WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

# GEOLOGICAL INVESTIGATION

OF THE

# ALLUVIAL VALLEY OF THE LOWER MISSISSIPPI RIVER

CONDUCTED FOR THE

MISSISSIPPI RIVER COMMISSION

VICKSBURG, MISS.

*By*

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*Consultant*

*1 December 1944*

WAR DEPARTMENT

CORPS OF ENGINEERS

OFFICE, PRESIDENT, MISSISSIPPI RIVER COMMISSION

VICKSBURG, MISSISSIPPI

**Subject:** Geological Investigation of the Alluvial Valley of the Lower Mississippi River

**To:** The President, Mississippi River Commission, Vicksburg, Mississippi

Transmitted herewith is the final report of the Geological Investigation of the Alluvial Valley of the Lower Mississippi River.

Respectfully submitted,

HAROLD N. FISK, Ph. D.
*Consultant*

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1 DECEMBER 1944

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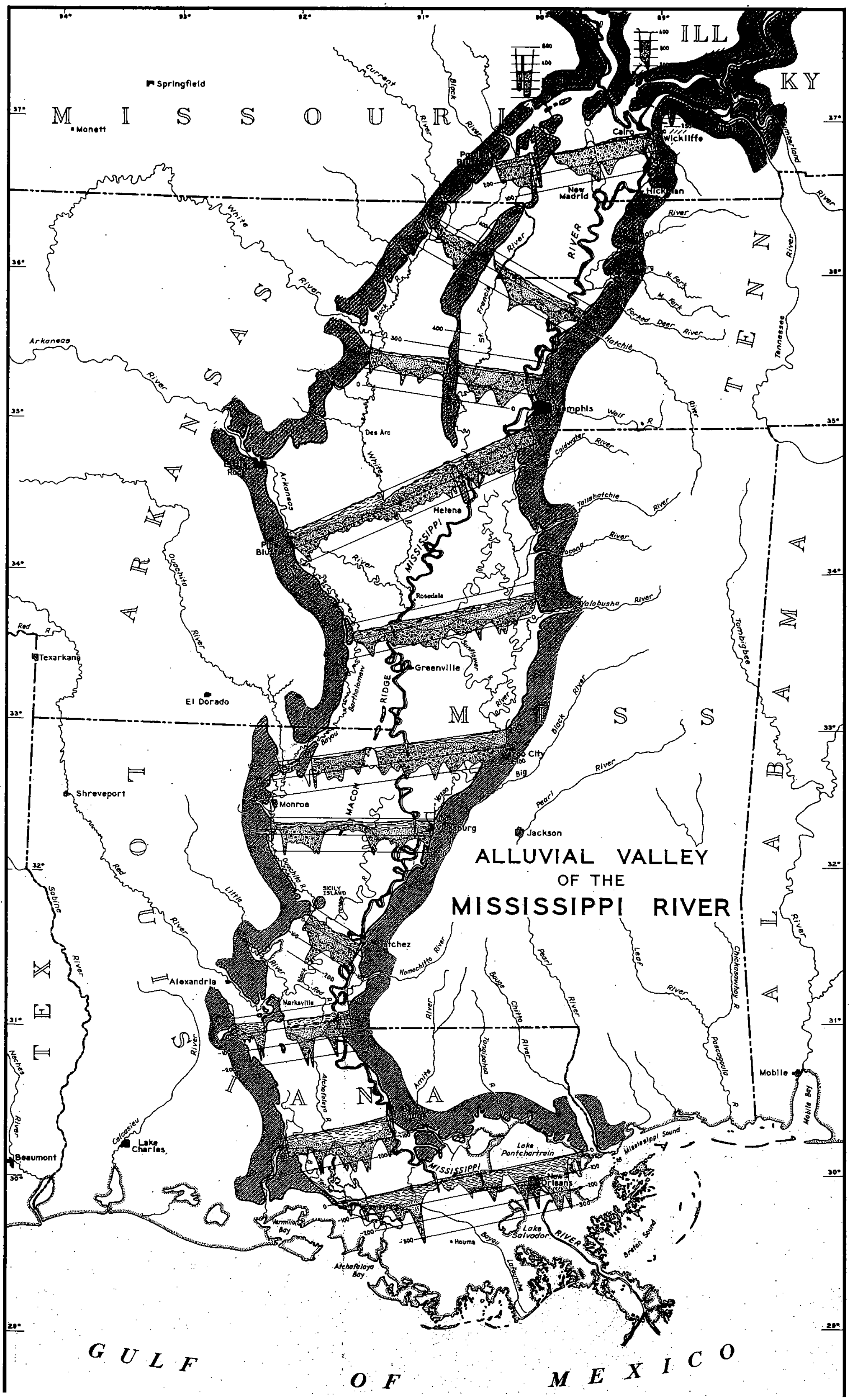
ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
MISSOURI
ILL
KY
TENN
ARKANSAS
MISS
ALABAMA
TEX
LOUISIANA
GULF OF MEXICO
Springfield
Monett
Cairo
Wickliffe
New Madrid
Hickman
Memphis
Des Arc
Helena
Rosedale
Greenville
Texarkana
El Dorado
Shreveport
Monroe
Jackson
Natchez
Alexandria
Marksville
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# GEOLOGICAL INVESTIGATION

# OF THE

# ALLUVIAL VALLEY OF THE LOWER MISSISSIPPI RIVER

*By*

HAROLD N. FISK, Ph. D.

## INTRODUCTION

The present geological investigation of the Alluvial Valley of the Lower Mississippi River was conducted for Brigadier General M. C. Tyler, President, Mississippi River Commission, under the general supervision of Mr. Gerard H. Matthes, Head Engineer, Director, U. S. Waterways Experiment Station, Vicksburg, Miss. The project was authorized by the Chief of Engineers, U. S. Army, Washington, D. C., in May 1941. It is the intent of this report to present the results of the investigation as concisely as possible and to record graphically the detailed information accumulated in the extensive area under consideration. In order to keep the report within reasonable length, no attempt is made herein to review systematically the literature of the region or to introduce unnecessary details.

The several parts of the report consider the general geological features of the alluvial valley in the following order: a summary of the major characteristics of the valley; the nature of the Mississippi entrenched valley system; the nature and distribution of the Recent alluvium filling the entrenched valley system; the characteristics of the alluvial plain; the Recent history of the valley; a discussion of the Mississippi River and its activities; and summary and conclusions. An appended section presents the geologic setting of the alluvial valley and a brief summary of the pre-Recent geological history of the region.

**Personnel:** Personnel of the U. S. Waterways Experiment Station made up the geological staff. Mr. P. R. Mabrey, Associate Geologist; and Messrs. W. J. Hendy, Jr., Rufus J. LeBlanc, and R. H. Smith, Assistant Geologists, conducted the investigation under the immediate supervision of the consultant. Each member of the staff participated in the various phases of the project but was more closely concerned with certain aspects of the investigation. Mr. Mabrey supervised the program of project borings and collected much of the well log data in the alluvial valley region. Reconstruction of the history of the alluvial plain and of the Mississippi River and the paleontological interpretation of samples was largely the work of Mr. Smith. Mr. Hendy conducted much of the investigation of the geological setting of the alluvial valley and studied the alluvial deposits along the Mississippi River. Studies of the Quaternary deposits in the Mississippi Delta region and studies of the entrenched valley system and the Recent alluvium were conducted by Mr. LeBlanc. Each man helped prepare those parts of the final report which had been the object of his investigation. Illustrations for the report were prepared by Mr. W. O. Dement, Draftsman, Mississippi River Commission, Vicksburg, Miss.

**Nature of Investigation.** The geological investigation was made to ascertain the nature and origin of the Alluvial Valley of the Lower Mississippi River and to determine the sequence of events in valley evolution. Studies connected with the investigation made it possible to establish stages in the development of the Mississippi River system and to differentiate major factors which permitted the establishment of the river in its present course and which control its present behavior.

Events of the past 15 years have made it possible to conduct the geological investigation. Prior to 1927 accurate maps were not available for the entire region. Now topographic maps made by the Mississippi River Commission cover the alluvial plain, and planometric maps of the deltaic plain have been issued by the State of Louisiana. The region has been photographed from the air, and study of scaled photographs is possible. Many deep borings have been made for engineering projects along the river, for water supplies in many parts of the valley, and for petroleum exploration. Only scattered borings had been made in the valley prior to 1927.

Aerial photographs and contour maps were used in developing the history of the alluvial plain surface. The continuity of abandoned courses of the Mississippi River and its tributaries can be clearly traced on aerial photographs where the scars of abandoned channels and associated features are discernible from the patterns of soils, vegetation, and drainage. The distribution of soils and vegetation were checked by field examination of local areas, and soils distribution was further checked by study of samples taken from borings. Complete photographic coverage of the alluvial valley was available for this investigation except for some areas in the coastal marshes of south Louisiana. Photographs employed were those used by the Mississippi River Commission in mapping the alluvial valley region (scales, 1:10,000, 1:12,000, and 1:20,000) and more recent photographs made for the Department of Agriculture (scales, 1:20,000, 1:62,500, and 1:125,000).

Studies of the alluvium utilized the data from approximately 16,000 borings,[1] over 3,000 of which penetrated its entire depth. The borings are more closely spaced along the levee system of the Mississippi River in the central part of the valley, within the rice growing areas of eastern Arkansas, in the Monroe Uplift region of northeastern Louisiana, in the New Orleans area, and in the oil fields of southern Louisiana. Most of the more than 300 borings made for this project were located along four main transvalley lines; Harrisonburg, La., to Natchez, Miss.; Bastrop, La., to the vicinity of Yazoo City, Miss.; Pine Bluff, Ark., to the vicinity of Memphis, Tenn.; and Poplar Bluff, Mo., to Wickliffe, Ky. Lines of borings were also made across several tributary stream valleys at the northern end of the region.

The nature and local distribution of the alluvium of the valley are shown in detail in cross sections developed from the project borings. Subsurface contour maps showing the configuration of the floor of the valley (base of alluvium) and the top of the graveliferous sediments were constructed from all available data and were controlled by project borings.

Factors controlling the configuration of the alluvial valley were determined from studies of the structure and stratigraphy of the Central Gulf Coastal Plain. Lithologic logs, electrical logs, and paleontological reports of over 1,500 deep borings scattered throughout the region were examined. Of these, over 500 key borings are located on structural and isopachous contour maps. A few of these borings were drilled to depths of more than 13,000 ft., many of them to more than 10,000 ft., and most of them reached below a depth of 5,000 ft.

The geology and stratigraphy of the floor of the valley were developed from published data and from the lithological and paleontological study of several thousand samples of bedrock obtained from borings.

**Sources of Information.** Well log data and other information essential to the completion of the report were obtained from petroleum companies, government agencies, state geological surveys, water-well drilling companies, individuals, and published sources. The contributors are as follows:

**The War Department, U. S. Corps of Engineer Offices:**

- Office of the President, Mississippi River Commission, Vicksburg, Miss.
- U. S. Waterways Experiment Station, Vicksburg, Miss.
- U. S. Engineer Office, Little Rock, Ark.
- ~~U. S. Engineer Office, Louisville, Ky.~~
- U. S. Engineer Office, Memphis, Tenn.
- ~~U. S. Engineer Office, New Orleans, La.~~
- U. S. Engineer Office, St. Louis, Mo.
- U. S. Engineer Office, Vicksburg, Miss.

**Oil Companies:**

- Arkansas Fuel Oil Company
  - Mr. Alvin M. Jackson, District Geologist, New Orleans, La.
- Benedum-Trees Oil Company
  - Mr. J. M. Holliday, Vice-President, Pittsburgh, Pa.
- Gulf Oil Company, Houston, Tex.
- Humble Oil and Refining Company, New Orleans, La.
- Magnolia Petroleum Company
  - Mr. L. R. McFarland, District Geologist, Shreveport, La.
  - Mr. Grover Murray, Jr., Geologist, Jackson, Miss.
- The Ohio Oil Company
  - Mr. C. L. Moody, District Geologist, Shreveport, La.
- The Pure Oil Company
  - Mr. W. H. Hadley, Jr., District Geologist, New Orleans, La.
  - Mr. John Berg, formerly at Jackson, Miss.
- Sinclair-Prairie Oil Company
  - Mr. R. D. Sprague, District Geologist, Baton Rouge, La.
- Sinclair-Wyoming Oil Company
  - Mr. R. M. Gawthrop, former District Geologist, Jackson, Miss.
- Strake Petroleum Company
  - Mr. Ray Reynolds, Geologist, Houston, Tex.
- The Texas Company
  - Mr. G. W. Schneider, District Geologist, New Orleans, La.
- Union Producing Company
  - Mr. Preston Fergus, District Geologist, Monroe, La.
- United Gas Producing Company

**Consulting Geologists:**

- Mr. W. C. Spooner, Shreveport, La.
- Mr. A. F. Crider, Shreveport, La.

**Water-well Drilling Companies and Individual Drillers:**

- The Carloss Well Company
  - Mr. Leslie Carloss, Memphis, Tenn.
- Delta Drilling Company
  - Mr. Louis Journey, Greenwood, Miss.
- C. M. Journey Company
  - Mr. C. M. Journey, Memphis, Tenn.
- Layne-Arkansas Company
  - Mr. Kenneth Gilbert, Stuttgart, Ark.
- Layne-Central Company
  - Mr. J. I. Seay, President, Memphis, Tenn.

[1] Copies of logs of all wells or borings used in the preparation of this report are on file in the Office of the President, Mississippi River Commission, Vicksburg, Miss.

Layne-Louisiana Company, Lake Charles, La.
Louisiana Well Company
Mr. V. S. Scroggins, Monroe, La.
Stoval Drilling Company, Monroe, La.
I. B. White Drilling Company
Mr. I. B. White, Alexandria, La.
Fairbanks-Morse Company, Stuttgart, Ark.
Mr. Frank Casper, Weiner, Ark.
Mr. E. A. Cart, Weiner, Ark.
Mr. A. J. Landrum, Wilson, Ark.
Mr. Rufus Lee, Hickory Ridge, Ark.
Mr. R. R. Lilly, Carlisle, Ark.
Mr. Tom McConnell, Stuttgart, Ark.
Mr. T. B. Minyard (deceased)
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Louisiana Highway Department, Baton Rouge, La.
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Mr. H. L. Lehmann, Testing Engineer, Testing Laboratories
Mr. Leo Hough, Soils Engineer, Testing Laboratories
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Missouri Pacific Railroad, St. Louis, Mo.
Texas and Pacific Railroad, Dallas, Tex.

**State Geological Surveys:**

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Illinois Geological Survey, Urbana, Ill.
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Louisiana Geological Survey, Baton Rouge, La.
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Missouri Geological Survey, Rolla, Mo.
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**Ground Water Division of U. S. Geological Survey:**

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Mr. J. C. Maher, formerly Geologist in Charge, Baton Rouge, La.
Mr. D. G. Thompson (deceased)

**Farm Security Administration:**

Mr. Guy Watson, Engineer, Little Rock, Ark.

**The Federal Land Bank, St. Louis, Mo.:**

Mr. T. J. Fricke, formerly Engineer, Stuttgart, Ark.

**Acknowledgments.** The writer is indebted to the members of the geological staff for their hearty cooperation throughout the project, their assistance in the preparation of the various phases of this report, and their aid in developing many ideas which are incorporated in it.

The counsel and criticism of Mr. Matthes are gratefully acknowledged. He not only directed the project but was closely associated with its inception and development.

Professor H. V. Howe, Director, School of Geology, Louisiana State University, and Professor Richard Joel Russell, Head, Department of Geography, Louisiana State University, were generous with their time and offered many helpful suggestions and criticisms. Many of the ideas concerning the nature of the alluvial valley were originated while Professor Russell and the writer were making a reconnaissance field investigation prior to work on this project. Professor Russell also accompanied the writer on several field trips made for this investigation and was of great assistance.

The writer acknowledges the cooperation and assistance of Mr. W. J. Turnbull, Chief of the Embankment, Foundation, and Pavement Division, U. S. Waterways Experiment Station; Mr. William H. Jervis, Engineer, U. S. Waterways Experiment Station, who was helpful in getting the project started; Captain Joseph F. Friedkin, Corps of Engineers, U. S. Army, U. S. Waterways Experiment Station, for his assistance in problems concerning stream activity and Mr. Chas. W. Schweizer, Senior Engineer, Deputy Chief, River Division, Mississippi River Commission, who supervised the printing and final editing of this report.

The assistance of Mr. W. C. Holland, Assistant Geologist, and Mr. Louis Wilson, who worked with the geological staff for several months, is appreciated.

