined on aerial photos, follows closely the cuesta of the Ripley formation exposed in this section, and beyond the flood plain at the foot of the cuesta, the Bluffport marl member of the Demopolis is exposed. In this part of Bodka Creek (Sections 24, 25 and 36, T.12 N., R.18 E.), there appear on the aerial photos to be alternating small meander clusters, and rather straight reaches, for which the most plausible explanation seems to be adjustment of the stream to lines of weakness. As Melton has stated (Melton, Frank A., 1950). "It is not yet evident just what is the significance of the linears in the low-lying regions of sedimentary rocks. It is the writer's belief, however, that they represent zones of jointing. The zones of jointing, it is believed, are associated with deep-seated faulting in the basement complex which in the flat lands of North America is ordinarily composed of pre-Cambrian rocks."

Scooba Creek, part of the Tombigbee System, is formed by the confluence of three main tributaries, which flow southeast, east and northeast. It drains a large area of the Flatwoods, underlain by the Porters Creek clay, and flows eastward through the outcrop belt of the Clayton and Prairie Bluff formations.

Most of the tributaries of Scooba Creek in Kemper County are intermittent, and the course of the creek and its tributaries meanders intricately and sinuously through the Flatwoods. Much of its course is difficult to trace on aerial photos (1:20,000) because of the heavy forest through which it flows. In the map sketch of the creek (Plate 13-C), tributary A seems to be composed of three lengthy sub-tributaries, flowing parallel, almost along strike, until they are intercepted by reaches of the creek flowing eastward and southeastward toward the major basin of the Tombigbee River System in Alabama. Tributary B has a similar pattern, and both of these major tributaries appear to have been captured by eastward and southeastward flow, thus reflecting both the tendency of drainage in this portion of the Coastal Plains to flow along strike, and the strong diversion tendency of downwarping in southwest Alabama. The angularity and step-like pattern that may be observed at a number of points in the pattern (Plate 13-C) appear to be an adjustment to these larger tectonic features. Near to an angular step-like portion of the major stream course, a well drilled for oil and gas in Section 32, T.11 N., R.19 E., was dry and abandoned.

The eastward course of Tributary B repeats the eastward flow of Wahalak Creek to the north, and the similarity of the general pattern of Wahalak and Bodka-Scooba courses in their flow toward the Tombigbee System has been noted.

Tributary C of Scooba Creek (Plate 13-C), which is entirely intermittent in Kemper County repeats the dip direction of flow, as seen in part of tributary B, and nearly all of its sub-tributaries are elongated left-hand reaches that are influenced by strike direction, as well as the eastward trend toward the Tombigbee basin. Tributary C flows northeastwardly from Kemper County.

A stereo pair or aerial photos (1:20,000) covering part of Sections 13, 14, 23, and 24, T.11 N., R.18 E., show many sinuous changes in the stream pattern marked by foliage color changes in the thickly forested flood plain. An eroded scarp of the Clayton formation is noteworthy, and the Clayton-Prairie Bluff contact, noted in the field in this area, is evident on the photos.

Sucarnoochee System: Throughout the basic drainage pattern of the Sucarnoochee Creek System in Kemper County, also a part of the Tombigbee River System, there is an obvious tendency toward northwest-southeast orientation, and repetition of the step-like pattern (east, to southeast, to east again) noted in drainage in the county to the north of Sucarnoochee Creek. Possibly fault control is suggested by this general pattern, as well as the typical response to strike and dip directions, and to the downwarped Tombigbee basin to the east.

Southeast of DeKalb (Sec.6, T.10 N., R.17 E.) is an interstream surface practically outlined by north, northeast, east, and southeast flow of surrounding streams (Plate 13-D). At points on the course of Pawtifaw (Sec.20, T.10 N., R.17 E.; Sec.29, T.10 N., R.16 E.; Sec.3, T.9 N., R.16 E.; Sec.6, T.9 N., R.16 E.), there is topographic suggestion of significant structural control. In the generally easterly course of Blackwater Creek in Kemper County, the interstream pattern between sub-tributaries 7R and 8R (Plate 13-D), Secs. 13, 24, T.9 N., R.16 E., and Sec.18 T.9 N., R.17 E., seems significant. The interstream area northwest of Oak Grove (Sec.29, T.10 N., R.17 E.) is nearly surrounded by modified radial drainage, marked by peculiarities of the drainage pattern of Pawticfaw Creek between sub-tributaries 12R and 13R. A sharp change of direction in the pattern of Sucarnoochee Creek below tributary 8L (Sec.20, T.10 N., R.18 E.) is noteworthy. The parallelism between part of the pattern of Blackwater and the pattern of Pawticfaw, and the similar parallelism of 1R and 2R tributaries of Sucarnoochee Creek, is interesting. These patterns may well reflect elements of the north-south faulting, as well as the northwest-southeast, northeast-southwest fault trends, noted by numerous workers in areas of the Coastal Plains.

Aerial photos under the stereoscope reveal that the area south of DeKalb, with pattern angularity, (Secs.2, 3, 10, and 11, T.10 N., R.16 E.) is an area of sand hills eroded into deep, almost vertical-walled gullies, where relief is close to 100 feet in places.

Farming practices have influenced the drainage in this easily eroded material, and the surface is masked by accidents of use and erosion. Channels are filled with sand, and contain many braided segments. Numerous and rough gullies gash the surface in every direction.

About one mile north of DeKalb, Sec.21, T.11 N., R.16 E., on Highway 39, a fault in the Matthews Landing beds exposed in road cuts has been noted. Stereoscopic study of aerial photos (1:20,000) of this area reveals a striking change in the channel pattern in addition to the sharp right-angle bend of tributary 1R of Sucarnoochee Creek which may be observed on the drainage map (Plate 13-D).

From a rather wide, clearly marked, meandering bed, the stream assumes a narrow, not clearly marked, sinuous pattern, apparently related to position of strata where faulting may be reflected in this channel pattern.

Pascagoula System: Okatibbee Creek and its tributary Penders Creek, part of the Pascagoula River System, drain part of the North Central Hills province, where the Hatchetigbee and the Bashi are exposed. In the map of Okatibbee and Penders Creeks (Plate 13-E), angularity is conspicuous at certain bends (4R, 5R Okatibbee; and 7R Penders), and the angle of junction of tributary 5R with Okatibbee Creek appears unusual. The most noteworthy feature at this scale (1:126,720) perhaps is the alinement of angular bends, as well as the flow of a rather long subtributary of tributary 5R of Okatibbee Creek, all in a northeast-southwest direction. On aerial photos (1:20,000) the intricately meandering courses of the creeks and their tributaries contrast with the peculiar straightness of the courses in some reaches, such as in Section 22 and 27, T.9 N., R.14 E.

Pearl River System: Bogue Chitto, part of the Pearl River System, has been influenced by the northwest-southeast, and northeast-southwest fault zones within the Central Gulf Coastal Plain. The large swampy area in parts of Sections 19, 20, 29, 30, 31 and 32, T.12 N., R.14 E., and in Sections 5, 8, 16, 17, 20, 21, 27, 28, 32, 33, and 34, T.11 N., R.14 E. (Plate 13-F), may be accounted for by the presence of a perched water table on upper clays of the Nanafalia, an inlier in the general outcrop area of the Tuscahoma (MacNeil, personal communication, 1955). The tributaries of Bogue Chitto in Kemper County are entirely intermittent, except in the swamp area.

GEOLOGICAL HISTORY AND DEPOSITIONAL CONDITIONS

GENERAL STATEMENT

The geologic record that may be deciphered from the rock exposed at the earth's surface spans more than two billion years. The hiatuses in the record in many regions are greater than are the parts for which evidence is preserved. For example, the great hiatus separating the Pre-Cambrian from the Cambrian, or the Cryptozoic eon from the Phanerozoic eon, is greater than all geologic time from the Cambrian to the present. Only by reconstructing incomplete records from one locality and from another can a chronologic story of the geologic events of the past be deduced, and the story in one locality fitted into its proper place in the continental and world-wide picture. The compilation of the geologic history in a specific locale as well as world wide depends on the correct interpretation of the rocks, and, secondly, correct correlations from one region to another.

The rocks of Kemper County represent only a small part of known geologic time. Figure 58 is a spiral graph of the geologic time scale showing the relative lengths of time involved in the deposition of rocks in Kemper County as compared with the total geologic time scale. Lengths of time as shown are approximately correct. The space allotted for the Quaternary in proportion to the rest of geologic time is too small to show representation of alluvial deposits in Kemper County. The exposed rock deposits of the county have a total thickness of 1,625 feet and represent only a fraction of the Mesozoic and Cenozoic eras.

MESOZOIC HISTORY

The Mesozoic Era in Kemper County is represented by rocks of Upper Cretaceous age belonging to the Gulf Series. The formations involved are, in ascending order, the Demopolis chalk in part and its Bluffport marl member at the top, the Ripley formation, and the Prairie Bluff chalk.

