NORTH–SOUTH STRUCTURAL CROSS-SECTION,

DESOTO COUNTY TO ISSAQUENA COUNTY, MISSISSIPPI

By

James H. Hoffmann, RPG and C. Madison Kymes

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State Geologist

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Introduction

The information presented in this report is part of a larger study of subsurface geology that encompassed all or portions of nineteen counties in northwestern Mississippi. In this study, more than 800 borehole geophysical logs were analyzed for the purposes of subsurface correlation and mapping within the Claiborne, Jackson, and Vicksburg Groups. The base map used for this report (Plate 1) shows the location of the study area within the state (inset) and the locations of the wells and boreholes utilized in preparation of the cross-section. It also shows the boundaries of each of the nineteen counties of the study area, the eastern margin of the alluvial plain, and Public Land Survey System (PLSS) information concerning township and range, and sections within each township.

The alluvial plain extends over an area of about 7,000 square miles. This area of low topographic relief, commonly known as the Delta, extends from Memphis, Tennessee, on the north, to Vicksburg, Mississippi, on the south. It is bounded by the Mississippi River on the west and the Bluff Hills of the uplands to the east.

The land surface of the alluvial plain slopes gradually southward from an elevation of approximately 215 feet above Mean Sea Level (MSL) in DeSoto County to as low as 60 feet near Vicksburg in Warren County. For this report, MSL references the National Geodetic Vertical Datum of 1929 (NGVD). The entire alluvial plain is underlain by fluvial deposits that are the product of multiple cycles of erosion and alluviation within the Mississippi River valley resulting from several episodes of advance and retreat of glaciers. Glaciation during the Pleistocene lowered sea level. This effectively increased gradients of the streams, causing them to erode down into the Tertiary surface. As the ice sheets melted and sea level rose, stream gradients decreased, and the alluvial valley filled with sediments.

The alluvial plain lies within a larger geologic feature, the Mississippi embayment, a north-south sloping structural trough, the axis of which is approximately parallel to the Mississippi River (Figure 1). Thousands of feet of sediments ranging in age from Jurassic to Quaternary have been deposited within the embayment. The sedimentary deposits that filled the trough have been extensively modified by various structural features and sedimentation occurred concurrently with subsidence and inundation in the Mississippi embayment (Cushing, Boswell, and Hosman, 1964).

Geologic units that subcrop beneath the Mississippi River Valley alluvium (MRVA) range in age from Eocene to Oligocene and are classified within the Tertiary System (Table 1). From oldest to youngest these are the Zilpha, Sparta, Cook Mountain, and Cockfield formations, the Yazoo Clay and Moody's Branch of the Jackson Group, and the Forest Hill formation. Each of the Tertiary units generally dips to the west beneath the northern part of the alluvial plain and southwest in most of the central part. They are structurally affected by the Desha Basin in Bolivar and Washington Counties, the Monroe-Sharkey Uplift (Figure 1) in southern Washington and adjacent Issaquena and Sharkey Counties, the Midnight Volcano in Humphreys County, and structures at Cary in Sharkey County and Tinsley in Yazoo County.

The cross-section prepared for this report (Plate 1) shows the subsurface structural relationships and character of geologic units from the top of the Meridian Sand to land surface beneath the Mississippi River alluvial plain of northwestern Mississippi. Locations of wells used to construct the cross-section were selected through the center of the study area from DeSoto County in the north to Issaquena County in the south.

Methods

The interpretations presented in this report were developed from information obtained from analyses of geophysical logs of boreholes drilled for water wells, oil and gas exploration, geotechnical investigations, and stratigraphic tests. Evaluation of the character of geophysical logs was the primary factor in these assessments although information from water well driller's logs, descriptions of cuttings from boreholes, and oil and gas scout cards were also reviewed. The types of borehole geophysical data used in this study were spontaneous potential, resistivity and induction, and natural gamma radiation logs.

Paillet and Crowder (1996) defined geophysical logs as a series of measurements made along the axis of a borehole. They stated: "Although each geophysical measurement is interpreted according to the specific physical principals involved, all sets of geophysical logs have three fundamental attributes that contribute to the analysis of aquifer properties in a way that is unique to this class of measurement."