# Part 1

# THE ALLUVIAL VALLEY

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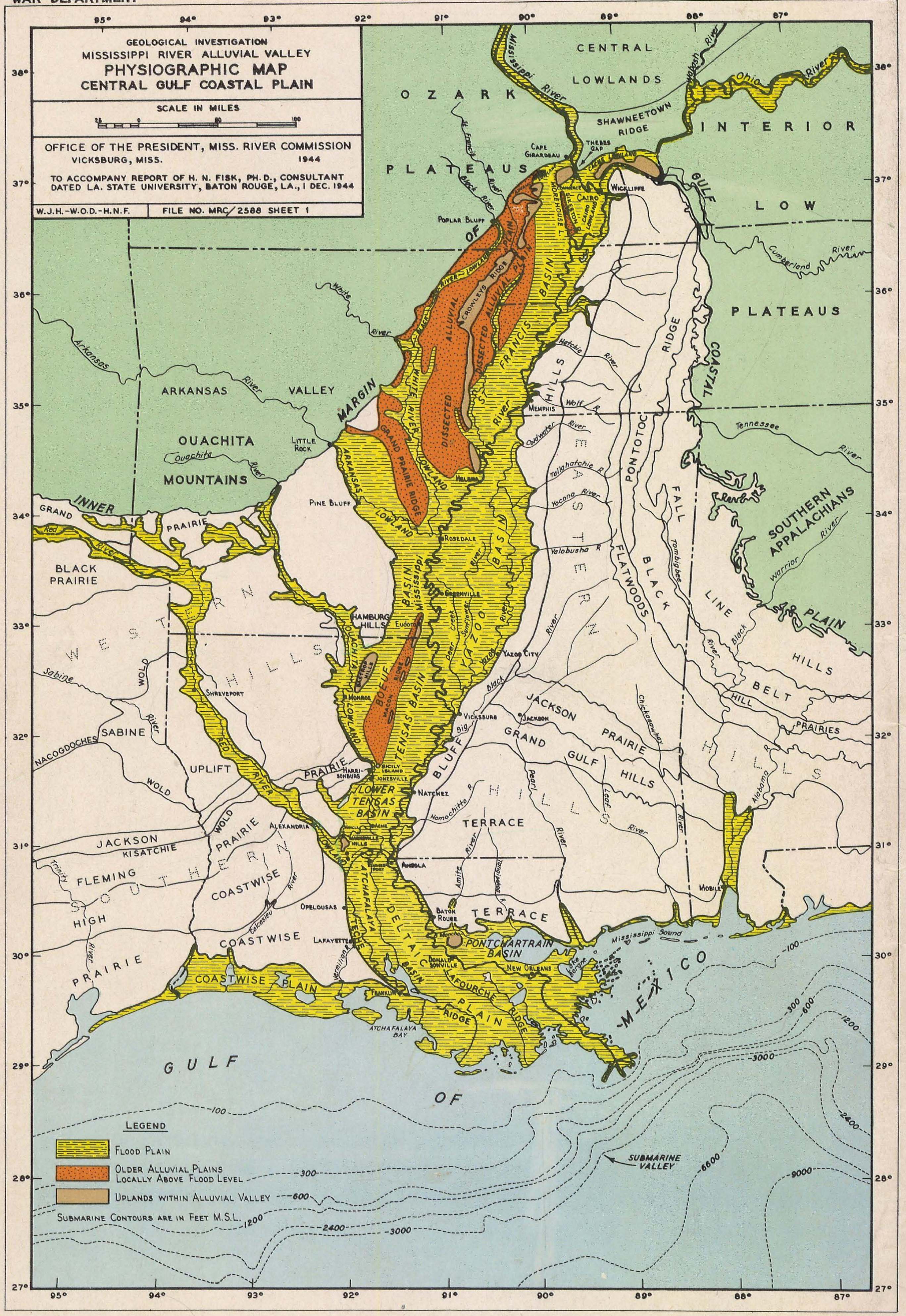



PLATE 1

## Part I

# THE ALLUVIAL VALLEY

The Lower Mississippi River and its tributaries follow a broad gulfward-sloping lowland for more than 600 miles across the Central Gulf Coastal Plain from Cape Girardeau, Mo., to the Gulf of Mexico (plate 1). The lowland is bordered by abrupt escarpments and is known as the Mississippi Alluvial Valley.

In point of origin, the alluvial valley is a compound feature, a "valley-within-valley" formed during the final cycle of world wide glaciation. During the last glacial stage, when sea level was several hundred feet lower than at present, the Mississippi River valley system became deeply incised within the coastal plain sediments. Slow aggradation, during and subsequent to the period of rising sea level when glacial ice masses were melting, incompletely filled this entrenched valley system and gave rise to the present surface, the alluvial plain. The topography buried under the alluvium is rugged, and in many places the bottoms of the trenches extend farther below the plain than the exposed valley walls rise above it.

The alluvial plain of the Mississippi Alluvial Valley merges with the alluvial plains of the tributary valleys that extend into the marginal uplands (plate 2). These plains also overlie deep trenches and are bordered by steep valley walls. Inasmuch as the overall pattern is similar to that exhibited by coastlines embayed by estuaries, the expressive term "alluvial drowning"[1] has been used to point out that the valleys of the Lower Mississippi River system are drowned by a deep and wide filling of alluvium in much the same fashion that the embayed coastline of the northeastern United States is drowned by the sea.

The alluvial plain includes both the floodplain subject to seasonal flooding and dissected alluvial plains not completely covered by flood waters. The floodplain has a total area of about 35,000 square miles, including the 13,000 square miles of near sea level deltaic plain south of the head of the Atchafalaya River. The dissected alluvial plains, once a part of the river floodplain, are set off from the floodplain by definite escarpments frayed in places by many minor stream valleys. They cover nearly 15,000 square miles in the northern and central parts of the alluvial valley, and the stream valleys incised within them are subject to backwater flooding.

Streams have been the dominant agents in the construction of the alluvial plain, but only the latest epoch of the aggradational history can be interpreted from the present stream courses and from traces of their abandoned counterparts (plate 2). Each floodplain stream maintains a highly sinuous course about the axis of which it constantly shifts to form meander loops and bends. Such channel shifting takes place within well-defined zones, meander belts, whose widths are determined by the size of the streams. The many scars left within a meander belt when a stream migrates or cuts off and abandons meander loops (figure 1) provide a means of interpreting the local aggradational history.

Streams of the valley have large stage variations and in their natural state periodically overflow their banks. Sediments deposited on the outside of bends during overflow stages form natural levees, low alluvial ridges which slope away from the river. Continued occupation of a meander belt causes natural levees of adjacent meanders to coalesce leaving continuous alluvial ridges in the floodplain. These meander-belt ridges rise above adjacent swampy lowlands to form the highest aggradational floodplain features (figure 1).

Sweeping across the valley in great arcs, the present Mississippi meander belt impinges against the valley walls or alluvial ridges to inclose or block off large floodbasins, such as the St. Francis, Tensas, and Boeuf basins (plate 1). Flood waters entering these basins drop their load of suspended sediments and slowly aggrade the valley surfaces.

The outlines of abandoned meandering stream courses comparable in size and shape to those of the Mississippi River and its tributaries are clearly visible on the alluvial plain (plate 2). Segments of abandoned Mississippi River courses can be traced across flood-basin areas to the points where they diverge from the present meander belt (figure 2). Meander loops, natural levees, and other features characteristic of the parent stream are distinguishable along the abandoned courses, but the formerly wide channels are now largely filled with sediments and are followed by small streams (figure 3). Minor streams, such as Bayou Teche or the Black-Tensas River (plate 2), follow the position of abandoned Mississippi River channels for long distances; other old courses are followed by a series of small streams each of which leaves the abandoned channel after following it for a few miles. The natural levees of older courses are partially buried under flood-basin alluvium and are somewhat narrower than levees along active streams, but their elevation and slope are similar.

Abandoned courses of tributary streams radiate from the mouths of their alluvial valleys upon the surface of low alluvial fans which the minor streams constructed upon the alluvial plain. The alluvial fans with their complex of interwoven tributary courses provide proof that the aggradational process has been slow and continuous and that filling of the alluvial valley is still in progress.

Braided streams were the dominant agents of valley aggradation throughout most of Recent[2] time, as indicated by the lenticular nature of the alluvial fan deposits. There are no large modern streams with braided channels within the valley, but the surface of the dissected alluvial plain and the early-formed parts of the floodplain bear traces of the shallow multiple channels of braided drainage (figure 4). This type of drainage continued to function in parts of the valley until after sea level had reached its present level.

The outline of the valley (plate 1) is that of an elongated curved horn or cornucopia, narrow from the Gulf to the vicinity of Natchez, Miss., and widening to an open end with an almost straight northwest margin against the Ozark and Ouachita highlands on the northwest. Closer inspection shows that the horn consists

[1] Russell, R. J., and Howe, H. V., "Cheniers of Southwestern Louisiana," Geog. Rev., vol. 25, no. 3, pp. 449-61, 1935.

[2] Recent, used geologically, covers an epoch of 25,000-30,000 years.

of several arcuate segments. The northernmost arc extends from Cape Girardeau, Mo., to the latitude of Little Rock, Ark.; its chord has a southwestern trend. The next one stretches southward to the latitude of Greenville, Miss., and has a southeastward-trending chord. From Greenville an arc with a southwestward-trending chord extends to the latitude of Angola, La., where it joins the southern arc which reaches to the Gulf.

The valley surface is not a continuous plain; it is broken by two narrow ridges alined with the valley axis. Crowleys Ridge extends for 200 miles from Commerce, Mo., to Helena, Ark. It rises more than 200 ft. above the alluvial plain, separating the northern part of the valley into the Eastern and Western lowlands. Macon Ridge in the central part of the valley extends from Eudora, Ark., to Sicily Island, La., a distance of approximately 100 miles. This low ridge rises 20 to 40 ft. above the floodplain and separates the lowland of the Mississippi River from the Boeuf and Ouachita River lowlands on the west. The two ridges are the highest divides between the major tributary streams of the entrenched valley system.

The northern part of the valley has an average width of about 70 miles and varies in elevation from 350 ft. at the north to 200 ft. at the south. It has steeper valley slopes, coarser surface alluvium, and shallower river channels than any other part of the valley.

The Eastern and Western lowlands include large areas of both the dissected alluvial plains and the floodplains. The dissected alluvial plains within the Western Lowland are remnants of the alluvial fan of the Mississippi River and its western tributaries, those in the Eastern Lowland remnants of the Ohio alluvial fan. The Western Lowland includes the Advance and Drum lowlands to the north, southwest of Cape Girardeau, and the floodplains of the White River and its tributaries. In the Eastern Lowland, the Advance Lowland merges with the Morehouse Lowland to form the alluvial plain extending south from Cape Girardeau. The Morehouse Lowland is separated from the Cairo Lowland to the east by Sikeston Ridge which rises 20 to 30 ft. above the floodplain. Extensive remnants of a high dissected alluvial plain, the Malden plain, once continuous with Sikeston Ridge, lie to the west along the eastern foot of Crowleys Ridge. South of New Madrid, Mo., is the St. Francis Basin, which lies west of the Mississippi River.

The central section includes both the widest and narrowest parts of the valley. It is 125 miles wide in the latitude of Helena, Ark., within the region of confluence of the Arkansas, White, and Mississippi rivers, and only 25 miles wide between Natchez, Miss., and Sicily Island, La. Above Natchez the valley is nowhere less than 50 miles wide and has an average width of 75 miles; below there it is less than 50 miles wide. Its average elevation gradually decreases from 200 ft. at the north end to 50 ft. at the south. The valley slope decreases downstream, and fine-grained deposits gradually increase in area and thickness.

Low ridges divide the central part of the valley into several basins. Macon Ridge separates the Tensas Basin on the east from the Boeuf Basin and Ouachita Lowland. Westward the Boeuf Basin merges with the Arkansas River Lowland which is bounded on the north by Grand Prairie Ridge. The large fertile Yazoo Basin east of the Mississippi River between Vicksburg, Miss., and Memphis, Tenn., is sometimes referred to as the "Yazoo Delta." To the south, the Lower Tensas Basin lies between the head of the deltaic plain and Natchez in the narrowest segment of the alluvial valley.

The southern part of the valley maintains an average width of 50 miles from the northern limit of the deltaic plain as far south as a line joining the ends of the escarpments between Donaldsonville and Franklin, La. Southward the valley widens and merges with the coastwise deltaic plains. The average elevation of the deltaic plain at its northern limit is less than 30 ft., and to the south much of the region lies close to sea level. The valley slope to the Gulf is the lowest of the entire valley. Surficial alluvial deposits of silt and clay are characteristic of the region.

The deltaic plain, coincident with the southern valley arc (plate 1), extends from the head of the Atchafalaya River to the Gulf of Mexico. It is separated from the floodplain area to the north by a low alluvial ridge made up of the natural levees of Bayou Des Glaises which trends westward across the valley from the Mississippi River to the Marksville Hills. The Atchafalaya Basin, the central part of the deltaic plain, is inclosed between the Bayou Teche Ridge on the west and an alluvial ridge on the east composed of the Mississippi meander belt ridge, between Angola and Donaldsonville, and the Lafourche Ridge from Donaldsonville to the Gulf. The Pontchartrain Basin lies between the Mississippi meander belt ridge south of Donaldsonville and the eastern and southern valley escarpment. The Barataria Depression is located between the Lafourche Ridge and the Mississippi River on the east.

The streams of the alluvial valley are the Mississippi River and its tributaries and distributaries. The main load of the Mississippi River is brought into the valley by the Missouri, Arkansas, and Red rivers, turbid streams which impart to the Mississippi its muddy character. The Ohio River, although it supplies more than half the total discharge of the master stream, is less turbid. The characteristics of the main tributaries, their discharge, type of load, and watershed area are summarized in table 1.

The Mississippi River enters the upper end of the Eastern Lowland through Thebes Gap, a rock-walled gorge extending for approximately 7 miles between Grays Point, Mo. (slightly upstream from Thebes, Ill.), and Commerce, Mo. The Mississippi is joined by the Ohio River at Cairo, Ill., 40 miles below Commerce and approximately 55 miles downstream from Cape Girardeau. The river follows a course which has a broad curvature similar to the curvature of the alluvial valley. Below the mouth of the Ohio, the river flows close to the eastern valley wall as far as Memphis, Tenn., and from there swings southwestward to Arkansas City, Ark., thence southward to the eastern valley wall at Vicksburg. South of Vicksburg the river flows close to the eastern valley wall to Donaldsonville, La., where it turns abruptly eastward to New Orleans. South of New Orleans it makes a great bend, English Turn, and flows to the Gulf.

All major tributaries of the Mississippi except the Ohio River enter the master stream from the western side of the valley. The St. Francis River flows across the Western Lowland, crosses Crowleys Ridge in a narrow gap, and enters the Mississippi near Helena, Ark., at the south end of the Eastern Lowland. The White River system drains the Western Lowland south of the St. Francis River and enters the Mississippi 50 miles southwest of Helena. The Black, Current, and Spring rivers, which drain the western uplands, form parts of the White River system. The Arkansas River enters the alluvial valley near Little Rock, Ark., and joins the Mississippi River near Rosedale, Miss., slightly downstream from the mouth of the White River.


FLOOD PLAIN FEATURES
OF THE
LAKE PROVIDENCE REACH PORTION
OF THE
MISSISSIPPI RIVER MEANDER BELT
SCALE IN MILES
0 1 2 3 4
N
COUNTY
CHICOT COUNTY
RIVER
2B-110
GASSOWAY
3B-95
PARISH
RIDGE
4B-30
LEVEES
Gassoway Lake
2B-30
3B-35
ISSAQUENA
2B-15
DUNCANSBY TOWHEAD
2B-95
MILLIKIN
MACON
OPPOSSUM POINT
Oppossum Chute
MISSISSIPPI
3B-30
4B-50
LEBANON
2B-11
3B-100
2B-35
NATURAL
WAINWRIGHT
CARROLL
Old River
4B-25
2B-10
SHELBURN
BACK SWAMP
MACON
2B-90
BAYOU
3B-25
OX BOW LAKE
4B-55
COALESCING
Basin
3B-105
2B-40
LAKE PROVIDENCE
BALESHED TOWHEAD
MISSISSIPPI
COUNTY
NATURAL LEVEE
WEST
4B-20
TENSAS
3B-84
STACK ISLAND
CARLISLE LAKE AREA
BACK SWAMP
2B-5
2B-123
2B-85
Tensas B.