The Cretaceous seas were second only to those of the Ordovician in maximum extent on the continent of North America. In Early Cretaceous time the western Gulf region began to

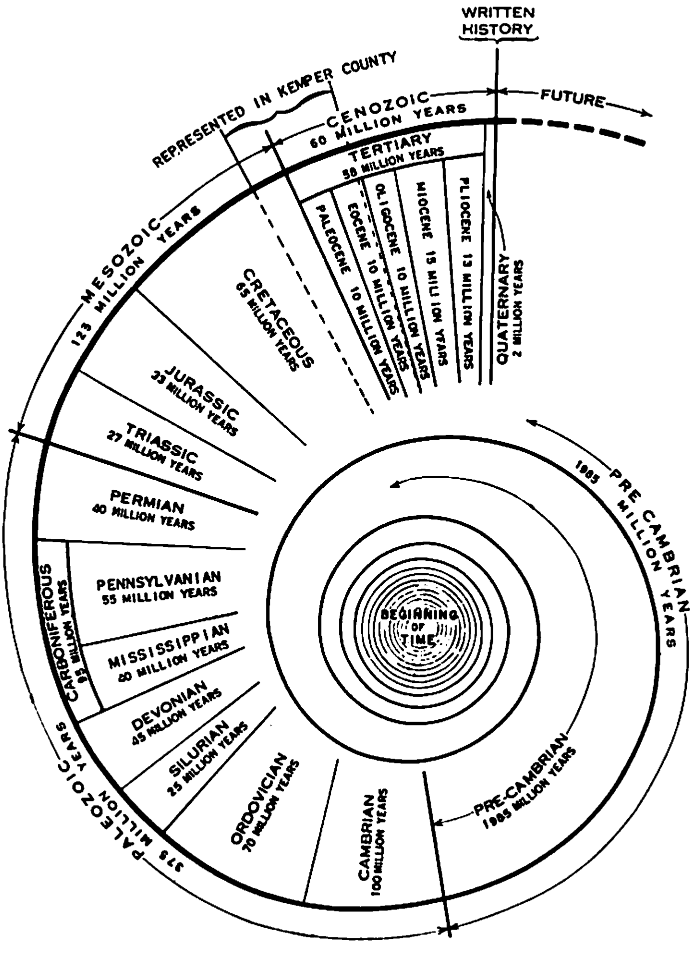


Figure 58.—Geologic Time represented by spiral graph.

subside and the sea began to spread over the continent, first from the Gulf of Mexico through the Mexican geosyncline into the southern United States; next from the Arctic into the Rocky Mountain trough, and finally across both the Pacific and Atlantic margins of the continent. During the deposition of the Upper Cretaceous sediments in and along the borders of the oceans of that period there were oscillations and warpings of the land with respect to the sea level, which caused minor retreats and advances of the strand line, and each such retreat is marked in the sediments by an unconformity of relatively short time significance; but at the close of the period there was a general continental uplift which freed the land of its flood of ocean water, and forced the strand line oceanward perhaps as far as the edge of the continental shelf. Erosion throughout the extent of the newly emerged surface produced the regional unconformity which separates the Upper Cretaceous from the overlying Paleocene sediments. With the irregular and pulsating advance, or transgression and regression, the interior seas gradually united and submerged almost 50 percent of North America, forming at their culmination one of the greatest marine floods of all time. The climax came shortly before the middle of the Late Cretaceous epoch, and thereafter the interior sea retreated southward, was gradually silted up, and finally disappeared near the close of the period. This was the last extensive submergence North America experienced, for in Cenozoic time the continent had its present outline and almost its present size.

The Upper Cretaceous submergence is well recorded in the sediments of the Gulf series. Shallow to moderately deep water sands, clays, marls, and chalk comprise the largest part of the sediments. Unconformities within the series record slight retreats and advances of the sea in the area. During the early part of the Upper Cretaceous time the Mississippi Embayment began to subside, and toward the end of that epoch the sea had advanced to the latitude of Cairo, the southern end of Illinois.

The Laramide orogeny in the West at the end of the Cretaceous, as well as a general uplift of the North American continent caused the shallow epeiric seas to retreat, not only from the Western Interior, but also from the Atlantic and Gulf Coastal Plain. Evidence is lacking as to the maximum extent of retreat of the seas, but large areas certainly became land, as attested by great differences of faunas of the uppermost Cretaceous, such as *Exogyrae* and *Grypheae,* which are not found in rocks of the lowermost Paleocene. The region was again subjected to erosion and reduced to an almost plane-like surface.

CENOZOIC HISTORY

At the close of Cretaceous time North America assumed approximately its present size and configuration. The Gulf

Coastal Plain was partly submerged from the Paleocene to the Oligocene epochs, but emerged more and more nearly completely thereafter.

Any picture of the Gulf Coast Tertiary must be a composite of many overlaps and offlaps, and accurate delineation of boundaries between the many transgressive and regressive sequences

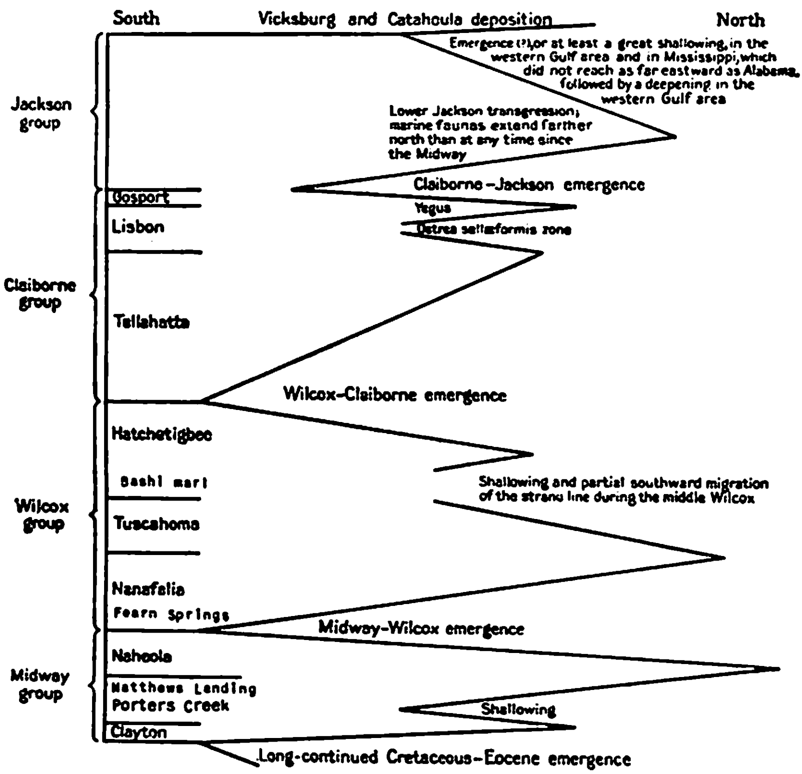


Figure 59.—South-north cross-section showing transgressions and regressions of sea from Midway time through Jackson time. (Modified from Berry).

is impossible, because they merge one with the other (Figure 59). As the late Frederic Byron Plummer (Sellards, Adkins, Plummer, 1932, p. 527) so aptly stated, "The history of the Cenozoic era is a history of the transgressions and regressions of the marine waters, and the correct interpretation of the geology depends upon a knowledge of the remarkable intergrading and interbedding of the two types of sediments, the continental and the marine, as well as the recognition of intermediate types, the littoral and lagoonal sediments. Not only does one type of sediment replace the other vertically, as the Wilcox land deposits replace the Midway marine strata, but also, if some formational units are traced laterally far enough, one facies may grade or change abruptly into another."

In early Tertiary time there was a general subsidence of the Gulf Coast area and the Mississippi Embayment, and the Midway sea began to spread inland, with extensive marine deposition. Transgression is represented by the marls, limestones, and calcareous shales and sandstones of the Clayton formation. The black clays of the Porters Creek clay represent an inundative phase between a transgressive phase and a regressive phase. Adjacent areas were uplifted, and as a result erosion was reactivated and a considerable amount of coarse clastic detritus was transported to the sea by ancient rivers. The embayment area was gradually filled with this when subsidence diminished or was completed. This caused a general slow retreat of the sea in Wilcox time. The marine clays and shales of the Midway were replaced by the coarser less marine clastics of the Wilcox. The regression of the sea was probably from Mississippi first, both to the east and west, as indicated by the non-marine early Wilcox sediments. The Wilcox deposits of the Nanafalia formation, the Tuscahoma sand, and the Hatchtigbee formation, then, might presumably be interpreted as representing a succession of estuarine, littoral, and continental deposits in the wake of the southward retreating sea.

Subsequent downsinking permitted the waters of the sea to spread inland over the eroded surface of the Wilcox formations, and in this sea were deposited the dominantly glauconitic sands, clays, and marls of the Tallahatta formation of Claiborne age. The advance of the Claiborne sea was not as great, and Clai-bornian sediments are more restricted in their areal distribution than those of the Wilcox or the Midway.

At the close of the Claiborne epoch there was a shallowing of the sea or the sea receded, as indicated by the sands, gray shales, and lignites of the Cockfield formation.

MINERAL RESOURCES

WATER

GENERAL STATEMENT

"Approximately 98 percent of the public water supplies in Mississippi are from wells. More than 85 percent of the water used for municipal and industrial supplies and for irrigation is derived from wells." (Mississippi Water Resources Policy Commission, 1955.) The following tabulation of data on surface and ground water in Kemper County is taken from "Water for the Future in Mississippi," Appendix, page 1:

Total number of water acres in county	1,800
Number of natural lakes in county	0
Estimated area that possibly could be irrigated from these lakes	0
Number of artifical lakes and ponds in county	3,600
Estimated area that possibly could be irrigated from these lakes	150
Number of year-round flowing streams in county	7
Estimated area that possibly could be irrigated from these streams	0
Number of intermittent streams	25
Average number of months they flow	4
Estimated area that possibly could be irrigated from these streams	0
Number of shallow wells in the county	3,000
Number of wells that are driven or drilled	1,000
Average depth	30
Estimated area that might be irrigated from this source	0
Number of deep wells in the county	60
Average depth of these wells	600
Average capacity, gallons per minute	You tell
Estimated number of year-round springs used for domestic water supply	200

Great strides have been made since 1915 toward meeting our needs for water. Throughout the country many new ground-water supplies have been developed in recent years for towns that have not previously had public waterworks. There has also been great advance in the methods of constructing wells to shut in pollution at the top of the well, at the point of intake, and at the intermediate segments of the well. Thus, careful and accurate ground water investigations, according to the best scientific principles, utilizing the most modern drilling equipment and mater-