The three attributes that they identified were:

1. Geophysical logs contain a continuous depth scale associated with a continuous series of measurements, each made in the same borehole in the same way with the same equipment.
2. Geophysical logs sample the undisturbed formation in situ around the borehole. The entire sampled volume includes the borehole itself and fluids within it, the surrounding annulus possibly affected by drilling, and the undisturbed formation containing natural formation fluids and invasive drilling fluids.
3. Geophysical logging equipment is designed so that more than one type of geophysical measurement, each of which is based on different physical principals, can be made in the same borehole.

Borehole geophysical tools can be used to measure physical properties of geologic materials around a borehole and fluids contained within those materials. These tools directly measure or enable interpretations to be made concerning properties such as the character of geologic materials and thicknesses of distinct intervals adjacent to the borehole. The radius of investigation around a borehole for most geophysical measurements typically varies from several inches to a few feet.

Interpretation of the resulting logs can be used to correlate geologic units from one well to another, determine thickness and lithologic character of intervals within the borehole, estimate the lateral extent in the subsurface of various geologic units, and broadly estimate water quality. The degree of detail displayed in the curves recorded on geophysical logs can be highly variable. This qualitative factor can affect the reliability of interpretations of log character because the response of logging tools to changes of the formation and fluids adjacent to the borehole may be less distinctly displayed in the curves from some wells with respect to others. Paper copies of logs can also be subject to various distortions which can sometimes influence correlation. These include "log stretch" and distortions of portions of the logs on copies reproduced from original prints.

The drill depth on each log and elevation relative to MSL were recorded for the top of each of the following Tertiary geologic units: Jackson Group, Cockfield, Cook Mountain, Sparta, Zilpha, Winona, Tallahatta, and the Meridian Sand formations. Correlations of geophysical logs were based primarily on electrical characteristics and may not correspond exactly to formational boundaries that might be established by direct lithologic or paleontological evidence. In the application of geophysical logs for subsurface interpretations in this area, the most consistently identifiable geologic units are the Winona formation of the Claiborne and the Yazoo Clay and Moody's Branch formations of the Jackson Group.

Geology

Plate 2 is a north-south structural cross-section through the middle of the Mississippi River alluvial plain from DeSoto County to Issaquena County that shows the stratigraphy and configuration of geologic units from the top of the Meridian Sand to land surface. Intervals of sand and gravel within these geologic units constitute the primary sources of groundwater used for human consumption, industry, and agriculture in the study area. Table 2 is a list of wells and boreholes with associated information that were used to construct the cross-section.

Along the line of the section from well number 6 to well number 18, the Tertiary units reflect the structural effects of the general westward to southwestward dip into the Mississippi embayment and the Desha Basin.

Well number 5 is located near the axis of the embayment where it is deflected to the east by a significant regional structural feature, the Monroe-Sharkey Uplift (Figure 1). The location of this structure is in west-central Mississippi, northeastern Louisiana, and southeastern Arkansas. Johnson (1958) stated, "The location of the Monroe Uplift is almost wholly in the flood plain of the Ouachita, Mississippi, and Yazoo Rivers, and the surface expression, if ever present, has been obscured by Quaternary alluvium deposits." He identified four major periods of growth and associated erosion. Johnson thought the most recent significant movement on the Monroe Uplift occurred during Claiborne time which is evident on the cross-section. Well number 4 is on the eastern part of the Monroe-Sharkey structure near the Midnight Volcano. Well number 2 is on the positive structure near Cary in Sharkey County and at well number 1 in Issaquena County, all the Tertiary units are dipping at an increased rate in a general southward direction into the Mississippi structural trough. The alluvium does not reflect the effects of deeper structural features that exist within the study area.

Many authors have extensively characterized the geology and groundwater resources of northwestern Mississippi and their reports are listed under the "Selected References" section of this report. For this reason, discussion of the Claiborne and Jackson will be limited to brief statements of previous authors and general observations of thickness and character noted in the course of this current work.