FIGURE 1

POINT OF DIVERSION
OF
MISSISSIPPI RIVER
FROM ITS
WALNUT BAYOU COURSE
STAGE 10
SCALE IN MILES
0 1 2 3 4
MISSISSIPPI
MISSISSIPPI
RIVER
DIVERSION POINT
TERRAPIN NECK CUT-OFF 1866
UPPER TENSAS COURSE
STAGE 6
STAGE 10
STAGE 10
STAGE 8
STAGE 9
STAGE 10
YAZOO RIV STAGE 10
TALLULAH
VICKSBU
ESCARPMENT
N


FIGURE 2

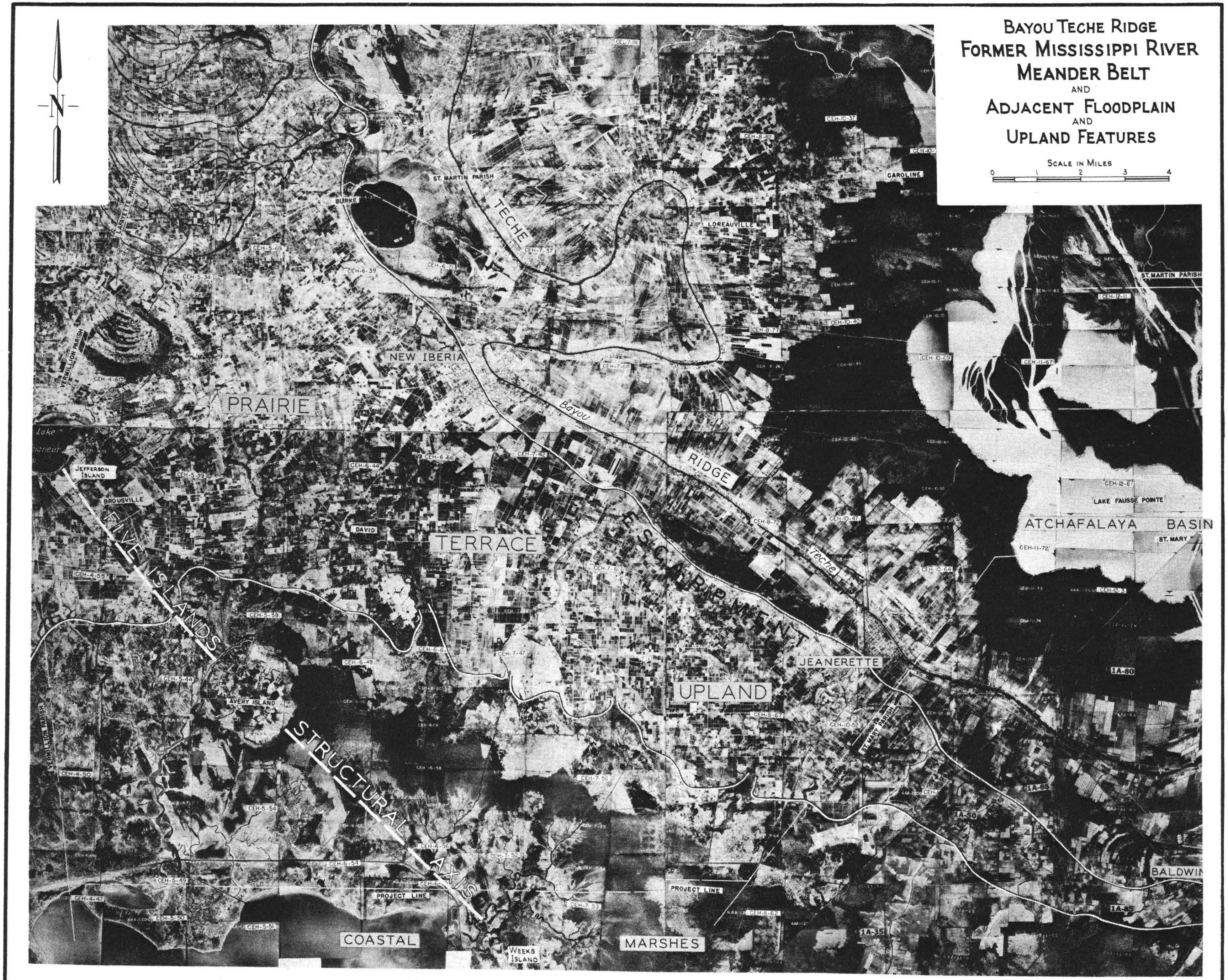

Bayou Teche Ridge
Former Mississippi River
Meander Belt
and
Adjacent Floodplain
and
Upland Features
Scale in Miles
0 1 2 3 4
N
St. Martin Parish
Burke
Teche
Loreauville
Caroline
New Iberia
Prairie
Bayou
Ridge
Jefferson Island
Brousville
David
Terrace
Escarpment
Teche
Five Islands
Lake Fausse Pointe
Atchafalaya Basin
St. Mary
St. Martin Parish
Jeanerette
Upland
Avery Island
Structural Axis
St. Mary Parish
Vermilion Parish
Project Line
Coastal
Weeks Island
Marshes
Baldwin

FIGURE 3

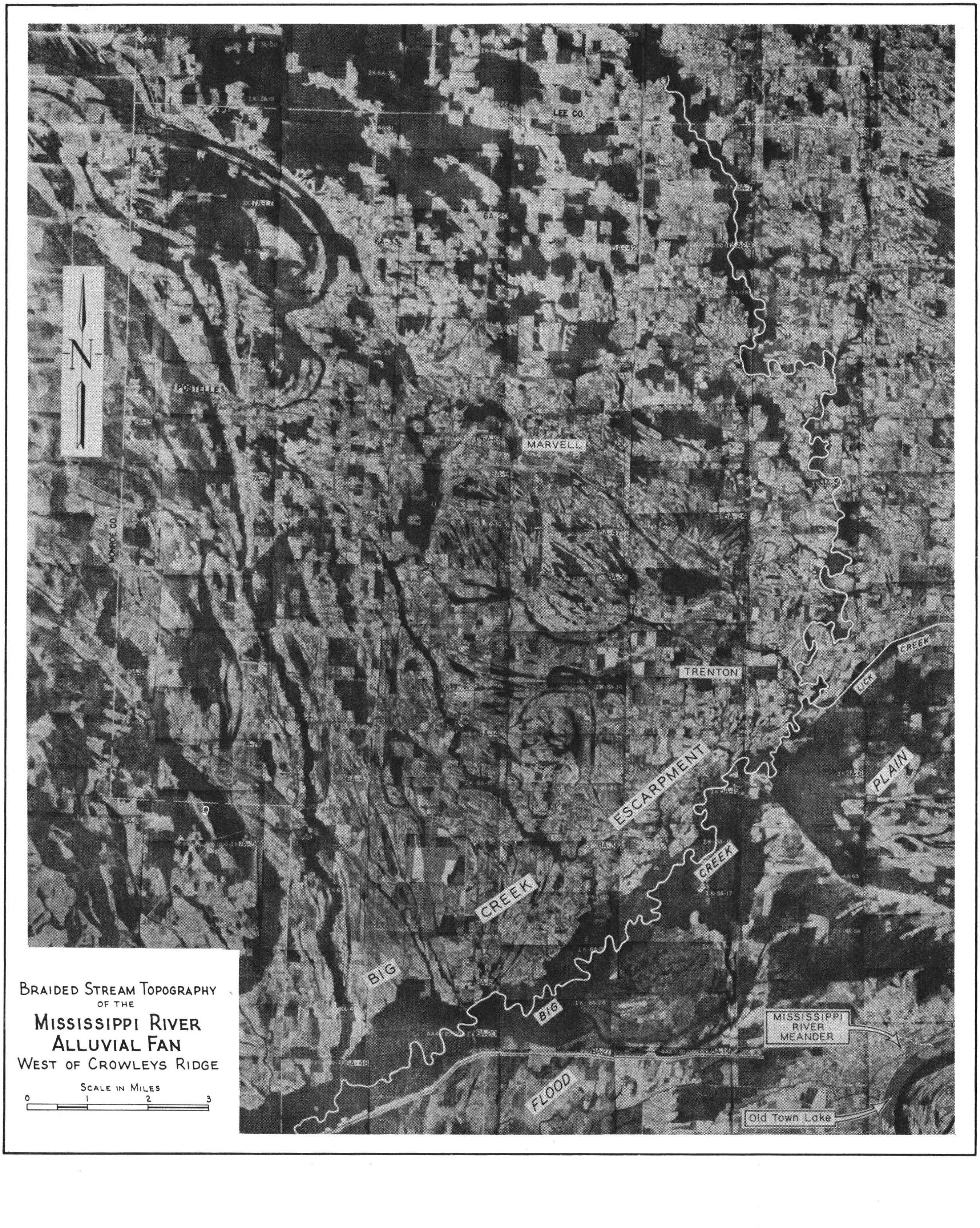

LEE CO.
POSTELLE
MARVELL
MONROE CO.
TRENTON
LICK CREEK
ESCARPMENT
PLAIN
CREEK
BIG CREEK
BIG
FLOOD
MISSISSIPPI RIVER MEANDER
Old Town Lake
N
Braided Stream Topography of the Mississippi River Alluvial Fan West of Crowleys Ridge
Scale in Miles
0 1 2 3

FIGURE 4

| Stream | Gage | Watershed Area in Square Miles[1] | Discharge in CFS | | | | | Character of Load |
|---|---|---|---|---|---|---|---|---|
| | | | Minimum[2] | | Average[1] | Maximum[2] | | |
| Mississippi System | Vicksburg, Miss. | 1,244,000 | 93,800 | (1936) | 509,900 | 2,080,000[3] | (1937) | |
| Ohio River | Metropolis, Ill. | 204,000 | 20,200 | (1930) | 274,700 | 1,780,000[4] | (1937) | Mainly sands |
| Missouri River | Hermann, Mo. | 529,000 | 4,200 | (1940) | 79,100 | 589,000 | (1903) | Mainly gray silts |
| Upper Mississippi | Grafton, Ill. | 171,300 | 14,800 | (1933) | 105,000 | 366,000 | (1903) | Mainly sands |
| Arkansas River | Little Rock, Ark. | 160,500 | 850[3] | (1934) | 39,500 | 813,000 | (1927) | Mainly red silts |
| Red River | Alexandria, La. | 66,600 | 1,180 | (1934) | 29,000 | 210,000 | (1908) | Mainly red silts |
| St. Francis River | Parkin, Ark. | 6,230 | 271 | (1941) | | 74,100 | (1937) | |
| White River | Georgetown, Ark. | 27,750[4] | 2,900 | (1936) | 23,400[3] | 440,000 | (1927) | Small amount sand |
| Yazoo River | Greenwood, Miss. | 7,450 | 872 | (1940) | | 72,900 | (1932) | |
| Ouachita River | Monroe, La. | 15,400 | 100 | (1934) | | 95,400 | (1932) | |
| Atchafalaya River | Simmesport, La. | Distributary | 11,600 | (1891) | | 480,000 | (1890) | |

[1] 74th Congress, 1st Session, House Document No. 259, 1936.
[2] Daily Discharge of the Mississippi and its Tributaries, Mississippi River Commission, 1941.
[3] U. S. Geol. Survey, Water Supply Paper 957, 1942.
[4] U. S. Geol. Survey, Water Supply Paper 953, 1942.

**TABLE 1. Watershed Area, Discharge, and Type of Load of the Major Streams of the Mississippi River System.**

The Ouachita River enters the alluvial valley near Monroe, La., and flows close to the western valley wall as far south as Harrisonburg, La. It joins the Black River near Jonesville, La., and the two join Red River near Acme, La. The Red River enters the alluvial valley through a gap in the low uplands near Moncla, La., and flows across the alluvial plain to join the Mississippi near Angola. There are no western tributaries to the Mississippi River south of Red River.

Largest of the minor tributaries entering the Mississippi Valley from the eastern uplands south of the mouth of the Ohio River are the Obion, Forked Deer, Hatchie, Loosahatchie and Wolf rivers of Tennessee. The Coldwater, Tallahatchie, Yocona and Yalobusha rivers, headwaters of the Yazoo System and the Big Black and the Homochitto rivers enter the valley from Mississippi.

Many minor tributary streams of the Mississippi have drainage basins confined wholly to the floodplain of the alluvial valley. The Tensas River of northeastern Louisiana is a typical example. Before construction of the artificial levee system, the Tensas functioned both as a channel for distributing floodwaters into the Tensas Basin and as the principal channel for flood-water release. The Sunflower River and the Yazoo River which drain the Yazoo Basin are also typical floodplain tributary streams, but the discharge of the Yazoo is increased by the waters from several of the minor upland streams. Many of the floodplain tributary streams follow abandoned channels of the Mississippi River; others follow lowlands between abandoned courses of the master streams.

Streams confined entirely to the surface into which they have been incised drain the dissected alluvial plains in the northern part of the alluvial valley. L'Anguille River, the largest, drains the southern end of the Western Lowland and enters the Eastern Lowland through a gap in Crowleys Ridge near Marianna, Ark. The Big Creek and Bayou De View systems, tributaries of the White River, afford excellent examples of minor drainage lines incised in the dissected plain of the Western Lowland. Bayou Meto, which is a tributary of the Arkansas River and drains Grand Prairie Ridge, is also typical.

The Mississippi River has had several distributaries or flood outlets within the deltaic plain region. All have been closed artificially save for the Atchafalaya River which heads on the western side of the Mississippi near Simmesport, La., in the Old River segment of Red River approximately 7 miles upstream from the Red-Mississippi junction. It flows for 140 miles to the Gulf of Mexico and in its lower part follows a system of near sea level lakes which start approximately 60 miles downstream from its head.

Bayou Plaquemine and Bayou Lafourche were active western distributaries of the Mississippi River in its natural state. Bayou Plaquemine headed at Plaquemine, La., and flowed 80 miles to the Gulf. It was blocked off from the Mississippi by the construction of the west bank levee in 1867-68; in 1909 a lock was constructed at Plaquemine permitting navigation between the Mississippi River and the bayou. Bayou Lafourche ceased to be an active distributary in 1903-04 when a dam was constructed across its head at Donaldsonville. It follows the main channel position of an abandoned Mississippi River meander belt for approximately 90 miles to the Gulf.

The only eastern distributary of the Mississippi River which operated in the historical period was Bayou Manchac. It headed approximately 15 miles downstream from Baton Rouge, La., and flowed eastward through a gap in the low uplands into Lake Maurepas. In 1828 a dam was constructed across its head.

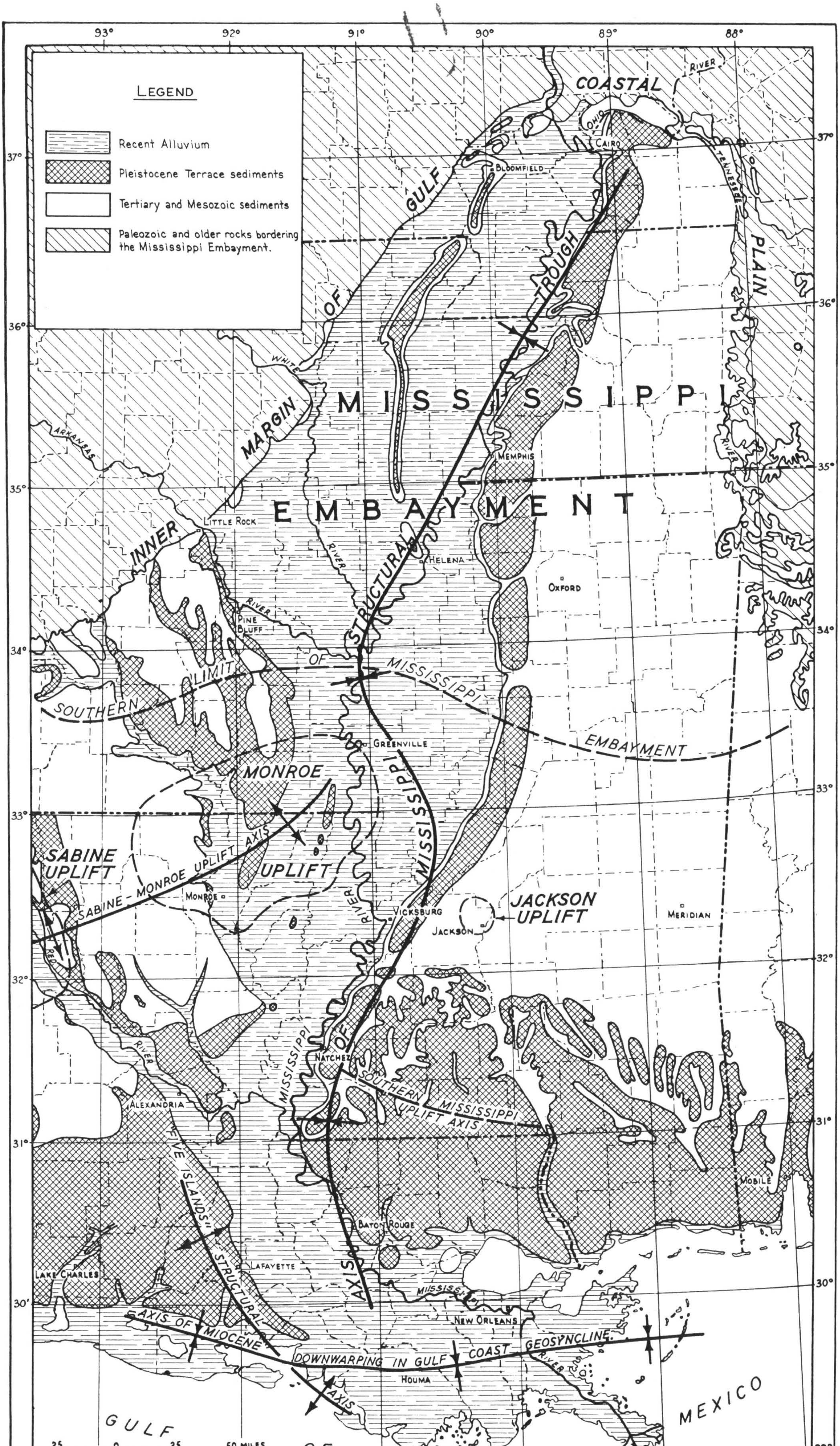
The parallelism of drainage lines is an outstanding feature of the alluvial valley. Floodplain tributaries follow courses alined with the Mississippi River or with major tributary streams for long distances before reaching their point of junction. The streams of the dissected alluvial plains are incised in courses roughly parallel to the main drainage lines of the floodplain. Meander belts, abandoned by the Mississippi and its principal tributaries and now occupied by floodplain streams, are alined with similar curvature to those in which the present streams flow. A striking alinement also exists between the trunk channel of the Mississippi River and its abandoned counterparts within the lower part of the deltaic plain. Each of the main channels (Bayou Teche, Bayou Lafourche, and the modern channel) turns southeastward in the latitude of New Orleans, at about the point where the first-formed minor distributaries of each course started to develop (see plate 2). The alinement of drainage features in the area of the Mississippi delta has been referred to as the "regional grain."[1]

The direction of alinement of the streams is similar to that of the major structural trends of the Central Gulf Coastal Plain, and the position of the streams is therefore considered to be a reflection of movements in the rocks through which the alluvial valley has been carved. The effect of structural movement upon the drainage of the alluvial valley and the recency of some movements are illustrated in the rectangular pattern of minor streams and lakes within the deltaic plain.