TABLE 2†

Analyses, in parts per million, by U. S. Geological Survey

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Silica (SiO_2)	----	----	----	----	----	----	----	----	7.80	----	----	----	----	----	----	----
Iron (Fe)	.02	.00	.06	.17	.00	.02	.13	.00	.13	.08	.00	.17	.02	.00	.00	.00
Calcium (Ca)	14.00	26.00	1.00	47.00	112.00	56.00	3.20	14.00	2.60	8.70	20.00	19.00	1.20	21.00	31.00	13.00
Magnesium (Mg)	5.70	11.00	.40	12.00	30.00	17.00	.60	7.00	1.10	3.10	8.70	5.80	.30	1.90	8.40	1.10
Sodium (Na)	1,020.00	1,660.00	1.50	1,510.00	2,640.00	1,310.00	420.00	876.00	383.00	321.00	913.00	1,090.00	1.50	1.80	11.00	2.10
Potassium (K)	----	----	.60	18.00	32.00	----	4.80	----	4.70	----	----	13.00	.60	1.10	2.90	1.10
Carbonate (CO_3)	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	12.00	.00	.00	.00	.00	.00
Bicarbonate (HCO_3)	456.00	394.00	5.00	378.00	243.00	370.00	420.00	486.00	366.00	258.00	455.00	470.00	6.00	77.00	164.00	48.00
Sulphate (SO_4)	45.00	.20	1.50	.80	2.00	1.20	5.40	1.80	1.20	1.40	1.40	.40	.80	1.00	1.60	2.00
Chloride (Cl)	1,320.00	2,390.00	2.00	2,220.00	4,170.00	1,970.00	400.00	1,090.00	370.00	370.00	1,190.00	1,480.00	2.50	3.00	1.80	2.20
Fluoride (F)	----	----	.10	2.00	2.00	----	4.00	----	2.00	----	----	2.80	----	.20	.00	.00
Nitrate (NO_3)	.20	.40	.20	----	3.90	.30	7.60	.20	.70	.20	.30	.60	.40	.00	.20	.20
Dissolved solids	2,680.00	4,380.00	20.00	4,140.00	7,530.00	3,610.00	1,080.00	2,300.00	959.00	865.00	2,410.00	2,980.00	13.00	78.00	158.00	56.00
Hardness as $CaCO_3$																
Total	58.00	110.00	4.00	166.00	403.00	210.00	10.00	64.00	11.00	34.00	86.00	72.00	4.00	60.00	112.00	37.00
Non-carbonate	.00	.00	.00	.00	204.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Color	6	4	5	4	6	6	5	6	5	6	5	7	7	5	10	5
pH	7.9	7.6	5.7	8.0	7.9	7.8	8.1	7.5	8.1	7.9	8.4	7.6	6.1	6.8	7.5	6.7
Specific conductance (microhmos at 25° C.)	4,880.0	7,900.0	29.7	7,360.0	12,700.0	6,590.0	1,910.0	4,180.0	1,710.0	1,610.0	4,420.0	5,310.0	19.0	118.0	254.0	88.9
††Temperature (°F.)	74.0	73.0	65.0	----	67.0	76.0	75.0	70.0	85.0	78.0	68.0	74.0	----	----	----	----
Depth (feet)	1,760.0	1,650.0	Springs	1,311.0	1,400.0	1,328.0	1,378.5	904.0	1,295.0	1,450.0	1,229.0	1,275.0	118.0	252.0	312.0	194.0
Water-bearing formation	Eutaw	Eutaw	Nanafalia*	Eutaw	Eutaw	Eutaw	Eutaw to 1,369 ft.	Eutaw	Eutaw	Eutaw, or Upper Tuscaloosa	Eutaw	Eutaw	Nanafalia*	Nanafalia*	Nanafalia*	Tuscahoma*
Use	Domestic stock	Domestic stock	Public water supply	Dairy stock	Stock	Domestic stock	Public water supply	Domestic stock	Public water supply	Stock	Domestic	School	Domestic public supply	Domestic public supply	Domestic public supply	Domestic public supply
Yield (g.p.m.)	5.0	5.0	200.0	5.0	3.0	----	50.0	2.0	50.0	20.0	10.0 est.	10.0 est.	----	----	----	----
Date of collection	7/28/55	6/24/55	11/ 4/54	10/ 5/55	12/ 1/55	7/28/55	11/ 4/54	6/21/55	11/ 4/54	6/22/55	6/21/55	9/23/55	10/25/56	10/23/56	10/23/56	10/23/56

1. Bill Conner property, SW.¼, Sec.11, T.11 N., R.16 E., northeast of DeKalb, Miss.
2. R. J. Spanks property, SE.¼, Sec.14, T.11 N., R.16 E., northeast of DeKalb, Miss.
3. City of DeKalb, Miss., SW.¼, Sec.21, T.11 N., R.16 E.; possibly NW. ¼, Sec.28, T.11 N., R.16 E.
4. L. M. McDade property, SW.¼, Sec.34, T.11 N., R.17 E., 6 miles east of DeKalb, Miss.
5. Vernon Simmons property, SE.¼, Sec.8, T.9 N., R.18 E., Enondale, Miss.
6. M. F. Rush property, NE.¼, Sec.31, T.10 N., R.18 E., 1.5 miles southwest of Porterville, Miss.
7. E. A. Temple property, T.11 N., R.18 E., Electric Mills, Miss.
8. V. W. Thomas property, NW.¼, Sec.1, T.12 N., R.17 E., Wahalak, Miss.
9. City of Scooba, Miss.
10. G. B. Luke property, SW.¼, Sec.6, T.12 N., R.18 E., 1.5 miles east of Wahalak, Miss.
11. Z. I. Bruton property, SW¼, Sec.11, T.12 N., R.17 E., 1.5 miles southwest of Wahalak, Miss.
12. Porterville High School, SE.¼, Sec.29, T.10 N., R.18 E., Porterville, Miss.
13. Glen Brown property, SE.¼, Sec.5, T.9 N., R.16 E., North Blackwater, Miss.
14. J. A. Pace property, SE.¼, Sec.33, T.10 N., R.15 E., Liberty, Miss.
15. E. E. Davis property, SE.¼, Sec.18, T.10 N., R.15 E., Moscow, Miss.
16. S. C. Palmer property, SE.¼, Sec.36, T.12, N., R.14 E., Linville, Miss.

† Analyses courtesy of U. S. Geological Survey, Ground Water Branch, Jackson, Miss.

* Water-bearing formations are the interpretation of the writer.

†† Not formation temperatures.

ials used in well construction is the answer to obtaining a better and more plentiful supply of ground water the consumption of which is on the increase in not only the cities, but also in the country.

Ground water is widespread in the rocks of Mississippi, and in Kemper County notable supplies are found in the sands and gravels of the Eutaw formation and in the sands of the Nanafalia, and the Tuscahoma formations of the Wilcox group. A very local and limited supply of water may be found in the Porters Creek clay. In the rugged Sand Hills topography encompassing all of the Wilcox group, springs are common and three such springs supply DeKalb, the county seat.

The deep well waters pumped from the Eutaw sands at Scooba, and at Wahalak are highly mineralized and are unusually high in chlorine. The first sand of the Eutaw is generally more highly mineralized and the second sand less so. The chloride content falls off in the deeper sands. The Tombigbee sand member of the Eutaw approximately 70 to 100 feet in thickness is very rich in chlorine and sodium and the waters are strong. The second sand, some 395 to 400 feet in thickness and separated from the first by approximately 100 feet of shales, etc. has much better water.

CHEMICAL ANALYSES

The analyses of ground water from 16 localities in Kemper County (Table 2) is of utmost importance when these properties are understood and interpreted.

In the following tabulation are shown the commoner salts present in natural fresh waters:

Compound	Equivalent Weight		Chemical Formula	Ionization Cation +	Formula Anion −
1. Calcium Bicarbonate	20.0	61.0	$Ca(HCO_3)_2 \rightleftharpoons$	Ca^{++}	$+2(HCO_3)^-$
2. Calcium Carbonate	20.0	30.0	$CaCO_3 \rightleftharpoons$	Ca^{++}	$+CO_3^{--}$
3. Calcium Sulphate	20.0	48.0	$CaSO_4 \rightleftharpoons$	Ca^{++}	$+SO_4^{--}$
4. Calcium Chloride	20.0	35.5	$CaCl_2 \rightleftharpoons$	Ca^{++}	$+2(Cl)^-$
5. Calcium Nitrate	20.0	62.0	$Ca(NO_3)_2 \rightleftharpoons$	Ca^{++}	$+2(NO_3)^-$
6. Magnesium Bicarbonate	12.2	61.0	$Mg(HCO_3)_2 \rightleftharpoons$	Mg^{++}	$+2(HCO_3)^-$
7. Magnesium Carbonate	12.2	30.0	$MgCO_3 \rightleftharpoons$	Mg^{++}	$+CO_3^{--}$
8. Magnesium Sulphate	12.2	48.0	$MgSO_4 \rightleftharpoons$	Mg^{++}	$+SO_4^{--}$
9. Magnesium Chloride	12.2	35.5	$MgCl_2 \rightleftharpoons$	Mg^{++}	$+2(Cl)^-$
10. Magnesium Nitrate	12.2	62.0	$Mg(NO_3)_2 \rightleftharpoons$	Mg^{++}	$+2(NO_3)^-$
11. Sodium Carbonate	23.0	30.0	$Na_2CO_3 \rightleftharpoons$	$2(Na)^+$	$+CO_3^{--}$
12. Sodium Chloride	23.0	35.5	$NaCl \rightleftharpoons$	Na^+	$+Cl^-$
13. Sodium Sulphate	23.0	48.0	$Na_2SO_4 \rightleftharpoons$	$2(Na)^+$	$+SO_4^{--}$
14. Ferrous (Iron) Bicarbonate	27.9	61.0	$Fe(HCO_3)_2 \rightleftharpoons$	Fe^{++}	$+2(HCO_3)^-$

Other materials may be present in small amounts such as potassium, silica, manganese, aluminum, ammonium, boron, fluorine, bromine, and iodine. Very occasionally may be encountered such substances as selenium, antimony, arsenic, barium, copper, lead and zinc. All these substances exist in chemical composition and not in the free state.

In water analyses it is necessary to determine the presence of various substances which are found in very small amounts. For this reason the results of water analyses are expressed in parts per million (p.p.m.) by weight of total dissolved solids rather than percentages, as in the case of other analyses. One part per million means one part in a million parts; for example, one ounce in a million ounces of water, or one pound in a million pounds of water. It makes no difference what units are used so long as the relation between the substance reported and the water is the same. Total dissolved solids in waters range from as low as 28 p.p.m. in the Catskills of New York to 34,300 p.p.m.

in sea water. Some saline lakes are much higher, for example, the Katwee Salt Lake, north of Albert Edward Nyanza, central Africa has 310,000 p.p.m. A water, for example, which contains approximately 1,273 p.p.m. total dissolved solids represents about the maximum to be expected in a "fresh" water. As mentioned above a water containing only 28 p.p.m. is one of the purest of waters. Waters containing less than 150 p.p.m. of hardness are generally classed as "good", those containing from 150 to 350 p.p.m. as "fair", and those exceeding 350 p.p.m. as "bad".