In describing these geologic units in the study area, the northern counties refer to the area mainly north of latitude 34 degrees north and includes the counties of Coahoma, DeSoto, Panola, Quitman, Tate, and Tunica. The central counties lie mainly in the area between 33- and 34- degrees north latitude and include all or most of the counties of Bolivar, Carroll, Grenada, Holmes, Humphreys, Leflore, Sunflower, Tallahatchie, and Washington. The southern counties refer to the area mainly south of latitude 33 degrees north which includes the counties of Issaquena, Sharkey, Warren and Yazoo.

Meridian Sand

The Meridian Sand formation is quite variable in thickness and character, ranging in appearance from a thick, prominent sand unit to a thin, somewhat nondescript sand interval. It can be differentiated on outcrop from the sediments of the underlying Wilcox Group, but the precise relationship between these geologic units is much more difficult to distinguish in the subsurface solely from interpretation of borehole geophysical logs. Identification of the top of the Meridian may be complicated by the presence, in some wells, of significant sand beds in the basal section of the Tallahatta formation. Brown (1947) considered the Meridian Sand to be the lowermost member of the Tallahatta formation.

Payne (1975) found the thickness of the Meridian Sand to be highly variable. He reported it to range from 0 in areas of nondeposition to 200 to 250 feet in the Desha Basin in Arkansas. He noted thicknesses of 300 to 450 feet in the area from Madison Parish, Louisiana northeastward to Holmes County, Mississippi. In Mississippi, Payne found that the Meridian usually consists of more than 80 percent sand.

The Meridian- upper Wilcox aquifer was described by Boswell (1976) as being comprised of the Meridian Sand and hydraulically connected sand beds in the underlying Wilcox. This aquifer system is of variable thickness in northwestern Mississippi but generally appears to average about 100 to 200 feet. In the southern counties, sand thickness of 200 to more than 300 feet may be developed. The U.S. Geological Survey (USGS) estimates water from this aquifer to be fresh, defined as 1,000 milligrams per liter (mg/L) or less of total dissolved solids (TDS), beneath all the area of the alluvial plain except for southwestern Washington, Sharkey, and Yazoo and all of Issaquena and Warren Counties (Gandl, 1982).

Tallahatta Formation

In much of its area of occurrence in eastern and central Mississippi, the dominant lithology of the Tallahatta formation is characterized by the beds of generally fine-grained sediments of the Basic City Shale Member. On outcrop these are predominantly claystones and siltstones along with the quartzite “buhrstone”. In the subsurface of northwestern Mississippi, the Tallahatta often contains several beds of sand of variable thickness separated by clay.

Brown (1947) found in the north that shale lenses are discontinuous where sands thicken. He noted a maximum thickness of about 500 feet of Tallahatta near the axis of the embayment and in Holmes County.

Dalsin (1978) reported that, in many of the counties in the central part of the alluvial plain, the Neshoba Sand Member of the Tallahatta is hydraulically connected to sand of the overlying Winona formation. He also noted sand beds in the lower part of the Tallahatta may be hydraulically connected to the Meridian Sand. Some water wells are completed in sand beds of the Tallahatta formation in the northern and central counties of the study area. The USGS (Gandl, 1982) estimates fresh water to be available from Tallahatta sands north of southern Holmes and northern Humphreys and Washington Counties.

Payne (1972) discussed the Cane River Formation and its equivalent units which, in Mississippi, include the Tallahatta, Winona, and Zilpha formations. He stated that, “thicknesses of individual sand units are rather variable, and thicknesses in excess of 75 feet are virtually limited to northwestern Mississippi.” The most transmissive sand units Payne found were in Bolivar, Leflore, and Sunflower Counties which coincided with areas of greater sand concentrations and thicker individual sand units.

In the northern counties, the total thickness of the Tallahatta is generally 200 to 350 feet but can exceed 400 feet. In this area, beds of clay are more prominent in the upper part of the formation and beds of sand characterize the lowermost 100 to 200 feet. Many sand beds are no more than 20 to 30 feet thick but can be 50 to 100 feet in thickness. At some locations sand may comprise nearly the entire thickness of the formation.

Total thickness of the Tallahatta in the central counties is primarily in the range of 250 to 500 feet but can be greater. In this area, the formation is more generally characterized as a sequence of interbedded sand and clay. Sand beds are usually 10 to 20 feet thick but can be 50 feet or more. Occasionally, sand may comprise most of the Tallahatta in this area.