The width and arcuate shape of the valley, the outlines of the valley walls, the position of the Mississippi meander belt, and the trend of the tributary valleys entering the alluvial valley are also major features shaped by earth movements associated with structural features in the coastal plains region. The southwest trending Mississippi meander belt within the Mississippi Embayment area (figure 5) lies directly over the axis of downwarping in the northern part of the Central Gulf Coastal Plain. The axis of the downwarped area, the Mississippi Structural Trough, can be traced southward as a sinuous line to a point near New Orleans, where it intersects the axis of the east-west trending downwarp, the Gulf Coast Geosyncline. The Monroe Uplift displaces the axis of the Mississippi Structural Trough eastward between Vicksburg and Greenville, Miss., and the Southern Mississippi Uplift displaces the trough westward between Natchez and Baton Rouge (figure 5). In the central and southern parts of the alluvial valley the sinuosities of the Mississippi meander belt and the curvature of the valley both closely approximate the bends of the Mississippi Structural Trough. The curvature of the southernmost portion of the western valley wall follows closely the curvature of the axis of the "Five Islands" Uplift (figures 3 and 5), and the deltaic plain widens to merge with the coastwise marshes near the axis of the Gulf Coast Geosyncline.

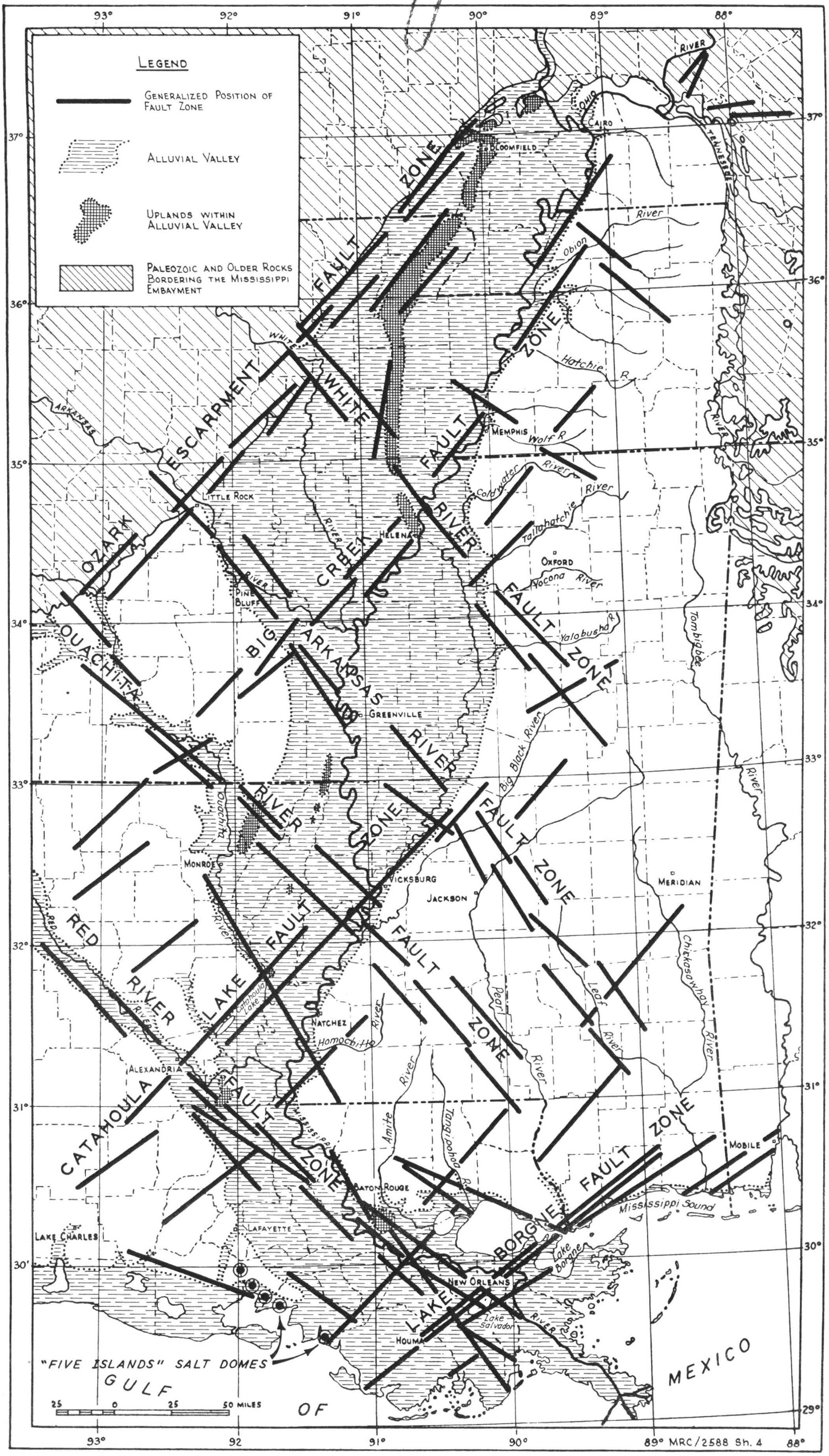
The width of the alluvial valley can be correlated with the attitude of the rocks forming the valley floor and thus with the structures of the region. The widest portion of the valley is in the area of nearly horizontal rocks north of the Monroe Uplift. The narrow southern portion of the valley south of Natchez coincides

[1] Russell, R. J., "Physiography of the Lower Mississippi Delta," Louisiana Dept. Cons., Geol. Bull. No. 8, pp. 3-199, 1936.




MAP SHOWING THE RELATIONSHIP BETWEEN THE DISTRIBUTION OF QUATERNARY SEDIMENTS AND THE MAJOR STRUCTURAL FEATURES IN THE CENTRAL GULF COASTAL PLAIN.

FIGURE 5




MAP SHOWING THE PRINCIPAL FAULT ZONES WITHIN THE CENTRAL GULF COASTAL PLAIN AND THEIR RELATIONSHIP TO THE ALLUVIAL VALLEY OUTLINE AND THE POSITION OF COASTAL PLAIN STREAMS.

FIGURE 6

with an area of active uplift, the northern limb of the Gulf Coast Geosyncline. The bedrock in this section of the Gulf Coastal Plain dips toward the geosyncline and away from the Monroe and Southern Mississippi uplifts.

Valleys entering the alluvial valley are alined in two distinct trends. Those of the western tributaries, such as the White, Arkansas, and Red rivers, trend northwest-southeast; those of the eastern tributaries, such as Homochitto, Big Black, and Yalobusha rivers, trend northeast-southwest. These directions parallel the trend of the major fault zones of the region and show that the location of the tributary streams has been controlled by the regional structures (figure 6).

The valley walls bear traces of modification at points where streams have impinged against them, but the main outlines appear to be governed by the same fault zones which are followed by the tributary valleys. The western escarpment of the valley in the Mississippi Embayment section is conspicuous for its straightness and the extreme angularity of its salients. The northeast-southwest trend of the escarpment is parallel with the Ozark Escarpment fault zone and has been previously considered a fault escarpment.[1] Although the eastern valley wall of the Mississippi Embayment follows the same trend, it is not as nearly straight. The outline of Crowleys Ridge also follows the trend of the same faults and has noticeable jogs corresponding with salients in the western valley wall, which were formed by faults parallel with the White River fault zone (figure 6). Farther to the south the outlines of the valley can be directly correlated with the northwest-southeast trending Arkansas River, Ouachita River, and Red River fault zones, or with the northeast-southwest Big Creek and Catahoula Lake fault zones. The Lake Borgne fault zone controls the shape of the coastal margin in southern Mississippi and has a direct influence upon the shape of the lakes and the alinement of the streams in the deltaic plain in Louisiana.

The coincidence between valley shape, alinement of tributaries, and the parallelism of the alluvial valley drainage lines is but a manifestation of the control which regional structures have exerted upon the formation of the Central Gulf Coastal Plain. Movement along the regional structural lines has been slow and long continued. The introduction of the Mississippi and Ohio river systems into the coastal plains occurred late in the geological history of the region after the lines of weakness had become well established. During early glacial time when the ice sheets first advanced upon the continent, many north-flowing streams of the continental interior were integrated around the ice margin to form the Mississippi and Ohio river systems which were diverted into the coastal plains at the north end of the Mississippi Embayment. The stream valleys of the coastal plains into which the major rivers were diverted had been carved along the structural lines which later localized the master streams and shaped their alluvial valleys.

Structural movements in the region have been active concurrently with the subsidence of the coastal margin under the great weight of accumulating deltaic masses of sediment.[2] It is probable, therefore, that they represent local adjustments to the regional subsidence. Accumulation of deltaic sediments has been taking place in the region for an extremely long time, and the cycles in which the sediments were deposited constitute the principal aspects of the geological history of the region. The late geological history of the coastal plain has witnessed a great influx of sediment accompanying the formation of the Mississippi River system. It is probable that structural movements have been greatly accelerated during this epoch and have become an increasingly active factor in shaping the region.

[1] Bucher, W. H., "Deformation of the Earth's Crust," Princeton Univ. Press, p. 356, 1933.

[2] See Appendix, p. 64.

# Part II

## THE ENTRENCHED VALLEY SYSTEM

The existence of a buried valley system underlying the Mississippi alluvial plain has been recognized since 1881, when deep borings made by the Mississippi River Commission disclosed that the alluvium extended far below the maximum depth of the channel of the modern river. Utilizing these Mississippi River Commission borings and other data, McGee[1] published a generalized contour map showing a deep embayment within the alluvial valley region which he considered to be of early Pleistocene age. From studies in the northern part of the valley, Marbut[2] and Salisbury[3] considered the buried valley to be middle Pleistocene in age. These early writers considered the buried valley to have been cut during interglacial time and to have been filled with alluvium during subsequent glacial stages. The writer[4] studied the nature and distribution of the Quaternary deposits in Louisiana and arrived at the conclusion that the buried valley was excavated during the latest glacial stage, the late Wisconsin,[5] and was filled with Recent alluvium.

The details of the valley system as reconstructed from logs of several thousand borings are similar to those of a normal stream system which has been incised in a region of low relief. The entrenched system consists of several major tributary trenches, separated by divides, each of which can be traced into the marginal uplands beneath the alluvial plain of a Mississippi tributary. The contour map (plate 3) shows the general configuration of the system. Transvalley cross sections (plates 4 to 8 inclusive) made from closely spaced borings show the valley floor profile, nature and age of ancient sedimentary rocks which make up the valley floor, and the details of the Recent alluvium filling the entrenched valley system. Generalized cross sections of the alluvial valley and its principal tributaries are shown on plate 9.

The entrenched streams were incised in steep-walled valleys whose sides were sculptured by many small steep tributaries. The master stream sloped gulfward from an elevation of approximately 100 ft. above present sea level in the northern part of the alluvial valley to more than 350 ft. below present sea level near the modern coast line. The streams had straighter courses and steeper gradients than the present ones and were incised in generally little-resistant sedimentary rocks. As a result of these factors, the stream system was enabled to excavate 1,280 cubic miles[6] of sediment from the alluvial valley area and to transport it to the Gulf of Mexico.

Trenches of the buried valley system are separated by divide areas which vary greatly in width and relief. Crowleys Ridge, the divide between the Ohio and Mississippi entrenched valleys, has a crest over 500 ft. above the valley floor. Macon Ridge stands 300 ft. high above the floor of the Mississippi and Arkansas entrenched valleys. Elsewhere the divide areas between the trenches are low and are buried under alluvium.

Downcutting by tributary streams to form the entrenched valleys was localized along fault zones in many places and was also controlled by major uplifts (figures 5 and 6). The trend of the subsurface trenches not only follows the trend of the narrow valleys in the marginal uplands but is parallel with known fault zones within the alluvial valley. The narrowing of the Ohio trench in the Eastern Lowland between Helena, Ark., and the eastern valley wall is probably the result of uplift of the region associated with earth movements along the Big Creek fault zone. The narrowing of the master trench between Natchez, Miss., and Harrisonburg, La., probably results from uplift associated with movement along the Catahoula Lake fault zone, but it is also related to the upwarp in the Southern Mississippi Uplift.

The trenches follow closely the position of the Mississippi Structural Trough. The Ohio River trench lies over the axis of the trough in the Mississippi Embayment area and is paralleled on the west by the Mississippi trench. The trench of the combined streams overlies the trough and is warped eastward around the Monroe Uplift in the central part of the valley. Between Natchez and Baton Rouge the master trench follows a broad arc around the Southern Mississippi Uplift area and parallels the Mississippi Structural Trough. Farther south the trench curves to the southeast and is parallel to the Five Islands Structural Axis.

The relation of the trenches to regional warping and faulting is shown on the hypothetical structure sections included on plates 4-7. Downwarping along the Mississippi Structural Trough was associated with a series of faults of minor surface displacement. The positions of the faults have been established from their surface expression. Displacement of bed rock sediments was established from a study of samples from borings and is shown in relation to a hypothetical bed.

### Position of Trenches

The tributary Mississippi trench underlies the narrow upper Mississippi Alluvial Valley between St. Louis and Cape Girardeau, Mo. South of Cape Girardeau, however, the trench occupies a position entirely different from that of the present stream which flows through Thebes Gap to enter the Eastern Lowland north of Cairo, Ill. The trench follows the Advance Lowland through the Paleozoic uplands to Poplar Bluff, Mo., where it abruptly widens and deepens. Below Poplar Bluff it lies close to the western margin of Crowleys Ridge as far south as Helena, Ark.; 50 miles southeast of Helena it joins the Ohio trench east of Rosedale, Miss.

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[1] McGee, WJ, "The Lafayette Formation," U. S. Geol. Survey 12th Ann. Rept., 1890-91.

[2] Marbut, C. F., "The Evolution of the Northern Part of the Lowlands of Southeastern Missouri," Univ. of Missouri Studies, vol. 1, No. 3, pp. 42-44, 1902.

[3] Salisbury, R. D., "On the Relationship of the Pleistocene to the Pre-Pleistocene Formations of Crowley's Ridge, and Adjacent Areas South of the Limit of Glaciation," Arkansas Geol. Survey, Ann. Rept. 1889, vol. II, pp. 224-248, 1889.

[4] Fisk, H. N., "Geology of Grant and LaSalle Parishes, Louisiana," Louisiana Dept. Cons., Geol. Bull. No. 10, pp. 149-174, 1938.

[5] The Late Wisconsin Glacial Stage started approximately 50,000-60,000 years ago and reached its maximum accumulation 25,000-30,000 years ago (see Appendix, p. 67).