Total dissolved solids may also be expressed as equivalents per million (e.p.m.) of the individually determined ions. For convenience, the cations (positive ions) may be arranged in one group and the anions (negative ions) in another.

The following example will serve to illustrate the method of computing the total dissolved solids by using e.p.m. calculations.

For example, to convert 150 p.p.m. of calcium as $CaCO_3$ to e.p.m., divide the 150 p.p.m. by the equivalent weight of 50 and obtain an answer of 3.0 e.p.m. To convert sulphate as SO_4 from p.p.m. to e.p.m., divide the p.p.m. of 96 by the equivalent weight of 48 and obtain the result 2.0 e.p.m. Conversely, multiplying the e.p.m. of the material present by the equivalent weight will give the p.p.m. of that particular material that may be present. Therefore, with 3.0 e.p.m. of calcium, to convert to calcium in p.p.m., multiply the 3.0 e.p.m. by 20, the equivalent weight of calcium, and obtain 60 p.p.m. of calcium present as Ca.

Calculations of Total Solids By e.p.m.

		ppm	e.p.m. + cations	e.p.m. − anions	ionic p.p.m.
Calcium	as $CaCO_3$	150 =	3.0	=	60 as Ca
Magnesium	as $CaCO_3$	50 =	1.0	=	12 as Mg
Sulphate	as SO_4	96 =		2.0 =	96 as SO_4
Chloride	as Cl	18 =		0.5 =	18 as Cl
Bicarbonate	as $CaCO_3$	120 =		2.4 =	146 as HCO_3
Sodium	as Na (difference)		0.9	=	21 as Na
Total Dissolved Solids					353
			4.9	4.9	

PHYSICAL TESTS

Physical tests, which relate to the attractiveness of a water, include odor, taste, color, turbidity, sediment and temperature.

Odors — Of all the physical characteristics which may form a part of drinking water, odor and taste are least tolerated by the public. The various odors that may be reported, and their abbreviations, are classified by Whipple (Whipple, 1899) as follows:

a aromatic	g grassy	S hydrogen sulphide
C free chlorine	m mouldy	v vegetable
d disagreeable	M musty	
e earthy	p peaty	
f fishy	s sweetish	

The intensity of the odor is relative, and depends on the observer. Whipple rates the intensity on a numerical scale.

0 no odor	3 distinct
1 very faint	4 decided
2 faint	5 very strong

For example 1v means very faint vegetable odor. Odors are due to dissolved gases, trade wastes, algae and diatoms, and the secretions of certain microorganisms.

Taste — Only four true taste sensations are recognized: (1) sour or acid, associated with hydrogen ions; (2) sweet, found in sugars and associated with hydroxyl; (3) salty, produced by chlorides, nitrates, and sulphates; and (4) bitter, associated with alkaloids. Most other so-called tastes are due to odors that reach the olfactory organs at the time the material is tasted. Sodium chloride, common salt, for example, causes a perceptible taste when present in amounts greater than 200 p.p.m., and water will be practically undrinkable if the amount is 3,000 p.p.m. Magnesium sulphate (Epsom Salts) and sodium sulphate (Glauber Salts) in large amounts, 500 p.p.m. or more, will both have natural laxative effects. Total dissolved solids of over 2,000 p.p.m. would probably be objectionable as to cooking tastes and industrial uses even if the minerals were not hardness producers. The Public Health Standards recommend 500 p.p.m. as the upper limit, with 1,000 p.p.m. permissible if better water is unobtainable.

Color — Waters usually vary from colorless to a deep brown. Color in natural water is found generally to be due to the presence of tannin in solution (from decaying vegetable growth) or from various industrial wastes. In the measurement of the color of a water, an arbitary standard scale is used as a means for comparison of color intensity with the water sample. A water which possesses a color of 5 units means that the intensity of the color of this water is equal to the intensity of the color of a sample of distilled water containing 5 milligrams of platinum (as potassium chloroplatinate) per liter. The "true" color of a water sample is that due only to the presence of soluble substances. The "apparent" color is that due to the presence of both soluble and suspended substances. For the measurement of color in the field, glass discs as used by the United States Geological Survey are quite satisfactory.

Turbidity and sediment — Turbidity is a term used to describe the presence of substances in a water which interfere with its clarity. Clay, silt, finely divided organic matter, or microscopic organisms may cause a water to have a turbidity.

The standard unit of turbidity is the optical obstruction of light caused by 1 p.p.m. of insoluble silica (using diatomaceous earth or Fuller's earth) in distilled water. Thus, the fact that a water has a turbidity of 15 p.p.m. as SiO_2 means that the obstruction of light through this particular water is equivalent to the obstruction of light by a sample of distilled water containing 15 p.p.m. of insoluble silica. Turbidities are expressed in parts per million by weight and may range in natural waters from 1 p.p.m. or less to as much as 40,000. The U. S. Public Health Service Standard for drinking water is not over 10 p.p.m. on the silica scale.

Temperature — The temperature of water to be acceptable as a municipal supply should be between 45° and 50° F. Warm waters are less palatable partly because of the dearth of dissolved gases. Ground waters normally have a constant temperature that is close to the mean annual air temperature for water from depths of 30 to 60 feet. Below 60 feet the temperature increases about 1° F. for each increase in depth of from 50 to 100 feet depending on location.

OTHER TESTS

Hardness — Hardness in waters is caused largely by the presence of salts of calcium and magnesium. For the layman water which requires a large amount of soap to form a lather is termed "hard water". The following four compounds account for the hardness of practically all waters.

Calcium bicarbonate — $Ca(HCO_3)_2$
Magnesium bicarbonate — $Mg(HCO_3)_2$
Calcium sulphate — $CaSO_4$
Magnesium sulphate — $MgSO_4$

Chlorides and nitrates of calcium and magnesium when present contribute to the hardness of a water in a manner similar to the sulphates of these elements. The hardness in water is expressed in terms of calcium carbonate ($CaCO_3$) for convenience of calculations. These hardness values of waters are given as *carbonate hardness,* which includes all bicarbonates and normal carbonates of calcium and magnesium, the *non-carbonate hardness,* which includes all other compounds of calcium and magnesium present in the water. The sum of these two is known as the *total hardness.*

Natural waters may be generally classified as follows:

Hardness	Classification
less than 15 p.p.m.	very soft water
15 to 50 p.p.m.	soft water
50 to 100 p.p.m.	medium hard water
100 to 200 p.p.m.	hard water
greater than 200 p.p.m. total hardness	very hard water

pH—pH may be defined as the logarithm of the reciprocal of the hydrogen ion concentration.

$$pH = \log_{10} \frac{1}{(H+)} = \log_{10} \frac{1}{1 \times 10^{-7}} = \log_{10} (1 \times 10^{7}) = 7$$

In common parlance this means that the pH value is a number between 0 and 14, denoting various degrees of acidity or alkalinity. Pure water has a pH value of 7 which is neutral. Values below 7 and approaching 0 are increasingly acid while values from 7 to 14 are increasingly alkaline.

Specific Conductance — Specific conductance is a measure of the total ionic concentration. Because of this property of the conductance test, it can be readily used to control the dissolved solids concentration of a boiler and to serve as an accurate means for the control of boiler blow down (letting water out of a boiler for the purpose of carrying out sediment to reduce the concentration of dissolved solids or for both purposes). Specific conductance is a direct measure of the conductivity and may be defined as the conductance of a cube of material having a volume of 1 c.c. The unit of conductance is the mho (reciprocal of ohm). Results are generally expressed in micro-mhos (millionth part of a mho).

Iron — Iron is present in the earths crust to the extent of about 4 per cent on the average and is often found in water supplies. Iron exists in two states — ferrous iron and ferric iron. In the ferric state (suspended ferric hydroxide in surface waters) the iron is completely oxidized, whereas, in the ferrous state (ferrous bicarbonate in subsurface waters) it is only partly oxidized. Often iron-bearing waters are clear and colorless when first drawn from a well, but on standing in contact with the atmosphere, they slowly cloud and finally deposit a yellowish to reddish brown precipitate of ferric hydroxide. The amounts of iron present in the majority of such waters will be in the range below 5 p.p.m. A few will contain 5 to 15 p.p.m., the latter figure representing the maximum with the exception of a very few, although an occasional one will range up to 40 p.p.m. or more.

The presence of iron in water to any appreciable extent causes rust, destroying the sanitary appearance of sinks, lavotories, etc. Iron renders water unsuitable for paper making, laundering, dyeing, and many other manufacturing processes. Its presence even to only the small extent of 0.5 p.p.m. will permit the growth of iron-depositing organisms such as *Crenothrix, Spirophyllum, Leptothrix, Didymohelix,* and the *Siderocapsa* which will cause the formation of incrustations on the inside of the mains of the distribution system if not checked. The content of iron should not exceed 0.2 p.p.m. if iron troubles are to be avoided, but many supplies exceed this limit. For many uses tolerance should not exceed 0.1 p.p.m.

Total solids — Total solids represent the sum of the disolved and suspended solids. The suspended solids are those solids which are not in true solution and which can be removed by filtration. Dissolved solids are in true solution and can not be removed by filtration.

Standards vary but the U. S. Public Health Service Drinking Water Standards recommend that the total solids of a palatable supply be limited to 500 p.p.m. for a water of good quality. The standards also state that the total solids may be 1,000 p.p.m., if such a water as above is not available.