In the southern counties, the Tallahatta is generally about 100 to 300 feet thick and clay interbedded with sand characterizes the formation. Sand beds are often no more than 5 to 10 feet thick, and while thicker sand beds may occur, they are not as common as those in counties to the north.

Winona Formation

The Winona formation, conformably overlying the Tallahatta, is the most useful geologic unit in northwestern Mississippi for subsurface correlation and mapping. It is typically recognized by water well drillers as the "greensand" due to the presence of the green-colored mineral glauconite. Priddy (1942) described the Winona as consisting, in order of abundance, of glauconitic silty sands, glauconitic claystone layers, and thin beds of slightly silty clay.

Total thickness of the Winona formation throughout the study area ranges from about 10 to as much as 40 to 60 feet. In the northern counties, it averages from 20 to 29 feet in thickness. Average thickness in the central counties is 19 to 33 feet and 10 to 39 feet in the southern counties.

Zilpha Formation

Conformably overlying the Winona is the Zilpha formation. The contact with the overlying Sparta formation is disconformable. Parks (1963) stated that thickness of the Zilpha may locally be 5 feet or less where it has been eroded by sands of the Sparta.

In much of northwestern Mississippi, clay constitutes the predominant lithology of the Zilpha although intervals of sand may be present in some wells and may even represent most of the formation in some locations. Taylor and Thomson (1971) found in Washington County that a persistent clay interval characterizes the lower part of the formation, but a sand and clay section in the upper part may be hard to separate from the Sparta.

Average thickness of the Zilpha derived from analysis of the geophysical logs used in this study was 44 to 62 feet in the northern counties, 37 to 143 feet in the central area, and 172 to 256 feet in the south.

Sparta Formation

The Sparta formation in the counties of northwestern Mississippi typically contains two or more significant sand intervals separated by clay beds of variable thickness up to 200 feet or more. Sand beds of substantial thickness are present in the Sparta throughout the area of northwestern Mississippi. Sand thicknesses of 50 to 200 feet are common and can be as much as 300 feet.

The position of thick sand units within the Sparta is quite variable throughout its area of occurrence. Taylor and Thomson (1971) reported that more than two beds of sand generally occur throughout the formation in Washington County. Bettandorf and Leake (1976) stated that the Sparta contains two or more sand beds separated by clay in Holmes, Humphreys, Issaquena, Sharkey and Yazoo Counties and sand makes up 40 to 80 percent of the formation.

Payne (1968) stated that the thickness of the Sparta generally exceeds 800 feet along and near the axes of the Mississippi Embayment and the Desha Basin in western Mississippi with a maximum thickness of 1,100 to 1,200 feet in Warren and Claiborne Counties. He concluded that variations in thickness are commonly associated with localized structural features which were developing during the time of Sparta deposition such as the Tinsley Dome in Yazoo County and part of the

Monroe-Sharkey Uplift in Sharkey County. Payne described local thickening of the Sparta in areas in which channels in the Sparta cut into and filled in the underlying Zilpha formation.

In the report of his study of the Sparta, Payne discussed the development of sand bodies within the formation. He stated, “Within the channel areas the maximum sand units range from 100 to 300 feet in thickness, but in the interchannel areas, they generally range from 10 to 50 feet. Maximum sand units 100 feet or more may coalesce or diverge, and as entities they are generally of limited extent, but the effect of overlap gives almost continuous interconnection for fluid flow.” He noted that thick sand bodies may occur at any stratigraphic position in the Sparta, but most are in the lower two-thirds of the section.

Thickness of the Sparta is limited in those areas in which the formation outcrops or where it subcrops beneath the Mississippi River Valley alluvium (MRVA) or terrace deposits and loess in the Bluff Hills. The Sparta generally thickens to the west and to the south. Average thickness of the formation in the northern counties is from about 288 to 535 feet. In the central counties, the Sparta averages from 220 to 677 feet and 457 to 959 feet thick in the southern area.