[6] Computation includes only volume of sediments removed from alluvial valley as far south as a line drawn between Donaldsonville and Franklin, La. It does not include volume excavated from lower Red River valley or that removed from the area of the present-day deltaic plain. An estimate of 1,500 cubic miles for total of sediment removed from entire alluvial valley is considered conservative. The total volume of sediments transported to the Gulf of Mexico is much greater because it includes the load of the tributary systems, derived from erosion of their valleys, and also the load derived from the meltwaters of the glaciers.

The Ohio entrenched valley in southern Illinois, between Golconda and Cairo, occupies the Cache Lowland, not the existing Ohio valley. South of the Cache Lowland the trench is near the center of the Eastern Lowland to the latitude of Jonesboro, Ark.; south of Jonesboro it is near and parallel to the eastern margin of Crowleys Ridge.

The combined Mississippi-Ohio trench between Rosedale and Natchez, Miss., is slightly east of the center of the valley and roughly parallel to the eastern valley wall. South of Natchez the trench is centrally located within the valley to Houma, La. Widely distributed borings indicate that the trench trends southeastward from Houma and may merge with the submarine valley southwest of the present delta (plate 3).

The White River trench extends from its upland valley southeastward beneath the present White River course as far south as the junction of the White and Mississippi rivers. It continues southeastward from the junction for 35 miles and joins the Mississippi trench about 15 miles east of Greenville, Miss.

The Arkansas trench leaves the uplands at Little Rock, Ark.; its position beneath the alluvial plain is entirely different from that of the present course of the river. The trench is parallel to the closely adjacent western wall of the alluvial valley to the latitude of Bastrop, La.; south of Bastrop it continues southeastward to join the Mississippi trench in the center of the valley northeast of Sicily Island, La.

The extremely short entrenchment valley of the Ouachita River within the alluvial valley region extends eastward through the narrow gap north of the Bastrop Hills and joins the Arkansas trench about 5 miles east of the valley wall. The gap in the uplands is now occupied by Bayou Bartholomew and the Ouachita River flows southward along the western valley wall west of the Bastrop Hills.

The Red River did not occupy its present course through the gap of the Marksville Hills during late Wisconsin time. Its trench extends south and east of the Marksville Hills for 60 miles to join the Mississippi trench in the center of the valley east of Opelousas, La.

Many minor tributary trenches are mapped along the eastern margin of the valley between the Ohio River and Baton Rouge, La. (plate 3). They include not only valleys of principal eastern tributaries but many short steep-sided gulleys which headed in the eastern valley wall. South of Baton Rouge, the Lake Pontchartrain Basin is underlain by eastward-trending trenches of the Amite River system. The present course of the Mississippi River southeast of Donaldsonville, La., does not overlie the master entrenched valley but follows a course across the divide between the Amite and Mississippi trenches.

## Entrenched Valley Floor Deposits

The bedrock deposits forming the floor of the Mississippi entrenched valley system vary in age from Paleozoic in the northern end of the valley to late Pleistocene in southern Louisiana. The age of bedrock deposits, their nature, general distribution, and attitude have had an important bearing on determining the width, depth, and slope of the entrenched valley system. The Paleozoic rocks are better indurated and more resistant to stream erosion than the younger ones. Of the younger deposits, thick clays, silts, and limestone sections are more resistant to erosion than are the sand sections. Flat-lying, relatively resistant valley floor rocks coincide with the widest part of the alluvial valley and with a local flattening of the trench profiles. Structurally deformed areas in which rocks have steeper dips coincide with zones in which the valley is narrow.

A study of the lithology and paleontology of subsurface samples permitted the separation of several groups of sediments which form the valley floor. The data derived from these studies were correlated with published information and with data from electrical logs of borings made in the search for petroleum. A geological map (plate 10) was constructed from these data to show the generalized distribution of valley floor sediments. The relationship of these sediments to Central Gulf Coastal Plain deposits is shown on figure 7.

The general nature of the broad stratigraphic units of the Central Gulf Coastal Plain is discussed in the Appendix. The following discussion takes up the lithologic characteristics, distribution, attitude, and other general features of the entrenched valley floor deposits. The nature of the beds is summarized in table 2.

### *Paleozoic Rocks*

Well-indurated sedimentary rocks of Paleozoic age form the walls and floor of the entrenched valley of the Mississippi between St. Louis and Poplar Bluff, Mo. They also form the walls and floor of the Ohio entrenched valley in southern Illinois from Golconda to Ullin, Ill. The rocks consist of well-indurated limestones and cherty dolomites interbedded with sandstones and shales. Because of their greater induration the Paleozoic rocks offer more resistance to erosion than any other group of sediments in the entrenched valley. No attempt is made on plate 10 to subdivide the Paleozoic rocks, because it would be of little importance to this study. Local age determination, however, is shown on the cross section (plate 7).

### *Upper Cretaceous*

Upper Cretaceous deposits outcrop in the northern part of the valley along Crowleys Ridge. These deposits overlie the Paleozoic rocks and dip to the southeast beneath the younger Tertiary sediments. The Upper Cretaceous sediments within the entrenched valley are confined to a narrow southwest-northeast belt less than 10 miles wide from a point about 25 miles southwest of Poplar Bluff, Mo., to a few miles northwest of Cairo, Ill.

The Upper Cretaceous deposits outcropping in the northern part of the Mississippi Embayment area of western Kentucky and Tennessee are subdivided into three formations,[1] but in the area of the alluvial valley in southeastern Missouri only one Upper Cretaceous formation, the Ripley, has been recognized.[2] The greater part of this formation consists of fine to coarse sands and quartzitic sands with thinly interbedded clays. The upper part of the Ripley formation is characterized by fossiliferous, glauconitic, sandy shale lentils which comprise only a minor part of the formation. For details of the Upper Cretaceous section in southeastern Missouri, see plate 7.

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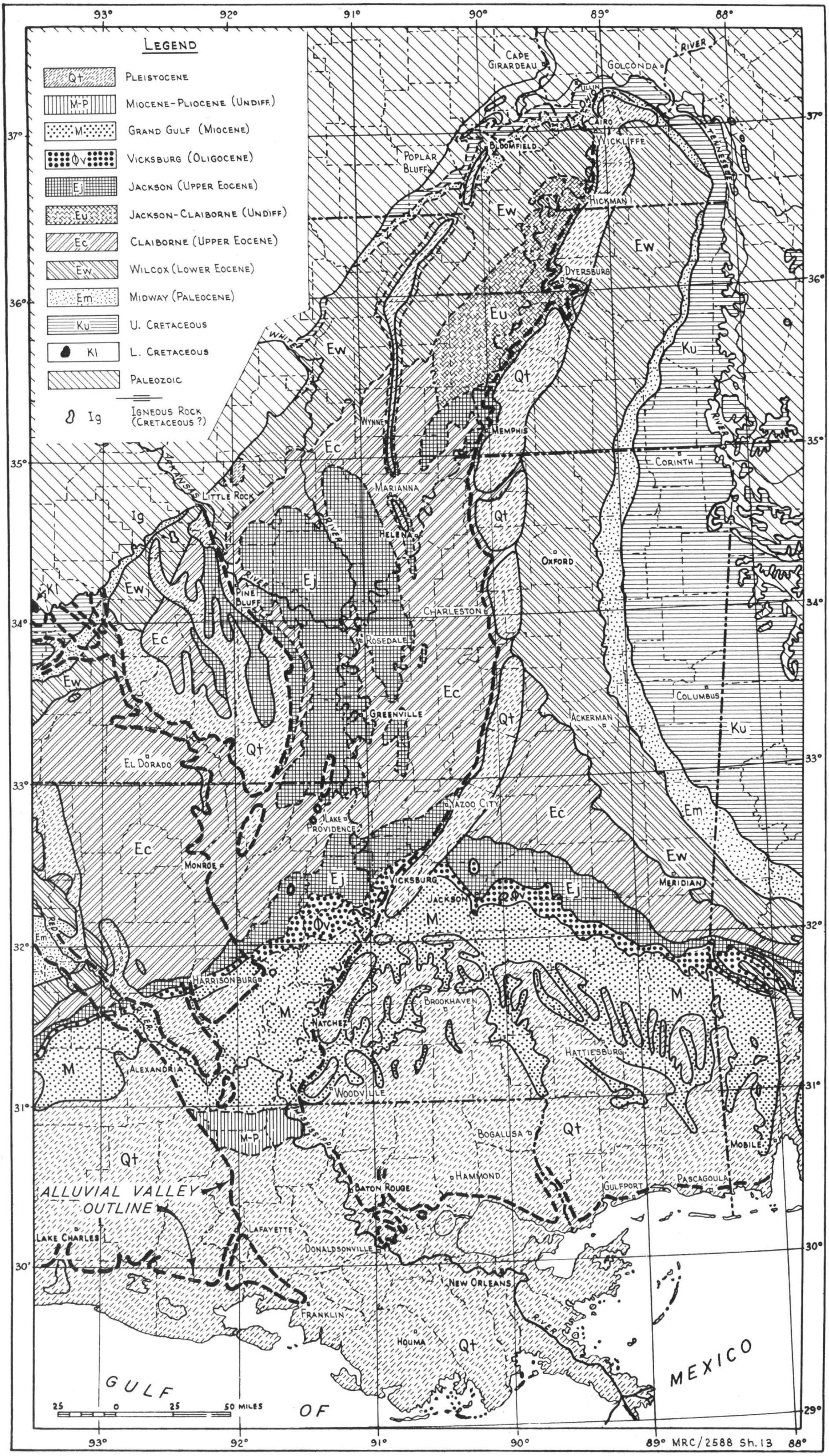
[1] McFarlan, A. C., "Geology of Kentucky," Univ. of Kentucky Press, pp. 115-121, 1943.

[2] Farrar, Willard, "The Geology and Bleaching Clays of Southeast Missouri," Missouri Geol. Survey, 58th Biennial Report, Appendix I, pp. 7-35, 1935.




Geological Map of Floor of Mississippi Alluvial Valley and Adjacent Upland Areas. (Upland Areas Modified after Geologic Map of the United States, U. S. Geol. Survey, 1932).

FIGURE 7

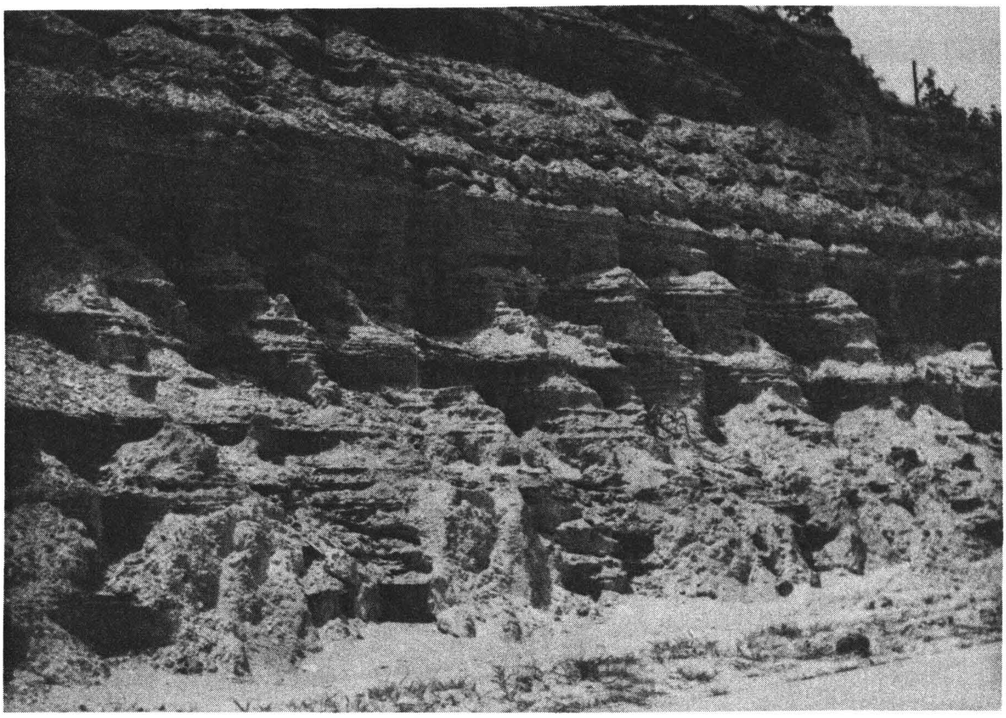


FIG. 8 Thin Bedded Silts, Silty Clays, and Sands of the Basal CLAIBORNE TALLAHATTA Formation Exposed in Road Cut 2 Miles South of Grenada, Mississippi. These Deposits are Interbedded with Massive Sands and Lignitic Clays and are Typical of Both the Upper WILCOX and Lower CLAIBORNE Beds Forming the Valley Floor. Beds Shown in this Photograph were Long Considered to be Typical of the Upper WILCOX GRENADA Formation.

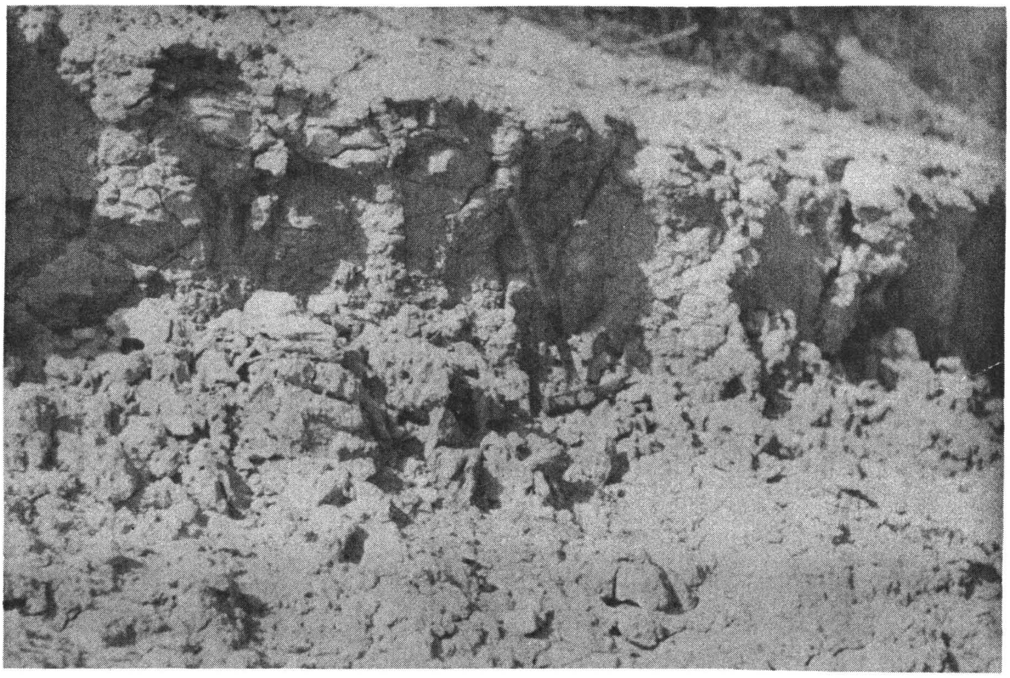


FIG. 9 Calcareous Clay of the Middle JACKSON (Eocene) YAZOO CLAY Formation Exposed in Perry Creek, 1 Mile South of Valley, Mississippi. These Clays are Typical of Deposits of JACKSON Age Forming the Floor of the Entrenched Valley System near Greenville, Mississippi.

| Era | System | Series | Group | Formation | Lithologic Character |
|---|---|---|---|---|---|
| CENOZOIC | Quaternary | Pleistocene | Terrace Deposits | Prairie | Well compacted, oxidized, clays and silty clays yellowish brown in color underlain by sands and fine gravels. |
| | | | | Montgomery | Not present on floor of entrenched valley. |
| | | | | Bentley | |
| | | | | Williana | |
| | Tertiary | Pliocene-Miocene (?) | | Undiff. | Interfingering silts and sands with interbedded brackish water silts and clays. |
| | | Miocene | Grand Gulf | Fleming | Interfingering facies of fluviatile silts and sands with interbedded brackish water silts and clays. |
| | | | | Catahoula | Tuffaceous siltstones, silty sands, loosely compacted sands, silts and clays. |
| | | Oligocene | Vicksburg | Byram | Marine sandy clay marl and lignitic silty clays. |
| | | | | Glendon | Alternating limestones and marls. |
| | | | | Mint Spgs. | Glauconitic sandy marl. |
| | | | | Forest Hill | Lignitic silts, silty clays and sands. |
| | | Eocene | Jackson | Danville Landing | Predominantly marine, calcareous clays and shales. |
| | | | | Yazoo Clay | Clays, lignitic clays, interbedded marine and brackish water silts. |
| | | | | Moodys Branch | Glauconitic shell marl and clays. |
| | | | Claiborne | Cockfield | Lignitic sands, silts and clays. |
| | | | | Cook Mountain | Glauconitic clays, silts and sands. |
| | | | | Undiff. | Lignitic sands, sandy clays, silts and silty clays at the north end of the valley. |
| | | | Wilcox | Grenada | Lignitic sands, silty sands, and silty clays. |
| | | | | Holly Springs | Coarse lignitic sands, locally graveliferous, with sandy clays, clay lentils and fossil leaves. |
| | | Paleocene | Midway | Porters Creek | Massive gray to black clays, sandy clays with local sandy shale interbeds. |
| | | | | Clayton | Glauconitic sandy clays. |
| MESOZOIC | Cretaceous | Upper Cretaceous | | Ripley | Chiefly sands, varying from fine to coarse, with thin interbedded clays and quartzitic sands. Upper part of section marked by fossiliferous sandy shales. |
| | | Lower Cretaceous | | Not present on floor of entrenched valleys. | |
| | Jurassic | | | Not present on floor of entrenched valleys. | |
| | Triassic | | | Not recognized in valley region. | |
| PALEOZOIC | Not subdivided in this report. | | | | Well indurated limestones, cherty dolomites, interbedded with sandstones and shales. |

**TABLE 2.—Age and Lithologic Characteristics of Deposits forming the Floor of the Mississippi Entrenched Valley System.**

*Paleocene Series*

**Midway Group.** Midway deposits form only a minor part of the entrenched valley floor. Like the Upper Cretaceous deposits, they are confined to a narrow northeast-trending belt less than 10 miles wide from Little Rock, Ark., across southeastern Missouri and northwestern Kentucky. These beds form the floor of the valley underlying the present Ohio River west of Metropolis, Ill. (plate 10).