IRON ORE

The iron ores of Kemper County are mainly in the form of limonite (cryptocrystalline goethite with adsorbed or capillary water, $HFeO_2 \cdot nH_2O$). The Sediment Color Chart, Plate 14, shows the FeO/Fe_2O_3 ratios. Note the limonite-lepidocrocite, limonite-goethite relationships. Minor amounts of the ore siderite (carbonate of iron, $FeCO_3$) and ferruginous grits, are found. The

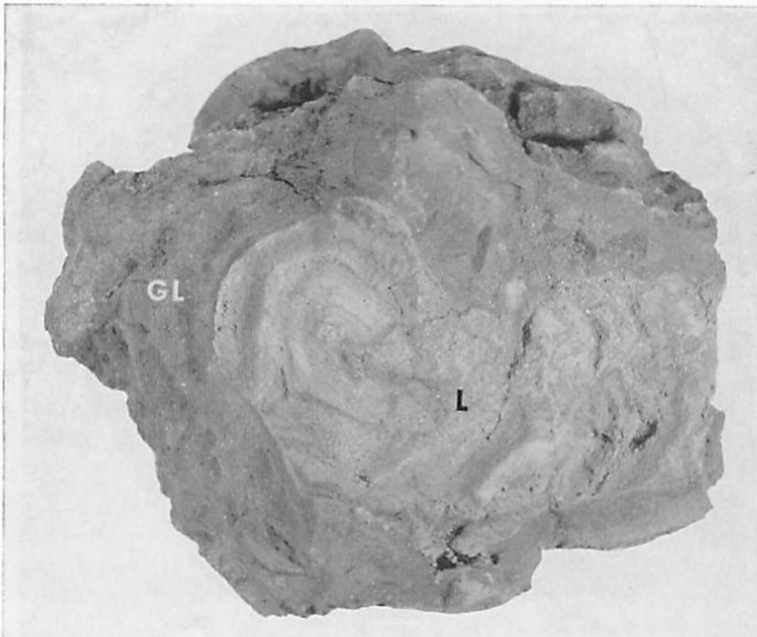


Figure 60.—Photograph of a limonite (L), goethite or lepidocrocite (GL) concretion from the Matthews Landing marl member of Porters Creek clay. Specimen collected from road cut at foot of hill, 0.5 mile northeast of an intersection (NE.¼, Sec.19, T.10 N., R.17 E.). x7/8.

Matthews Landing marl member of the Porters Creek clay is the main iron-bearing unit in the county. As previously mentioned, it is a persistent bed cropping out throughout the entire county, its thickness averaging 5 feet. The ore is concentrated into irregular shaped masses and concretions which are ellipsoidal and disc like (Figure 60). The siderite ores are not economically important in Kemper County but range throughout the entire thickness of the Porters Creek clay, mainly in the form of concretionary masses. Much of the topographic relief of the Matthews Landing marl is slight and dips are low and these conditions are to be considered in general as favorable for strip-mining operations. Furthermore the geographic locality of Kemper County is favorable for strip-mining operations. It is located near Bessemer, Alabama and Granite City, Illinois to which places the ores could be shipped, if mined on a commercial scale. Roads and truck lines or spur railroads could be easily constructed at a comparatively small cost because of probable cheap right-a-way costs over cut-over timber lands, of little value for agriculture and because of slight topographic relief.

No calculations have been made as to the exact amount of ore within the county. The total of the iron ore is perhaps several million tons — or approximately 10,000 - 15,000 tons per acre. Chemical analyses were made of nine samples of the Matthews Landing marl from different localities in the county. The results of these analyses are as follows:

ANALYSES OF IRON ORE

Laboratory Analyses No. Miss. State Chemical Laboratory	Type Sample and Location	Percent Iron
275,407	Core, Sciples Mill SW.¼, Sec.24, T.12 N., R.15 E.	26.39
275,408	Core, Sciples Mill Sw.¼, Sec.24, T.11 N., R.15 E.	32.82
275,409	Creek bed, Sciples Mill SW.¼, Sec.24, T.11 N., R.15 E.	22.95
275,410	Outcrop, creek bed, Indian Branch SE.¼, Sec.24, T.11 N., R.15 E.	38.10
275,411	Outcrop, creek bed NW.¼, Sec.25, T.11 N., R.15 E.	45.90
275,412	Outcrop—Side road E. of U.S. Hwy. 45 SW.¼, SE.¼, NW.¼, Sec.18 T.9 N., R.18 E.	39.01
275,413	Outcrop—Side road E. of U.S. Hwy. 45 SW.¼, SE.¼, NW.¼, Sec.18 T.9 N., R.18 E.	34.88

275,414	Outcrop—Side road E. of U. S. Hwy. 45 SW.¼, SE.¼, NW.¼, Sec.18 T.9 N., R.18 E.	42.92
275,405	Limonite concretion-type ore, outcrop NE.¼, Sec.19, T.10 N., R.17 E.	44.75

Disseminated throughout the Nanafalia formation are very coarse ferruginous sandstones which the writer prefers to call

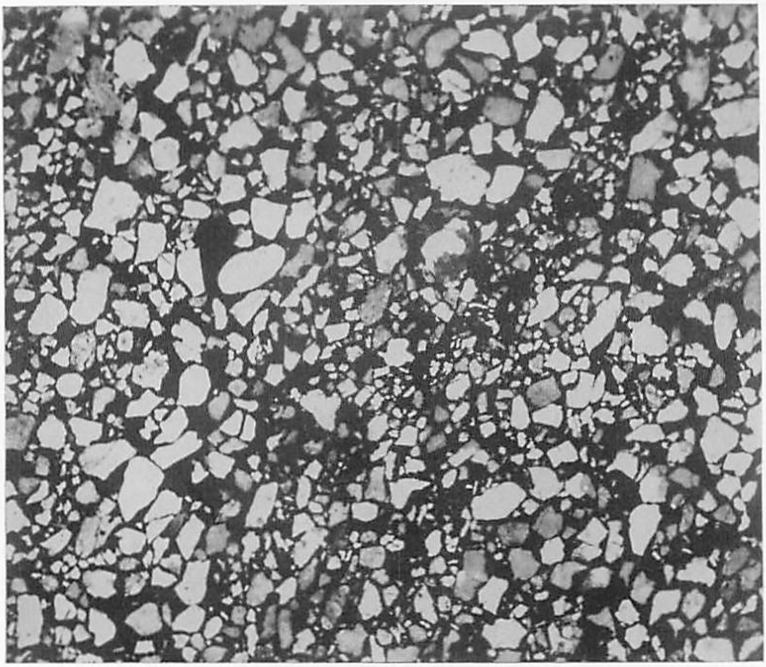


Figure 61.—Microphotograph of thin section of ferruginous grit. Note optical alignment of quartz grains exhibiting parallelism of C-axes in a NE-SW direction. Light-colored material of aggregate is quartz. Black matrix is earthy hematite. Crossed nicols. x8.

ferruginous grits. Although these grits are unimportant commercially they present an interesting study. Chemical analysis of one sample (Sample No. 275,406) from the large gully at Oak Grove, NE.¼, Sec.33, T.10 N., R.17 E., showed only 28.00 percent iron. A petrographic modal analysis showed the following:

MINERAL COMPOSITION

Ferruginous Grit

Aggregate** (percent)		Cementing Material (percent)		Accessories (percent)	
Quartz	90	Hematite	90	Zircon	0.5
Muscovite	1	Limonite	10	Tourmaline	Trace
Chlorite	1				
Biotite	0.5				
Chert*	2				
Enstatite***	5				

* Chert is here designated as minute amorphous silica making up several grains of quartz in the section.

** The ferruginous grit is composed of 65 percent aggregate and 35 percent cement (iron).

*** The material designated enstatite is badly weathered and exact determination is difficult. Orthopyroxene is perhaps a better term to use.

Figure 61 is a microphotograph of the ferruginous grit. Quartz grains make up the greater part of the aggregate and are mostly angular. A few of the grains are, however, sub-rounded, with an occasional well-rounded grain.

SAND

There is an abundant supply of sand in Kemper County. However, large economically workable deposits favorably located with respect to consumers' plants are more limited.

"The principal uses for sand and gravel are as fine and coarse aggregate for concrete for construction of buildings, bridges, dams, highways, runways, and similar structures and for concrete blocks, pipes, and other concrete products. Large quantities are used without admixtures for subgrade or bases for highways and airports. Significant quantities are used also for township and county secondary or tertiary roads, with or without admixtures, and for railroad ballast.

"Metal industries consume substantial quantities annually as molding sands. Similar but smaller tonnages of sand are consumed in making glass of all types. Railroads consume large quantities to increase brake friction on slippery or wet rails.

"Municipalities require considerable quantities of both sand and gravel for water filters in purification of city water supplies.

"Smaller quantities of special types of sands are consumed in sand blasting, grinding, and polishing." (Staff, U. S. Bureau of Mines, 1956.)

The sands in Kemper County are relatively impure, quartzose (SiO_2) sands. The chief impurities are clay balls, muscovite, and limonite, disseminated as concretionary aggregates, and as coatings on the sand grains. The sands are mostly in a loose, unconsolidated condition and can be readily scooped up without recourse to blasting. No crushing is required.