The USGS has estimated that the Sparta contains fresh water throughout the area of northwestern Mississippi (Gandl, 1982). Excessive color may be a water quality problem in some areas, particularly in Issaquena, Sharkey, Warren, and parts of Yazoo Counties.

Cook Mountain Formation

Brown (1947) described the Cook Mountain formation as characteristically marine in the southern counties of the Mississippi River alluvial plain and nonmarine from the central area northward. Thomas (1942) described the Shipps Creek Shale Member as shales with interlaminated silts and sands and reported that it comprised the entire Cook Mountain section in some areas. In the central and northern counties of the alluvial plain, beds of sand occur in this interval. Taylor and Thomson (1971) and Dalsin and Bettandorf (1976) noted the difficulty of distinguishing the Cook Mountain from the underlying Sparta formation and the overlying Cockfield formation in these areas.

Overall thickness of the Cook Mountain can be highly variable. It may be no more than a few feet thick in parts of those areas in which it subcrops beneath the MRVA and has been subjected to erosion. On the other hand, it may be up to 250 feet thick elsewhere. In the northern counties, the average thickness of the formation is about 65 to 70 feet. Average thickness in the central counties is from approximately 70 to 150 feet and 85 to 210 feet in the southern counties.

Cockfield Formation

Like the Sparta, the Cockfield formation normally contains two or more thick sand intervals separated by beds of clay. Sand intervals of 50- to 100-foot thickness are common and may be up to 200 to 300 feet in some areas. Sand beds most commonly occur in the lower part of the Cockfield. Clay intervals of 100 to 200 feet in thickness may be found at some locations. Stenzel (1939) described the Creola Member of the upper part of the Cockfield which contains marine fossils, glauconite, and beds of limestone.

Brown (1947) reported the Cockfield formation beneath the alluvial plain to range from a thickness of no more than a few feet to approximately 650 feet along the embayment axis in Washington County. Dalsin (1978) found the Cockfield to be up to 450 feet thick in Bolivar and 350 feet in Sunflower County.

Bettandorf and Leake (1976) stated that the Cockfield is 400 to 500 feet thick in the central and southern parts of their project area. Sand constituted about 40 to 60 percent of the total thickness of the formation. Sand intervals 40- to 100-feet thick were found to occur commonly and maximum sand thicknesses of 200 feet were observed.

The USGS (Gandl, 1982) considers the Cockfield to contain fresh water throughout its area of occurrence in northwestern Mississippi although excessive concentrations of chlorides and color affect water quality in some areas.

Jackson Group

In the study area, the Jackson Group is restricted to Washington County, a very small part of Bolivar, and the southern counties. Overall thickness ranges from a few feet to 550 feet.

The Moody's Branch formation occurs at the base of the Jackson Group and unconformably rests upon the Cockfield formation. It is described by Mellen (1940) as a glauconitic, fossiliferous, sand-marl. Thickness of the Moody's Branch is usually about 20 to 40 feet.

Above the Moody's Branch, most of the thickness of the Jackson Group is represented by the Yazoo Clay which may also contain beds of silt or silty clay, limestone, and marl. In the study area, the Yazoo Clay may be no more than a few feet thick near its updip limit of occurrence. The Yazoo Clay may be nearly 100 feet thick in some wells in Washington County and in Issaquena, Yazoo, and Warren Counties, it may reach thicknesses from 400 to 550 feet.

Mississippi River Valley Alluvium

The surficial unit, the Mississippi River Valley alluvium (MRVA), was deposited on an irregular, erosional contact across sediments of Tertiary age with thicknesses ranging from less than 100 feet to more than 200 feet in isolated locations (Hoffmann, 2018). Thickness of the alluvium along the line of section A – A' ranges from 108 to 220 feet. The contact of the MRVA with the underlying Tertiary units is depicted as a red line on the cross-section and is only an approximation of the configuration of the relationship of these intervals between the wells used to construct the cross-section.

Limitations

Due to the interpretive and generalized nature and scope of this document, information presented herein should not be considered a substitute for the collection of site-specific data. Additionally, the accuracy and completeness of some source data utilized in the preparation of this report cannot be warranted. These include, but are not limited to, such information as well location and elevation of land surface or other point of vertical reference for the geophysical logs which are presented as reported from their original sources.

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