The Midway group in the northern part of the valley is known to consist of two formations. The basal Clayton beds are less than 10 ft. thick[1] and consist of deposits of glauconitic, fossiliferous, sandy clays; because of their thinness they are grouped with the overlying Porters Creek Clay (plate 10). The characteristics of the Midway "black shale" which outcrops in many parts of the Central Gulf Coastal Plain are exhibited by the Porters Creek Clay. This formation reaches a thickness of approximately 200 ft. in the northern end of the valley and is made up of sparingly fossiliferous, massive, gray to black clays and thinly interbedded sandy shales.

*Eocene Series*

**Wilcox Group.** The thick Wilcox beds form a belt 20 to 50 miles wide, trending northeast from Little Rock, Ark., to Wickliffe, Ky. The belt is parallel to the trend of the Upper Cretaceous and Midway sediments and to the outcrop of Paleozoic rocks along the Ozark Escarpment in Arkansas and Missouri. The Wilcox beds dip toward the axis of the Mississippi Embayment where they reach a thickness of 1,500 ft.

The Wilcox sediments which are present on the entrenched valley floor (table 2 and plate 10) consist of fluviatile, cross-bedded, lignitic, locally graveliferous sands which interfinger with thin-bedded shales and with sandy clay lentils bearing fossil leaves. These beds appear to be the lithologic equivalent of the surface Wilcox beds of western Kentucky and Tennessee which are divided into two formations, the Grenada (Upper Wilcox) and the Holly Springs. In southeastern Missouri and Arkansas surface deposits of this group are undifferentiated. In the northern part of the valley the deposits grade upward into the lithologically similar sediments of the Claiborne group (figure 8), and separation of the two groups is difficult.

**Claiborne Group.** Claiborne beds are distributed over wide areas within the central and northern parts of the entrenched valley system and closely follow the structure of the region. The beds extend up the Mississippi Embayment region north of Memphis to near Hickman, Ky., along a belt 20 miles wide. Beds in this belt overlie the central part of the Mississippi Structural Trough and dip toward its axis. In the west-central part of the valley, in a region of nearly horizontal rocks, the Claiborne beds are found principally in the bottom of the narrow deep trenches. In the south-central part of the valley they are slightly upwarped as a low swell in a belt 20 to 30 miles wide extending northeastward from Monroe, La., to Yazoo City, Miss. The Claiborne beds trend northward from Yazoo City in a belt about 35 miles wide in the east-central part of the entrenched valley.

The surface deposits of the Claiborne group south of the Mississippi Embayment in Louisiana and Mississippi are divided into several formations. Only the two youngest, the Cockfield and the Cook Mountain, have been recognized on the entrenched valley floor.

The uppermost Claiborne formation, the Cockfield, is largely nonmarine and consists mainly of fluviatile silts, sands, and clays which reach a thickness of approximately 500 ft. The formation has been recognized on the entrenched valley floor along the northeast belt between Monroe and Yazoo City, and it extends northward to Memphis, Tenn. (plates 5 and 6).

The Cook Mountain formation, underlying the Cockfield, is predominantly marine. It reaches a total thickness of about 250 ft. and consists of fossiliferous sandy clays, silts, sandy silts, and local limestones. Cook Mountain deposits were encountered in borings only in the narrow entrenched valley between the western valley wall and the Bastrop Hills north of Monroe (plate 5). The distribution of this formation in other parts of the entrenched valley floor has not been determined; however, beds of this formation may occur in the extreme east-central part of the valley.

North and west of a line between Pine Bluff and Marianna, Ark., the facies of Claiborne sediments are all similar and the group is undivided. Lower Claiborne deposits within that part of the Mississippi Embayment north of Memphis are difficult to distinguish from the underlying Wilcox, and the uppermost Claiborne beds are hard to separate from the overlying Jackson. This group of beds is mapped as undifferentiated Eocene on plate 10.

**Jackson Group.** Deposits of the Jackson group form the entrenched valley floor over a large area in southeastern Arkansas and western Mississippi. They reach a total thickness of 125 ft. and are very slightly downwarped into the roughly triangular structural basin area between Pine Bluff and Marianna on the north and Greenville, Miss., on the south. West of Memphis, Jackson sediments form the entrenched valley floor along the divide area between the Hatchie and Loosahatchie trenches. The divide between the Tallahatchie and Ohio trenches is also partly formed by Jackson beds as indicated on plate 10.

The Jackson beds are known to outcrop in the eastern valley wall as far north as Hickman, Ky.,[2] but they can not be distinguished from the Claiborne beds on the valley floor. From a point about 15 miles northeast of Memphis, the Jackson and Claiborne beds are not separated and are grouped as undifferentiated Eocene on plate 10.

The Jackson group is present on the entrenched valley floor as a narrow northeastward trending belt between a point north of Harrisonburg, La., and Yazoo City, Miss. The beds of this belt dip to the southeast beneath younger sediments of the Vicksburg group.

The Jackson group is divided into three formations in the south-central Gulf Coastal Plain area of Louisiana and Mississippi; the Moodys Branch Marl, the Yazoo Clay, and the Danville Landing beds. The Moodys Branch consists of a fossiliferous, glauconitic, sandy marl with limestone concretions. It is readily distinguishable from the underlying Cockfield formation, which is largely nonmarine and practically devoid

[1] Farrar, W., op. cit., p. 20.
[2] McFarlan, A. C., "Geology of Kentucky," Univ. of Kentucky Press, p. 124, 1943.

FIG. 10 EXPOSURE OF VICKSBURG (OLIGOCENE) SEDIMENTS AT VICKSBURG, MISSISSIPPI. THE LIMESTONE LEDGES MARK THE GLENDON FORMATION AND ARE OVERLAIN BY FOSSILIFEROUS SANDS AND CLAYS OF THE BYRAM FORMATION. THE GLENDON LIMESTONE HAS BEEN ENCOUNTERED IN BORINGS AT DIAMOND CUT-OFF SOUTH OF VICKSBURG.

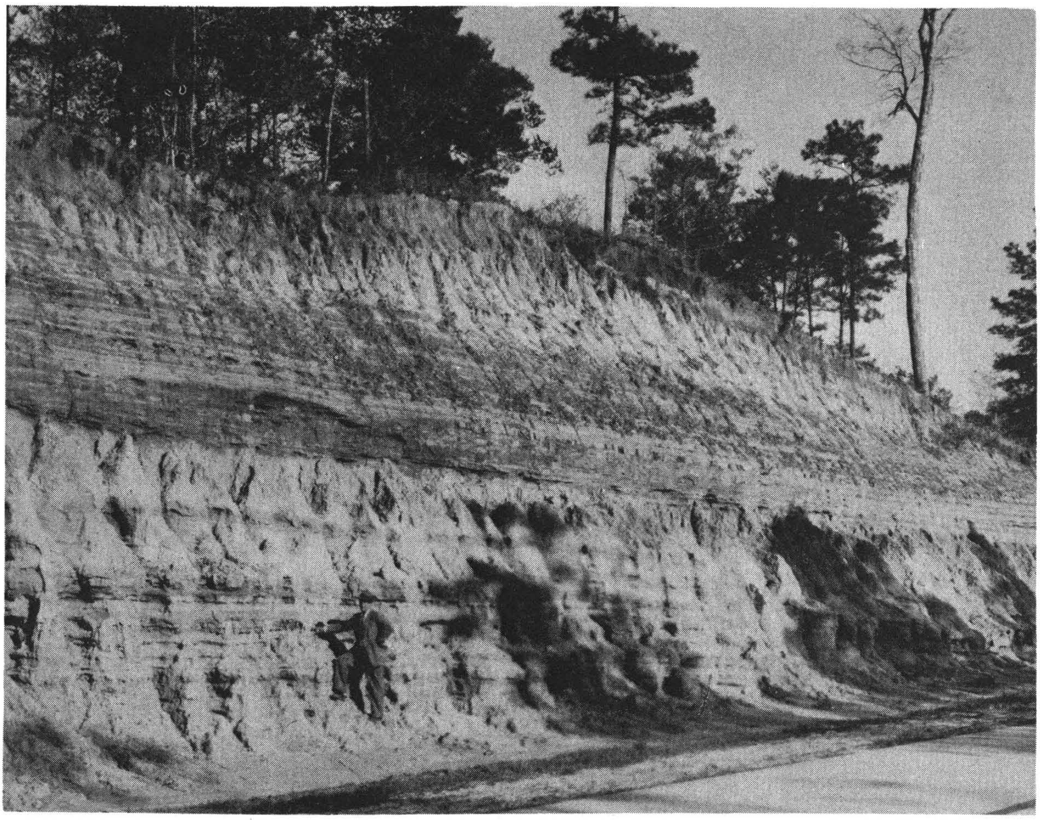


FIG. 11 THIN BEDDED SILTY CLAYS AND SILTY SANDS OF THE FLEMING (MIOCENE) FORMATION (PASCAGOULA FORMATION OF THE MISSISSIPPI GEOLOGICAL SURVEY) EXPOSED IN CUT ALONG U. S. HIGHWAY 61 NORTH OF WOODVILLE, MISSISSIPPI. THESE SEDIMENTS TOGETHER WITH MORE SANDY FACIES - (SEE FIG. 12) ARE TYPICAL OF ALLUVIAL VALLEY FLOOR DEPOSITS BETWEEN NATCHEZ, MISSISSIPPI AND MARKSVILLE, LOUISIANA.

FIG. 12 MASSIVE SILTS AND SANDS OF THE FLEMING (MIOCENE) FORMATION (PASCAGOULA FORMATION OF THE MISSISSIPPI GEOLOGICAL SURVEY) EXPOSED AT DOLOROSA, MISS. THESE SILTS AND SANDS ARE SIMILAR TO THOSE OF THE BASAL MIOCENE CATAHOULA FORMATION.

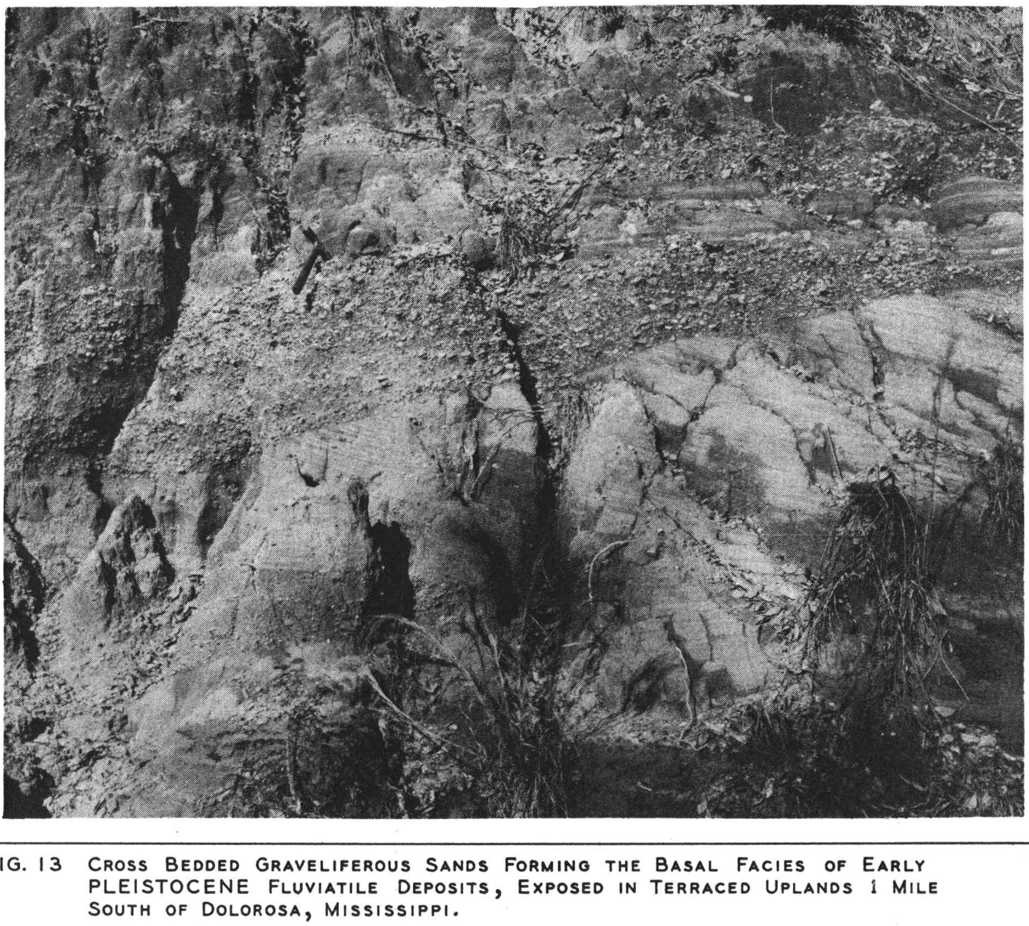


FIG. 13 CROSS BEDDED GRAVELIFEROUS SANDS FORMING THE BASAL FACIES OF EARLY PLEISTOCENE FLUVIATILE DEPOSITS, EXPOSED IN TERRACED UPLANDS 1 MILE SOUTH OF DOLOROSA, MISSISSIPPI.

FIGURES 12 & 13

of fossils. The Moodys Branch marl is overlain by the Yazoo Clay formation which consists of basal fossiliferous, calcareous clays and middle and upper deposits of silty, lignitic, sandy shales (figure 9). The uppermost Jackson formation, the Danville Landing beds, is largely marine in origin and is characterized by fossiliferous and calcareous clays and silty shales.

*Oligocene Series*

**Vicksburg Group.** Deposits of the Vicksburg group form only a small part of the entrenched valley floor. Beds of this age occur in the valley as a narrow southwest-northeast belt of very irregular width which trends eastward from near Sicily Island, La., to Vicksburg, Miss. (plate 10).

Surface deposits of the Vicksburg group in Louisiana and western Mississippi are divided into the Forest Hill (oldest), Mint Springs, Glendon, and Byram formations. Each of these formations is well exposed along the valley walls in the vicinity of Vicksburg. The Forest Hill consists of about 50 ft. of fluviatile, lignitic silts, silty clays, and fine-grained sands. The Mint Springs formation is a fossiliferous, sandy marl which reaches a total thickness of about 25 ft. The Glendon formation, overlying the Mint Springs marl, is composed largely of alternating layers of argillaceous limestones, glauconitic marls, and minor amounts of bentonitic material; it reaches a maximum thickness of about 60 ft. The uppermost Vicksburg formation, the Byram, is characterized by a basal fossiliferous calcareous sandy marl overlain by fluviatile, carbonaceous, silty clays, silts and sands. The character of the basal Byram marl and the underlying Glendon formation is shown on the photograph, (figure 10).

The extent of each of the Vicksburg formations on the entrenched valley floor has not been determined, but borings at Diamond Cut-off show that the bedrock sediments are identical with those of the Glendon formation exposed near Vicksburg.