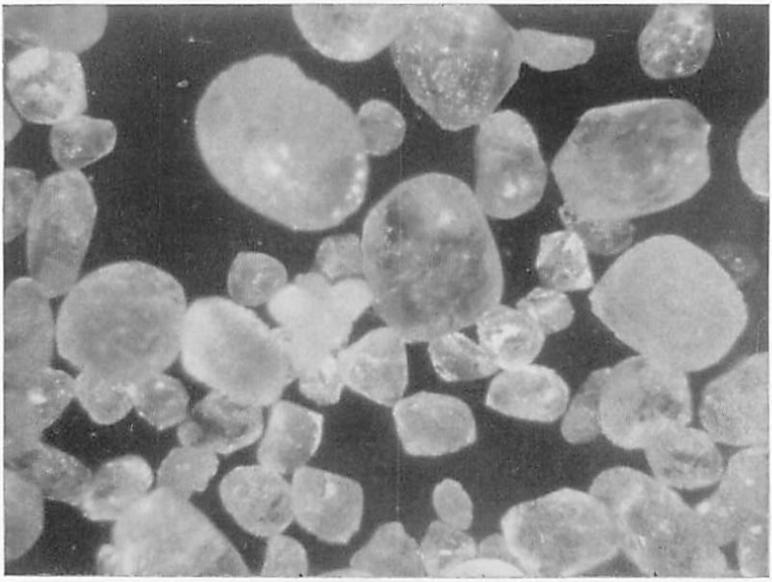
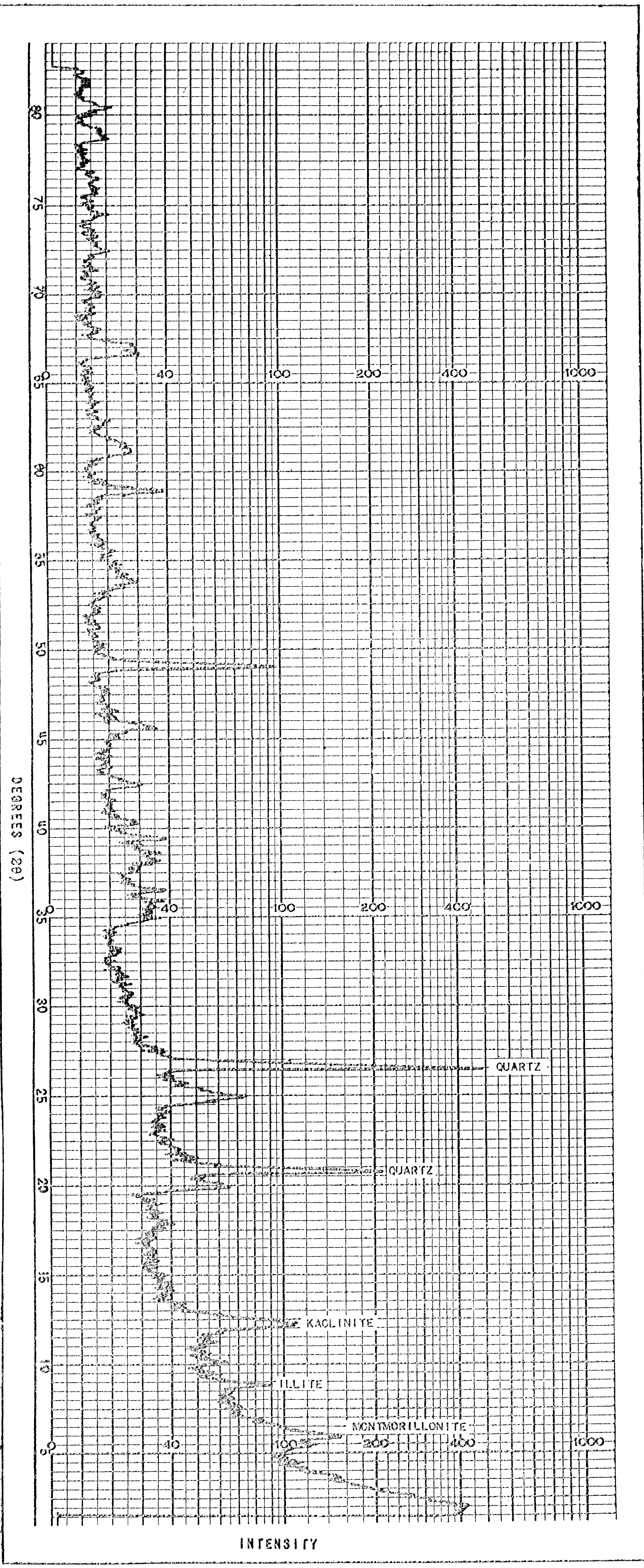


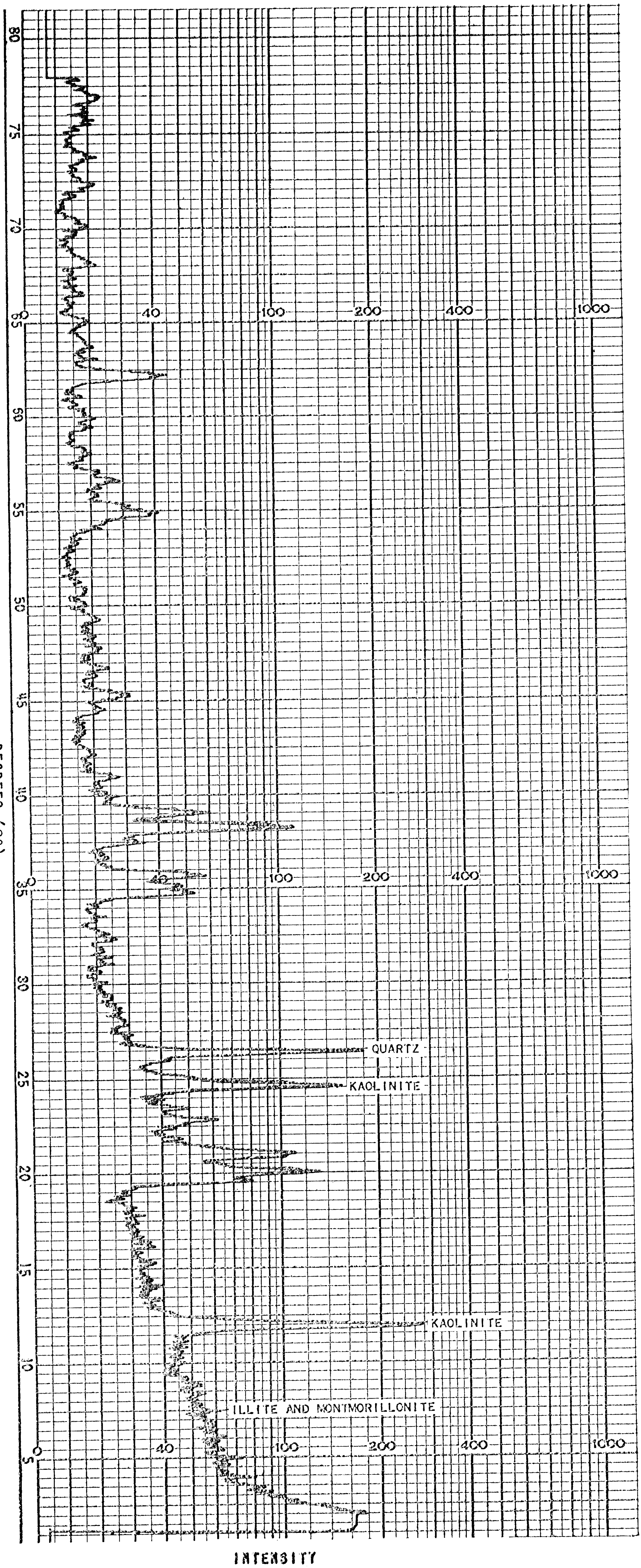
Figure 62.—Photomicrograph of a portion of washed sample of Fearn Springs sand showing rounded and angular quartz grains. x13.

The channel sands of the Fearn Springs sand member of the Nanafalia formation are best suited for general constructional purposes. Fresh exposures vary from white or light cream color to a light brown. Red to brown ferruginous streaks are developed locally along cross-bedding planes.

The texture of the Fearn Springs sand has been studied microscopically and megascopically and a photomicrograph appears as Figure 62. Fine and coarse to very coarse grains compose all samples examined. The photomicrograph of the washed sample shows that both small and large grains are indiscriminately mixed and that the grains range from rounded to angular in outline. Some grains are wholly angular, particularly the smaller grains; others are partly rounded; some are clear, others frosted;



X-RAY DIFFRACTION DIAGRAM OF BLUE-GRAY CLAY (SAMPLE A).



X-RAY DIFFRACTION DIAGRAM OF WHITE KAOLINITIC CLAY (SAMPLE 8).

and only a very small percentage is entirely rounded. The latter are very rarely perfectly round, but instead they are in most cases oblong or egg-shaped.

CLAY

No detailed investigation was made of clays in Kemper County. Samples were taken from two localities for X-ray diffraction analyses, the diagrams of which appear as Plates 15 and 16.

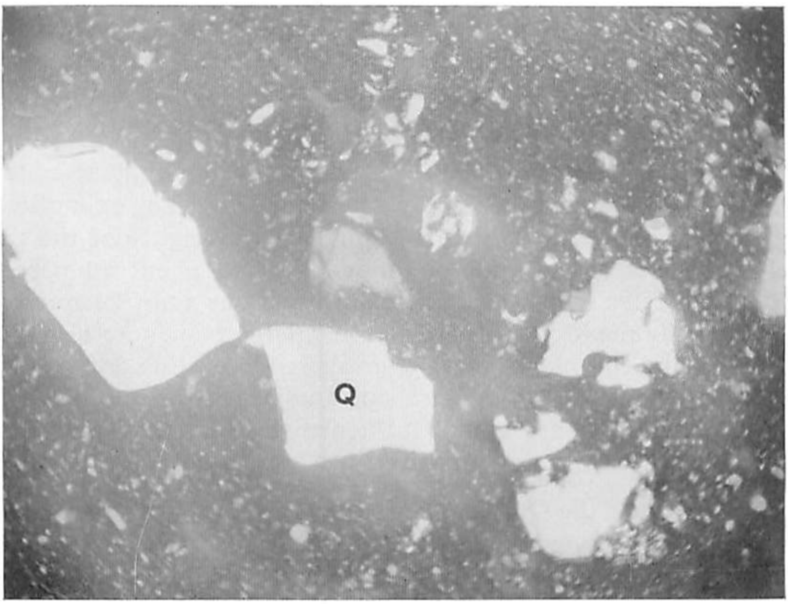


Figure 63.—Photomicrograph of thin section of impure kaolin showing quartz grains (Q) in a matrix of kaolinite and iron-stained clay. Crossed nicols. x110.

Sample A (Plate 15) was obtained from a small draw approximately SE.¼, SW¼, Sec. 28, T.12 N., R.15 E. The clay was dark bluish gray and was found to be overlain by approximately 30 feet of overburden. As shown in the spectrometer trace the sample is composed of about 35 percent quartz, 30 percent kaolinite, 20 percent montmorillonite, and 15 percent illite. In the industrial classification of clays this clay is considered to be the ball type.

Sample B (Plate 16) (NE.¼, Sec.4, T.11 N., R.16 E.) is of no economic importance in the county because of its spotty distribution. It is a white, kaolinitic clay composed almost entirely of the mineral kaolinite. On examining the spectrometer trace it is readily seen to be composed of about 75 percent kaolinite, 15 percent quartz and 10 percent montmorillonite and illite. A thin-section (Figure 63) with crossed nicols shows angular quartz grains ranging in size from 1 mm. to less than 10 microns in a ground mass of kaolinite and iron stained clay.

Many ceramic products are manufactured with clay as a constituent, or in some cases, the only raw material. A knowledge of the behavior of clay particles when subjected to various stresses is important in engineering operations. The success of the manufacturing operation, or foundation studies is, therefore, dependent on certain properties of clay-water mixtures.

Pure clay ($Al_2Si_2O_5(OH)_4$), or kaolinite, is found in nature as being composed of extremely small particles. For example, in a ball clay approximately three-fourths (by weight) of the particles are less than 1 micron in length, and about 70 percent of the particles of a residual kaolin are finer than 20 microns. Photographs made with the electron microscope show clay particles as thin, flat plates, mostly hexagonal in outline and exhibiting basal cleavage (010). The shape and size of the clay particles are important factors which influence the plasticity and other properties of clay-water mixtures.

Plasticity is the ability of the substance to undergo permanent deformation (beyond the elastic limit). In clay-water mixtures, the plate-like clay crystals are in stacked-up piles, hexagonal in shape (Figure 64-A).

The platy surfaces are separated by thin water films (Figure 64-B). The water film between the plate-like surfaces is pulled down into capillary spaces, and the capillary forces of attraction tend to pull the particles together. Electric charges on the particles set up repulsive forces and a state of equilibrium is brought about wherein the repulsive forces are just balanced by the hydrostatic tension forces. When a plastic clay-water mass is subjected to an increasing load, its initial deformation is within the elastic limit, but finally the yield point is reached, and permanent and plastic deformation results. The yield point is related to the holding together of the mass of clay particles and water by an outer surface film while plastic deformation is be-

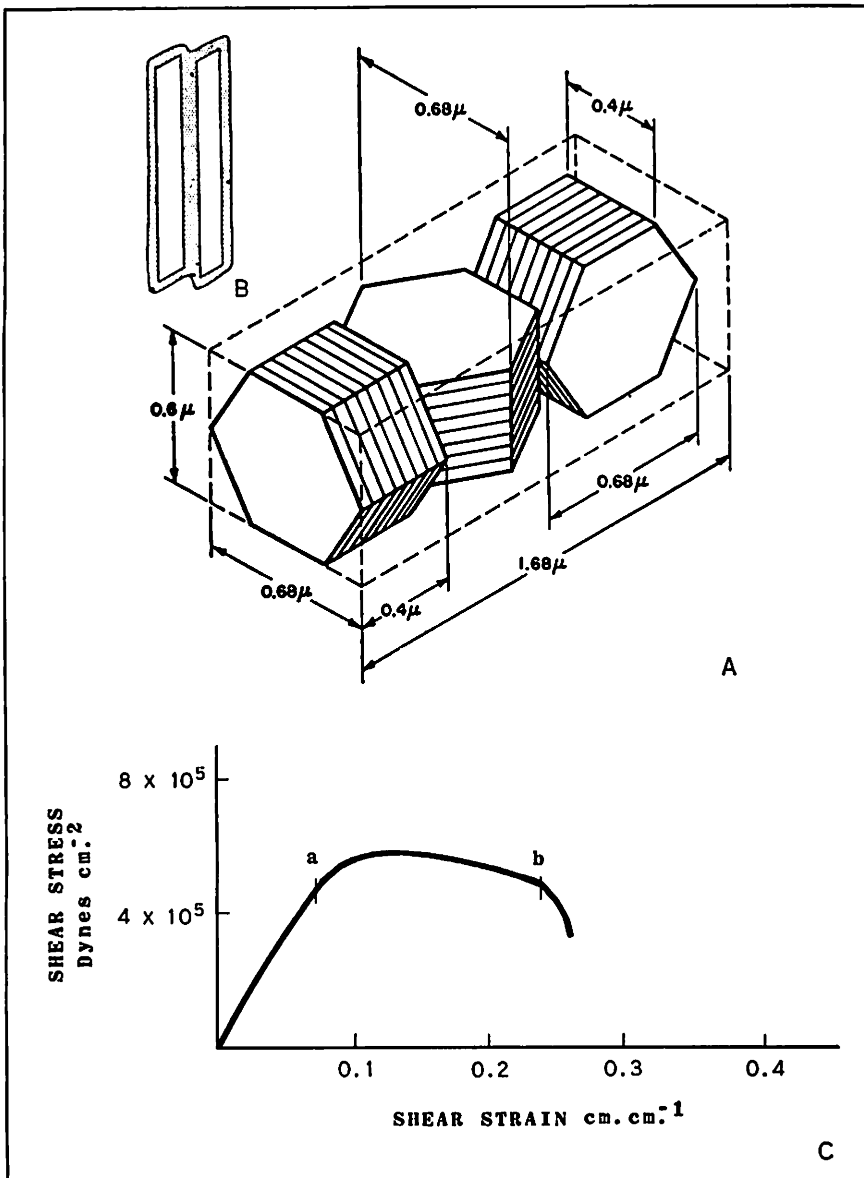


Figure 64.—Shape, arrangement, water-film surface and stress-strain diagram of a kaolinitic clay. A. Hexagonal, plate-like arrangement of clay crystals. B. Water film surface (Stipple) surrounding clay crystals. C. Stress-strain diagram illustrating concept of plasticity (After W. J. Knapp, Properties of Clays, pp. 125-127 in Basic Studies in the Clay Industry, 1956).

lieved due to the sliding of the plate-like particles over each other (shear) along an infinite number of glide planes.

The stress-strain diagram in Figure 64-C illustrates the concept of plasticity. The region of plastic deformation is indicated by a and b in the figure. A workable clay-water mass should have a yield value large enough to prevent the mass from deforming under it own weight, or by accidental loadings. The region a b should, therefore, be large enough to allow formings to take place without rupturing the mass. The workability of the clay-water mixture is directly proportional or equal to the product of the yield point value and the maximum extension. If a relatively stiff plastic clay is mixed with more water, there will be a decrease in the yield point and an increase in the region of plastic deformation. These changes proceed at unequal rates, and their product (i.e. workability) passes through a maximum value. The above is analogous to what happens by mixing clay and water (added in increments) by hand. The water (wetting agent) will reduce the surface tension of the water and likewise reduce the hydrostatic tension forces of attraction acting between the kaolinite plates. The yield point value is thereby reduced as in the workability.

Fine-grained clays will exhibit greater plasticity than the coarser-grained clays when mixed with water. The reason for this can be readily seen in the greater surface area in plate to plate interfaces in the finer-grained clays, and the smaller capillary channels between the fine-grained particles. It has been estimated that a gram of clay might have 200 to 900 square meters of surface. This would average about 2 million times the surface area of a single pebble one centimeter in diameter (Knapp, 1956).

BAUXITE

Bauxite is not present in commercial quantities in Kemper County. During World War II, nine cars of the ore (some 400 tons) taken from the Pete Flora property NW.¼, NW.¼, Sec.10, T.12 N., R.16 E. were shipped to the Monsanto Chemical Company. A negligible amount of ore remains there. The bauxite was of chemical-grade with 50 to 58 per cent of alumina, 17 to 21 per cent of silica, and little ferric oxide. The deposit was about 4 feet thick and overlay some 6 feet of kaolin.

OIL AND GAS

As of September, 1957 there have been a total of 14 wells drilled in search of oil in Kemper County, all of which were dry holes.

The first well was drilled in 1940 when W. E. Manning drilled the wildcat W. T. Caldwell No. 1 (C. SW.¼, SW.¼, Sec.25, T.9 N., R.15 E.) to a depth of 3,187 feet well into the Tuscaloosa sand. In the same year R. J. Dean drilled the W. A. Land No. 1 (353 ft.S., 353 ft.E., NW.Cor., NW.¼, NE.¼, Sec.12, T.10 N., R.14 E.). The well was drilled to a total depth of 2,101 feet, a few feet into the Eutaw sand, with no production.

Two wells were drilled in 1941. The A. E. Manning No. 1 McKelvaine (NE.¼, SE.¼, Sec.2, T.9 N., R.17 E.) was abandoned at 1,475 feet in the Eutaw. An offset well was drilled in October, 1941, by D. C. Williams. The No. 1 McKelvaine (SE.¼, NE.¼, Sec.2, T.9 N., R.17 E.) was drilled to 3,153 feet. The electric log shows the top of the Lower Cretaceous at 2,834 feet.

In 1943 the Waneta Oil Company drilled the No. 1 Carraway (SW.¼, SE.¼, Sec.36, T.10 N., R.17 E.) to a total depth of 2,808 feet. It was dry and abandoned.

One well was drilled in 1944. H. A. Hamilton and W. A. Walsingham Sallie K. Briggs No. 1 (SE.¼, NW.¼, Sec.6, T.9 N., R.18 E.). The well was dry and abandoned at a depth of 3,008 feet in the Lower Cretaceous.

In 1946 the S. Friedman Trustees' J. W. McKelvaine No. 1 (SE.¼, NE.¼, NE.¼, Sec.2, T.9 N., R.17 E.) was drilled to a depth of 1,320 feet, and abandoned.

There was no further drilling activity in the county until 1953. In that year two more wells were drilled. The first was the E. B. LaRue Edmonds-Longshore No. 1 (NW.¼, NE.¼, Sec. 32, T.11 N., R.19 E.). In this well 9 sidewall cores were taken from 1,793-3,160 feet. Schlumberger log shows a total depth of 3,415 feet. The Paleozoic was reached at 3,290 feet. Several months later Harvey J. Weir drilled the wildcat A. M. Fleming Estate No. 1 (NE.¼, SW.¼, Sec.17, T.10 N., R.18 E.). Thirteen side wall cores were taken from 2,004 to 3,370 feet with no shows. Total depth of hole was 3,829. Lower Cretaceous was penetrated at 2,590 feet.

October, 1954 witnessed the drilling of two wells. Lamb and Gault drilled the Henry B. Smith No. 1 (Fr. Cen. point of E. line of NW.¼, SW.¼, go N. 45° W., 50.82 ft. to location, Sec.1, T.9 N., R.17 E.) to a total depth of 3,200 feet. The Lower Cretaceous was reached at 2,755 feet. Lamb and Gault drilled another well, the Phillips Estate No. 1 (SW.¼, SE.¼, Sec.2, T.9 N., R.17 E.) which was dry and abandoned at a depth of 4,576 feet, well in the Paleozoics.

There was no further activity in the county until early in 1957 when E. F. Neely began drilling the W. W. Shepard No. 1 (810 ft.W., 400 ft.N., SE.Cor., NE.¼, SW.¼, Sec. 19, T.11 N., R.15 E.). The total depth was 2,522 feet, abandoned in the Tuscaloosa. E. F. Neely T. A. Stennis No. 1 (330 ft.E., 330 ft.S., NW.Cor., SE. ¼, NE.¼, Sec.14, T.10 N., R.15 E.) was dry and abandoned in the Tuscaloosa at a depth of 2,523 feet. E. F. Neely drilled a third well, the Clay No. 1 (NE.Cor., SE.¼, SE.¼, Sec.20, T.10 N., R.15 E.). The total depth was 2,710 feet in the Tuscaloosa.