*Miocene Series*

**Grand Gulf Group.** The Grand Gulf group of deposits is very thick and is present in the entrenched valley area as a wide east-west belt south of the Vicksburg group. It can be distinguished in borings as far south as the latitude of Angola. These deposits are located on the north flank of the Gulf Coast Geosyncline and dip seaward into the geosynclinal region where they reach a thickness of more than 8,000 ft. at the Louisiana coastline.

The Grand Gulf Group in Louisiana is divided into two formations, the Catahoula (lower Miocene) and the Fleming (upper Miocene). Eastward in Mississippi, beds the equivalent of the Fleming are mapped as the Hattiesburg and Pascagoula formations.[1] The nature of these beds is indicated on the cross section (plate 4).

The Catahoula formation is made up of basal tuffaceous siltstones, and coarse, graveliferous sands, interbedded silty clays, and silts which grade upward into the overlying Fleming formation. The Fleming consists of interfingering fluviatile silts with lenticular sands and brackish-water clays and silty clays. The character of the upper Miocene siltstones and silts where they are exposed on the surface in western Mississippi is shown on figures 11 and 12.

*Pliocene-Miocene (?) Series*

Valley floor deposits underlying the Pleistocene sediments and overlying the Grand Gulf beds are considered as Pliocene-Miocene (?) (see Appendix). These beds consist of interfingering facies of silts and sands with interbedded silts and clays and are in general similar to the previously discussed upper Miocene beds. They occur along a narrow east-west belt approximately 50 miles wide, lying south of the latitude 31°.

*Pleistocene Series*

**Prairie Formation.** The Gulf Coastal Plain Pleistocene deposits have been divided into four formations[2] of interglacial age: the Williana, Bentley, Montgomery, and Prairie (in order of decreasing age). Each of the formations and the Recent alluvium is represented by a sequence of fluviatile deposits which grade upward from coarse graveliferous sands (figure 13) through a central sand section into overlying silts and clays (plates 4 through 8). Each of the fluviatile sequences thickens seaward in the coastwise plains where it merges with a thick complex deltaic mass consisting of interfingering marine, brackish-water, and fluviatile deposits. No attempt has been made herein to separate the subsurface Pleistocene masses[3] which together have a total thickness of over 4,000 ft. The older fluviatile formations have been uplifted to form terraces in the uplands and only the youngest, the Prairie formation, is present on the entrenched valley floor.

The basal graveliferous facies of the Prairie formation form the valley floor in the latitude of Melville, La., and make it difficult to establish the exact base of the very similar Recent alluvium. South of Melville the fluviatile Prairie formation thickens rapidly and merges with its deltaic mass. In the latitude of Baton Rouge, where the basal gravels occur at a depth of over 400 ft., the entrenched valley was incised in overlying silty and sandy deposits of the central part of the Prairie formation. South of the latitude of Donaldsonville, the entrenched valley was incised in the thick silts and clays of the upper part of the Prairie formation delta.

The Prairie formation making up the low coastwise terrace is downwarped beneath the Recent alluvium of the deltaic plain, and oxidized deposits of its surface can be traced seaward from the uplands by means of borings. The shallow subsurface divide between the Amite and Mississippi entrenched valley systems is made up of these deposits and the present east-trending Mississippi River channel is incised in them as far as New Orleans. Borings at New Orleans show that the Prairie formation is a typical deltaic mass made up of marine sands containing abundant fossils,[4] brackish-water silty and clayey deposits, and local fluviatile sand and gravel beds.

[1] Vestal, F. E., "Adams County Mineral Resources," Mississippi State Geol. Survey, Bull. 47, p. 17, 1942.
[2] Fisk, H. N., "Geology of Avoyelles and Rapides Parishes, La.," Louisiana Dept. of Cons., Geol. Bull. No. 18, 1940.
[3] For a study of subsurface Pleistocene deposits see Frink, J. W., "Subsurface Pleistocene of Louisiana," Louisiana Dept. of Cons., Geol. Bull. No. 19, pp. 369-418, 1941.
[4] Hilgard, E. W., "Report on Examinations of Specimens From the New Orleans Artesian Well of 1856," (Appendix H of Report upon the "Physics and Hydraulics of the Miss. River" by Humphreys and Abbott) Prof. Paper No. 4 of Corps. of Topographical Engrs., U. S. Army Engrs., pp. 636-646, 1876.

### Characteristics of the Entrenched Valleys

The characteristics of the entrenched valleys were controlled largely by the nature and distribution of bedrock deposits which form the floor of the trenches and also by the structure of the region. Entrenched valleys are narrow and shallow and have low slopes in areas of hard Paleozoic rocks. Marked increases in width, depth, and slope of the trenches occur in "fall-line" areas where the streams crossed the contact between very resistant and relatively less resistant deposits. The buried "fall-line" area is very similar to the existing fall-line developed along the Atlantic Coastal Plain inland margin where Mesozoic and Cenozoic beds overlap the resistant Paleozoic rocks. Flattening of trench slopes south of the "fall-line" occurs locally where Tertiary bedrock deposits were more resistant to stream downcutting. The relation between the width, depth, and slope variations of the entrenched valleys of the Mississippi, Ohio, Arkansas, and Red rivers, the slope of the present surfaces of the alluvial plain overlying these trenches, and the general distribution of trench bedrock is shown on plate 11. The local nature of the trenches is well shown on the transvalley cross sections, plate 9.

The entrenched valley of the Mississippi River between St. Louis and Poplar Bluff, Mo., was excavated in the resistant Paleozoic rocks. It is narrow with a width varying between 5 and 10 miles, and has a maximum depth of about 160 ft. and an average slope of 0.68 ft. per mile as compared to 0.47 ft. per mile for the slope of the present alluvial plain surface which overlies the trench. Near Poplar Bluff where the trench crosses the contact between the Paleozoic rocks and relatively less resistant Cretaceous deposits, the width, depth, and slope of the trench increase abruptly. This area is designated as fall-line on plate 11. South of the fall-line the trench maintains an almost constant maximum depth of about 200 ft., has an average slope of 0.82 ft. per mile, and is 10 to 25 miles wide as far south as its junction with the Ohio trench east of Rosedale, Miss.

The entrenched valley of the Ohio along the Cache Lowland of southern Illinois is similar in character to the Mississippi trench between St. Louis and Poplar Bluff. Its width averages less than 5 miles, its maximum known depth is 160 ft. and its average slope is 0.45 ft. per mile. Paleozoic rocks form the walls and floor of the trench, hence it is very narrow. A few miles southwest of Ullin, Ill., the Ohio trench has its fall-line where it crosses the Paleozoic-Cretaceous contact (plate 11). South of this fall-line the width, depth, and slope of the Ohio trench increase abruptly. Between the fall-line and the Mississippi-Ohio junction, east of Rosedale, Miss., the Ohio trench reaches a maximum width of 35 miles and varies in depth from 210 to 220 ft. In this region the trench has an average slope of 0.63 ft. per mile as compared to 0.73 ft. per mile for the slope of the overlying alluvial plain surface.

The maximum depth of the combined Mississippi-Ohio trench between Rosedale, Miss., and Houma, La., increases from 210 ft. to over 350 ft. The slope of this segment of the trench averages 0.83 ft. per mile. The slope of the present alluvial plain surface overlying the trench is about 0.36 ft. per mile. A local flattening of the trench slope near Rosedale occurs in the area of Claiborne and Jackson sediments, and flattening near Vicksburg occurs in the area of relatively resistant Jackson-Vicksburg deposits (plate 11). The Mississippi trench is narrow and deep where it crosses the Miocene deposits between Natchez, Miss., and Angola, La. The narrowness reflects the resistance of the sediments and the active uplift on the north limb of the Gulf Coast Geosyncline.

Scattered borings and geophysical data show an abrupt increase in depth of the entrenched valley from 350 ft. at Houma to over 600 ft. near the present shoreline. It is considered that this increase in depth is the result of faulting along the Lake Borgne fault zone (plate 11) and of general subsidence under the Recent deltaic mass.

The entrenched valley of the Arkansas River in the Paleozoic rocks of the upland area northwest of Little Rock, Ark., is very narrow and shallow (plate 11). South of Little Rock the trench is marked by a fall-line at the contact between the Paleozoic and younger rocks (plate 11). South of the fall-line the depth of the trench, as well as the slope and width, increases abruptly.

The slope of the entrenched valley of the Red River between Shreveport and Alexandria, La., is 1.3 ft. per mile as compared to the 0.75 ft. per mile slope of the present Red River alluvial plain overlying the trench. This inland segment of the Red River trench varies in width from less than 5 miles to over 15 miles. In general, it is much wider than the valleys of the streams crossing the Paleozoic rocks because it was excavated in comparatively less resistant Tertiary deposits. Valley depth increases from 85 ft. at Shreveport to 120 ft. at Alexandria. Just south of Alexandria, the slope, depth, and width of the Red River trench increase very rapidly south of the point where the trench crosses the comparatively resistant basal Miocene deposits (plate 11). Between the fall-line and the point where the trench joins the Mississippi trench east of Opelousas, La., the average slope of the Red River trench is about 3.0 ft. per mile and ranges in depth from 120 ft. at the fall-line to 290 ft. at its mouth. The slope of this segment of the Red River is the steepest of any of the entrenched valleys.

Other tributary entrenched valleys, such as those of the St. Francis, White, and Ouachita rivers of Arkansas and Missouri, and the Coldwater, Tallahatchie, Yocona, Yalobusha, Big Black, and Homochitto rivers of Mississippi, are characterized by features very similar to those of the major trenches previously discussed. The general features of these trenches are shown on plates 3 and 9.

# Part III

## THE RECENT ALLUVIUM

The Recent alluvium is a huge mass of stream deposits which partially fills the Mississippi entrenched valley system. It has a volume of approximately 1,000 cubic miles[1] and an average thickness of 132 ft. Slightly more than half of this volume, 575 cubic miles, lies north of latitude 33° (the northern boundary of Louisiana). The average thickness of the alluvium is 125 ft. in the broad northern half of the valley as compared with an average thickness of 138 ft. in the narrower southern half. The maximum thickness of the alluvial section of the northern part of the valley is slightly over 200 ft. and in the southern half of the valley more than 350 ft.

The alluvium consists of a sequence of sediments which grades irregularly upward from coarse graveliferous sands into progressively finer deposits of sands, silts, and clays. This general upward decrease in grain size makes it possible to divide the section into a basal graveliferous unit and an upper non-graveliferous unit. The upper deposits can be further subdivided into pervious sands, gradational with the underlying graveliferous sands, and into relatively impervious sediments, the topstratum. Although non-graveliferous tongue-shaped deposits from 1 to 40 ft. thick occur within the graveliferous unit, fully 95 percent of the samples from the basal deposits contain gravels. Coarse materials also occur within the upper, generally non-graveliferous unit, especially within meander belts, but less than 1 percent of the samples from this unit contain gravel. The nature of the alluvium is shown on the transvalley cross sections (plates 4 to 8 inclusive).

### The Graveliferous Deposits

The graveliferous deposits comprise 45 percent of the alluvium, approximately 285 cubic miles of material in the northern part of the valley and 175 cubic miles in the south. Gravels characterize these basal deposits, but make up less than 25 percent of the mass and are generally disseminated through a sand matrix; locally they are concentrated in thick massive beds. There is a close correlation between the occurrence of gravels and the occurrence of coarse sands. Throughout most of the alluvial section the top of the gravels and the upper limit of the coarse sands are approximately at the same elevation (plates 4 to 8 inclusive). Most of the gravel concentrations are associated with coarse sands; where they are scattered in a medium and fine sand matrix they make up less than 1 percent of the deposit.

Detailed studies of data from closely spaced borings in local areas indicate that gravels and sands are complexly interfingered. They occur as thin, lenticular or tongue-like deposits which reflect deposition from shallow-channel braided streams.

The proportion of gravel to sand, the amount of coarse sand, and the size of the gravel and sand particles decrease upward through the section and also gulfward. The largest gravel tends to be concentrated at the base of the section where some boulders reach a diameter of over 1 ft. in the northern part of the valley. Few gravels larger than 3 inches in diameter were encountered in borings on the Harrisonburg-Natchez profile (plate 4). From the mouth of Red River southward most of the gravels are within the size range of pebbles; near the bluffs local concentrates of coarser particles occur. Few gravels encountered in the entrenched valley underlying the coastal marshes exceed 1 inch in diameter, and most of them are much smaller.

Brown chert particles derived from the Paleozoic rocks forming the highlands around the margin of the Mississippi Embayment region make up nearly all of the gravels. These cherts are mostly angular and unweathered, with smooth surfaces. Silicified fossils included in many of the chert pebbles indicate the age and locality from which the rocks were derived. In addition to the cherts a small percentage of igneous and metamorphic rock particles are found throughout the graveliferous unit. These include novaculites from the Ouachita Mountains; rhyolite porphyries and granites from the St. Francis Mountains of Missouri; weathered and unweathered gneisses, quartzites, amygdaloidal basalts, taconite, and granite from the Pre-Cambrian outcrops of the north-central United States.

A small percentage of locally derived gravels is also present within the graveliferous unit. Lumps of Jackson clay are found in the gravels dredged from the Mississippi channel near Greenville, Miss.; petrified wood fragments from Tertiary beds of the region have been found in many borings throughout the valley; and concretionary boulders of siderite and pebbles of Jackson limestone were found in borings between Pine Bluff, Ark., and Memphis, Tenn. It is considered that locally derived gravels were in part transported to the valley by tributaries draining the marginal uplands and in part scoured from the valley floor by river action. Gravel particles scoured from the valley floor bedrock are found on some river bars.

**Distribution and Thickness of Gravels.** The distribution of the graveliferous unit as indicated from logs of borings shows that its upper surface slopes away from the mouths of each tributary valley in the form of an alluvial fan. A contour map (plate 12) shows the general configuration of the top of the graveliferous deposits and is based on elevations indicated on logs of borings. The contouring of the map is an interpretation of the fan-like nature of the deposit; gravel lenses known to occur above the top of the graveliferous unit are not contoured.

The upper surface of the graveliferous deposits, as indicated by the contour map (plate 12), is fairly uniform; the principal variation in thickness of the graveliferous unit results from irregularities in the depth of the entrenched valley which the gravels fill. The gravel mass is, however, generally thicker at the north end of the valley; it forms the bulk of the alluvium in the region east of Crowleys Ridge and in places occurs within 5 ft. of the surface. The unit gradually thins southward as the upper part of the section is replaced by finer non-graveliferous deposits. Irregularities in the thickness of the basal unit are controlled also by the location of finger-like ridges of coarse deposits which radiate from the mouths of the tributary stream valleys (see plate 12). The unit is thinner at the margins of the alluvial fan ridges and in the central part of the valley between the marginal alluvial fans.

[1] Volume computed for that portion of the entrenched valley lying north of a line drawn between Franklin and Donaldsonville, La. This volume, therefore, does not include the mass underlying the coastal marshes. Volume of Mississippi River between Cape Girardeau and the Gulf, for comparison, is only 7.5 cubic miles.

The local thickness of the graveliferous unit is determined by the scouring and depositional activity of the master stream. The Mississippi River at several places is actively scouring shallow Tertiary bedrock which forms the divides in the entrenched valley and has removed the gravels from the channel of the river (see plate 11). Borings which penetrate the filling of abandoned river channels in the vicinity of Lake Providence, La., show non-graveliferous deposits resting directly upon the valley floor bedrock. Adjacent borings record graveliferous deposits bordering the abandoned channel and show conclusively that deep scouring action of the river removed the graveliferous deposits from the channel. In contrary manner, the deposition of gravels at the head of bars may locally form a graveliferous mass continuous from surface to valley floor and give abnormally thick sections. Such minor local irregularities in thickness are not indicated on the contour map (plate 12).

## The Non-graveliferous Section

The deposits forming the upper portion of the alluvial section are sands, silts, and clays (with minor local gravel concentrations). They comprise 290 cubic miles of material in the northern part of the valley and 250 cubic miles in the south. This section thickens irregularly southward to a maximum known thickness of over 250 ft. near the Gulf shore south of Houma. The pervious sands of the non-graveliferous section have a greater mass than the overlying relatively impervious topstratum. The two parts of the section are irregularly interfingered, the pervious sands reaching the surface as sand bars (figures 14-A and 14-B) along stream channels and in areas of the dissected alluvial plains. The topstratum mantles the remainder of the alluvial plain.

### *The Pervious Sands*

The pervious sands form the basal portion of the non-graveliferous beds and make up a huge, irregularly shaped lens. The thin edges of the lens lie in the northern part of the valley and along the valley margins where the graveliferous basal deposits extend almost to the surface. The lens also thins to the south where the sands are replaced by silty and clayey sediments. The thick portion of the mass lies in the central part of the valley where many borings have penetrated over 100 ft. of "clean" sand lying above the gravels and coarse sands.