LIGNITE

Lignite has only local distribution in Kemper County. Beds worthy of mention seen by the writer crop out in the bottom and walls of small creeks. The first locality (Sec.21, T.11 N., R.16 E.) is in a small draw just west of Mississippi State Highway 39. The lignite here is firm and in three beds whose thicknesses are, in ascending order, 3.0 feet, 2.8 feet, and 2.0 feet.

On the Kilpatrick property (SE.¼, Sec.22, T.11 N., R.16 E.) northeast of DeKalb, the deposit is well exposed in two small draws. The first is just to the east of the road. The lignite here is approximately 1.5 feet in thickness. A hundred yards or so about N. 60° W. from the house is another exposure. Several beds of firm black to soft brown lignite are exposed whose aggregate thickness is about 8.0 feet.

A third area worthy of mention is located in a small draw (SW.¼, Sec.34, T.10 N., R.17 E.) in a field just a few yards north of a country store. The lignite here is firm and black and its thickness measures 3.6 feet.

A fourth area shows a lignite bed approximately one foot in thickness in a carbonaceous clay pocket (SE.¼, NE.¼, Sec.4, T.9 N., R.17 E.). The lignite is overlain by an irregular ferruginous sandstone bed and underlain by approximately 6 feet of black carbonaceous clay which grades laterally and downward into a yellow gray plastic clay. The thin section of lignite from this locality was representative and a photomicrograph was made (Figure 65).

Four thin sections of lignites of Kemper County were examined in the Special Coal Research Section of the U. S. Bureau of Mines. The representative thin section in Figure 65 was thor-

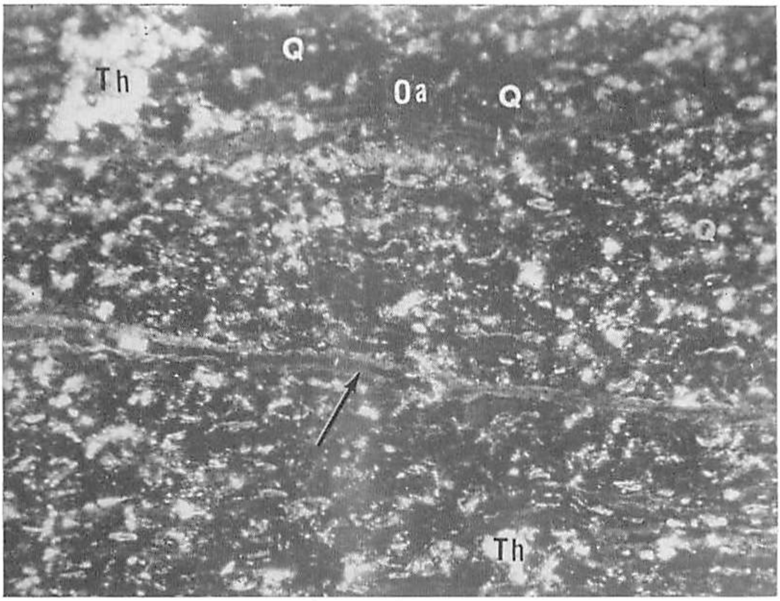


Figure 65.—Photomicrograph of thin section of lignite showing small quartz grains (Q), opaque attritus (Oa) which may be black or dark gray, depending on translucency or opaqueness, and small masses of translucent humic matter (Th). Arrow shows a fibrous strand of translucent humic matter. Uncrossed nicols. x63. (SE.¼, NE.¼, Sec.4, T.9 N., R.17 E.)

oughly examined and was found to be very similar to that of humic attrital coal. The predominant petrographic constituent is finely divided translucent humic matter. In the thin section this appears as a light-brown to black ground mass, depending on the degree of translucency. The particles comprising the ground mass are generally without distinct structural form, but some thin fibrous particles with residual cellular details are recognizable. Light areas in the thin section are parts torn out by grinding and polishing, and which were probably mineral matter harder than the lignite. Some of the smaller grains of mineral matter identified as clay minerals of silt particle size were not torn out by grinding. These are highly translucent in the thin section and appear as small white areas without structural outline in the photomicrograph.

Constituents of minor importance are yellow translucent attritus and opaque attritus. The yellow translucent attritus seems "to be derived from the waxy-resinous coverings of cuticles and spores, pollen exines, and excretory products such as resinous droplets and waxy grains." (Parks, 1958.) Identification of the yellow translucent constituents is difficult on the photomicrograph because they lack structural details commonly found in such ingredients of most coals. The opaque attritus is dark brown to black in the thin section and is shown on the photomicrograph as the darkest areas. It is finely divided, ranging from small particles to grains barely distinguishable at moderate magnification.

The lignite from which the thin section was made had its origin from woody plant remains subjected to intense biochemical decay, resulting in extreme maceration of plant debris during the peat stage.

Calvin Brown lists several localities in Kemper County containing lignite and analyses from two of these localities appear in Table 3.

TABLE 3

ANALYSES OF KEMPER COUNTY LIGNITES

No.	Locality	Moisture	Volatile Matter	Fixed Carbon	Ash	Total	Sulphur	Calories	B.T.U.
15	H. A. Hopper Property 1½ mi. N. DeKalb	11.40	32.61	37.00	18.99	100	1.80	5,112	9,201
16	Pool's Mill, Sec.14, T.10 N., R.16 E.	13.61	37.14	42.10	7.15	100	2.64	5,439	9,790

PHOSPHATES

No phosphate deposits of economic import were found in Kemper County. Phosphatic molds and casts of fossils were seen in the basal Prairie Bluff Chalk and at the Cretaceous-Paleocene contact.

In 1952 exploration for "sphalerite" and other deposits of economic importance was made in the vicinity of Sciples Mill by "prospectors." A 20-foot pit was dug (Figure 25) just across the road, north of the Sciples store (NW.¼, Sec.25, T.12 N., R.15 E.). Samples were collected to 15 feet by the Mississippi State Geological Survey and made available to the writer. Analyses of the samples, made by the Mississippi State Chemical Laboratory, appear below:

Depth Feet	Total P_2O_5 percent
0-3	0.58
3-4	0.32
4-5	1.08
5-6	1.70
6-7	1.02
7-8	1.12
8-9	0.38
9-10	0.44
10-11	0.52
11-12	0.62
12-13	0.96
13-14	0.26
14-15	0.66

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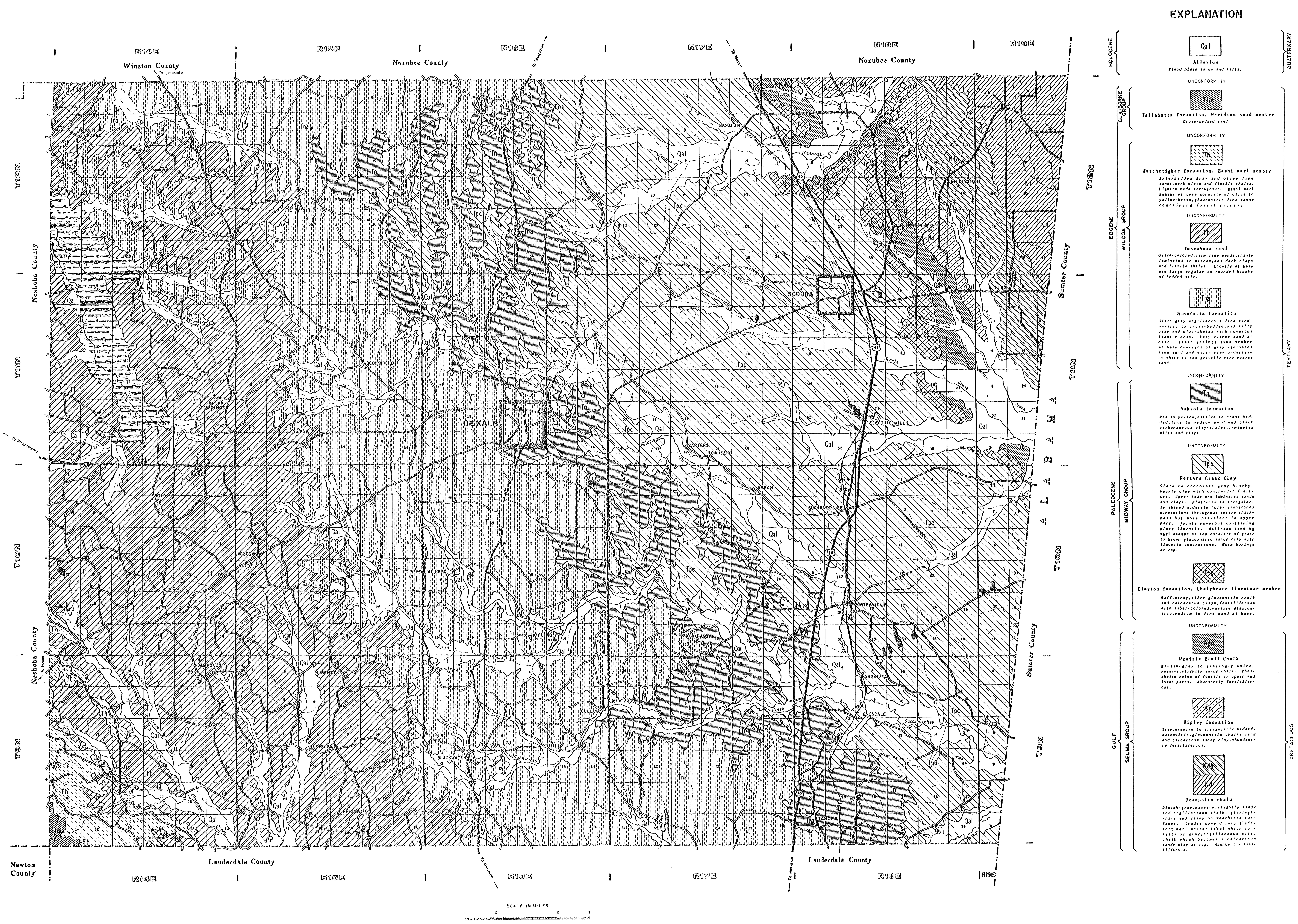

GEOLOGIC MAP OF KEMPER COUNTY