The pervious sands are transitional with the coarser basal sediments and contain thick beds of medium sands near the contact with the gravels (plates 4 through 8). The medium sands are replaced upward in an irregular manner by fine and very fine sands. Local tongues of fine-grained silty and clayey sediments and minor amounts of gravels are found throughout the mass.

The pervious sands of the bars grade downward into the graveliferous filling of the valley. The bar sands are cross-bedded throughout most of the mass (figure 15-A), but are interbedded with silts and clays toward the tail of the bar (figure 15-B). Gravels are brought up from the river bed and deposited at the head of bars in areas where the river is scouring into the basal graveliferous unit. Most of these gravels are scattered in the bar sands but some are concentrated in a surface layer where the sands have been winnowed by subsequent river action (figures 16-A and 16-B). Massive concentrates of gravel are found at the heads of some towheads or islands which separate chutes from the river channel. These concentrates are thick, locally form the bulk of the bar deposits, and may be continuous with the underlying graveliferous unit.

### *The Topstratum*

Various combinations of sand, silts, and clays give rise to a series of textural groups which make up the relatively impervious topstratum. These deposits mantle the underlying pervious sands and constitute most of the visible surface except for the sand bar areas along the present streams.

The color of topstratum deposits reflects, to a certain extent, the source of the floodwaters from which they were derived. Mississippi and Ohio river deposits are generally gray and grayish brown (blue when wet), whereas the deposits of the Red and the Arkansas rivers are red, reddish brown, and light brown. The sands within the topstratum, as elsewhere in the alluvium, do not show distinctive colors.

Detailed studies in many local areas throughout the valley show that the topstratum can be divided into several types of deposits and that their shape, distribution, and the size of their constituent particles bear a direct relationship to their mode of origin. Topstratum deposits form natural levee ridges, the uppermost part of sand bar ridges, and clay plugs which fill portions of abandoned stream channels, and sand bar sloughs. They also blanket the flood plain in the backswamp and form the great bulk of deposits underlying the deltaic plain. An example of the complexities of surface and subsurface distribution of topstratum deposits on the floodplain in the central part of the valley near Mayersville, Miss., is shown on plate 13.

Local lenticular masses of previous materials are found in the topstratum deposits. They generally have no connections with the underlying pervious sands and are therefore considered as part of the topstratum.

**Natural Levee Deposits.** A widespread topstratum deposit characteristic of floodplains is the natural levee (figures 1, 17-A and 17-B). It consists of a ridge-like mass of silts, silty sands, and silty clays laid down by over-bank flow along stream channels. The deposits are thickest and coarsest at their crests along the river bank. They thin rapidly and become finer landward where they merge with the flood basin deposits.

The size and shape of a natural levee depends upon the size and character of the stream and the position of the levee in relation to bends in the stream channel. The most widespread and thickest natural levee deposits occur on the outside of bends. The widest levees are generally associated with the largest streams, those of the Mississippi River being the widest levees in the floodplain, but width is not solely a function of discharge. The turbid Red River, for instance, has far more extensive levees than the relatively clear White River; a flood distributary stream, Deer Creek, north of Vicksburg, Miss., has levees nearly as wide as those of the Mississippi River from which it draws its flood waters.

In most cases, the sandiest portion of the natural levee deposits along a meandering stream is the ridge which forms on the lower end of the bends. These sandier portions of the levee merge with the downstream bar deposits.

The thickness of natural levee deposits varies greatly. In the northern part of the valley the deposits

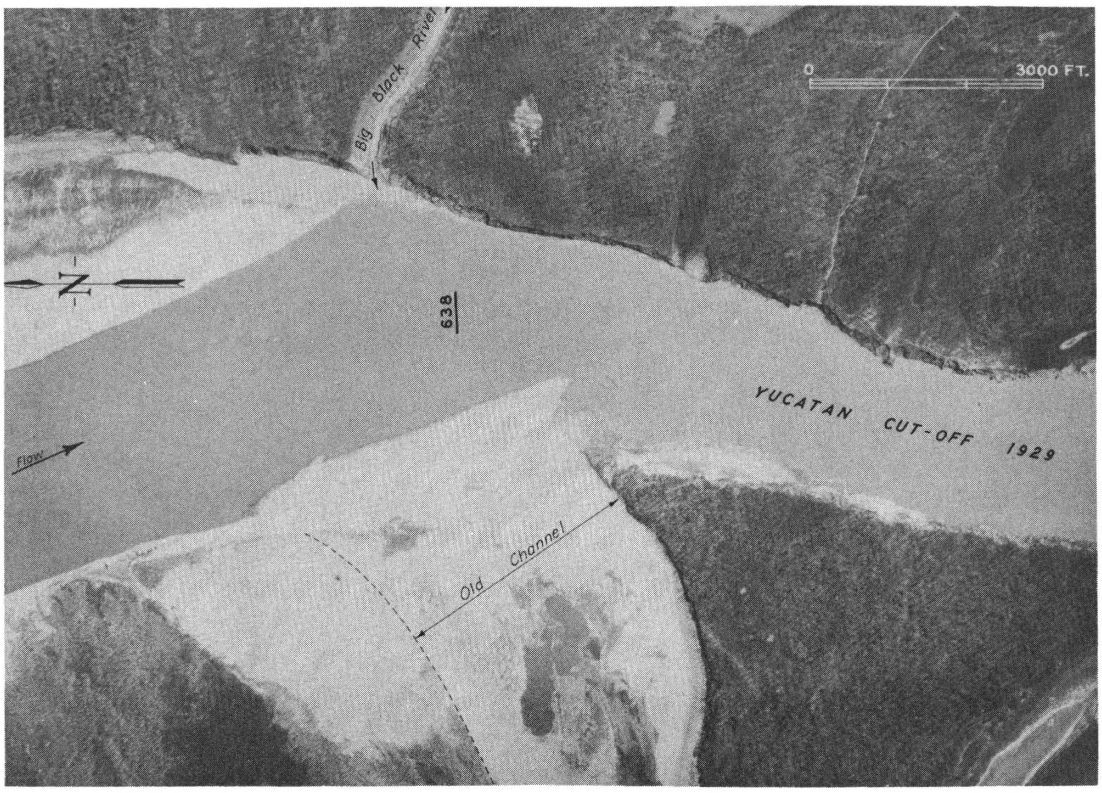



FIG. 14 A AERIAL PHOTOGRAPH SHOWING SAND BAR ACROSS OLD CHANNEL ABOVE MOUTH OF YUCATAN CUT-OFF, MILE 638 BELOW CAIRO.

FIG. 14 B SAND DEPOSITS OF BAR ACROSS OLD RIVER CHANNEL ABOVE MOUTH OF YUCATAN CUT-OFF. NOTE CROSS-BEDDED SANDS AND DRIFTWOOD SCATTERED OVER BAR. (NEW ORLEANS ENGINEER DISTRICT PHOTOGRAPH NO. 3143).

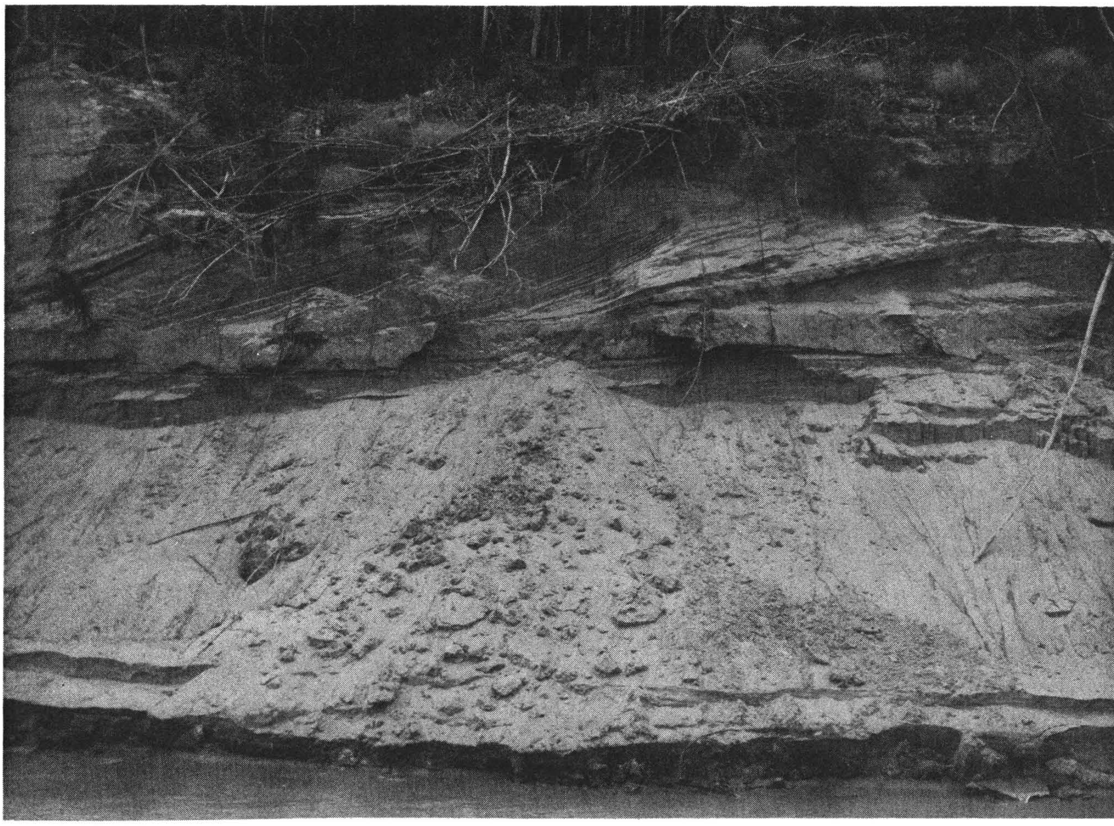


FIG. 15A Cross-Bedded Sands at Head of Bar near Upper End of Racetrack Towhead, Mile 607 Below Cairo. Exposed Section is 15 to 20 Feet Thick.

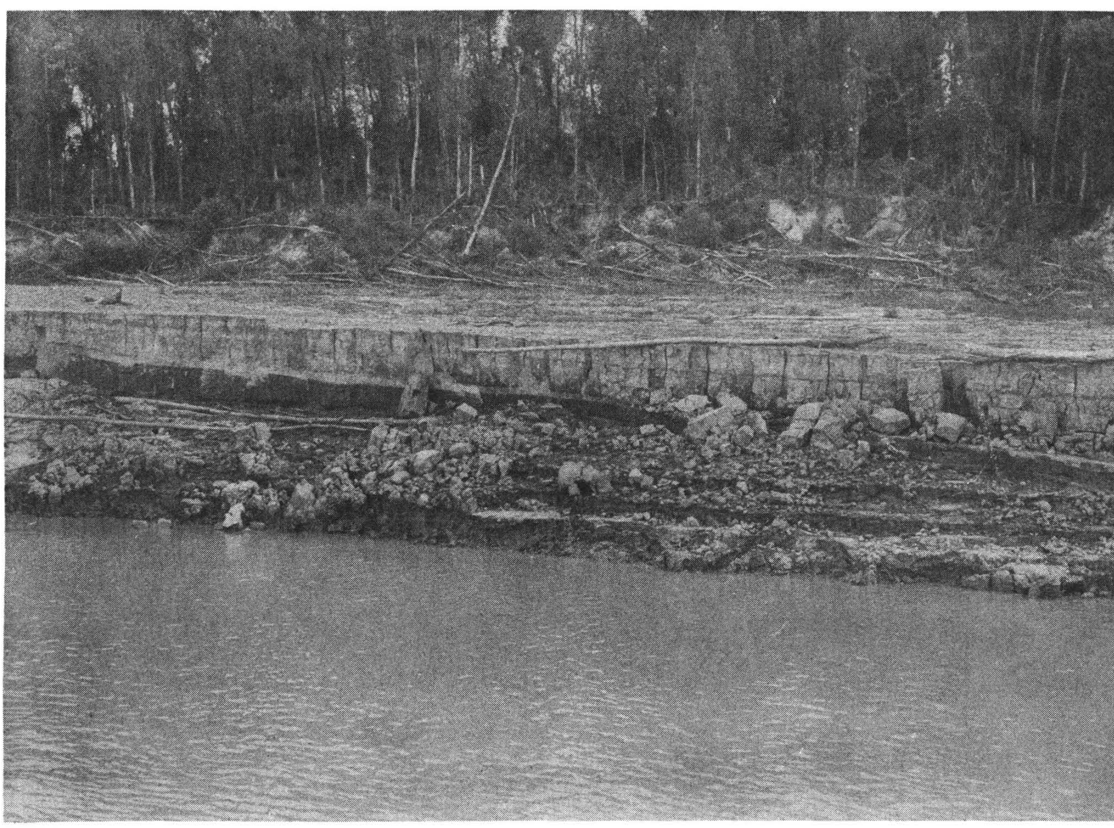


FIG. 15B Massive Silts and Silty Clays Interbedded with Sands at Toe of Sand Bar near Lower End of Browns Point, Mile 595 Below Cairo. Exposed Section is 8 to 10 Feet Thick.

FIGURES 15A & 15B

FIG. 16A  GRAVEL COVERED BAR EXPOSED DURING LOW WATER AT HEAD OF ISLAND NEAR MILE 598 BELOW CAIRO. NOTE CHUTE CHANNEL BACK OF ISLAND.

FIG. 16B  GRAVELS ON BAR NEAR MILE 598. CONCENTRATION OF DRIFTWOOD MARKS APPROXIMATE LIMIT OF GRAVEL AT SURFACE OF BAR. NOTE CHUTE IN FAR BACKGROUND AND WIDE GRAVEL-FREE SWALES IN CENTRAL BACKGROUND.

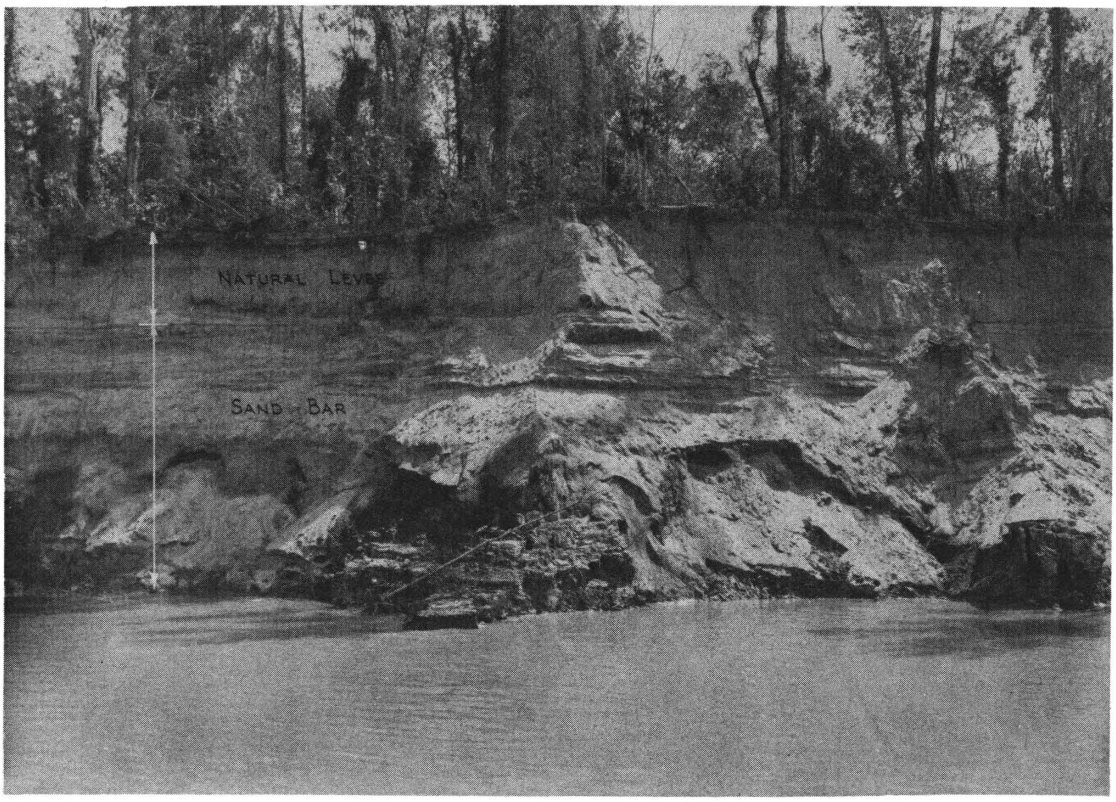



FIG. 17A Natural Levee Sands and Silts Overlying Cross-Bedded Sand Bar Deposits. East Bank of the River Below Browns Point, Mile 594 Below Cairo. Exposed Bank is Approximately 35 Feet High.

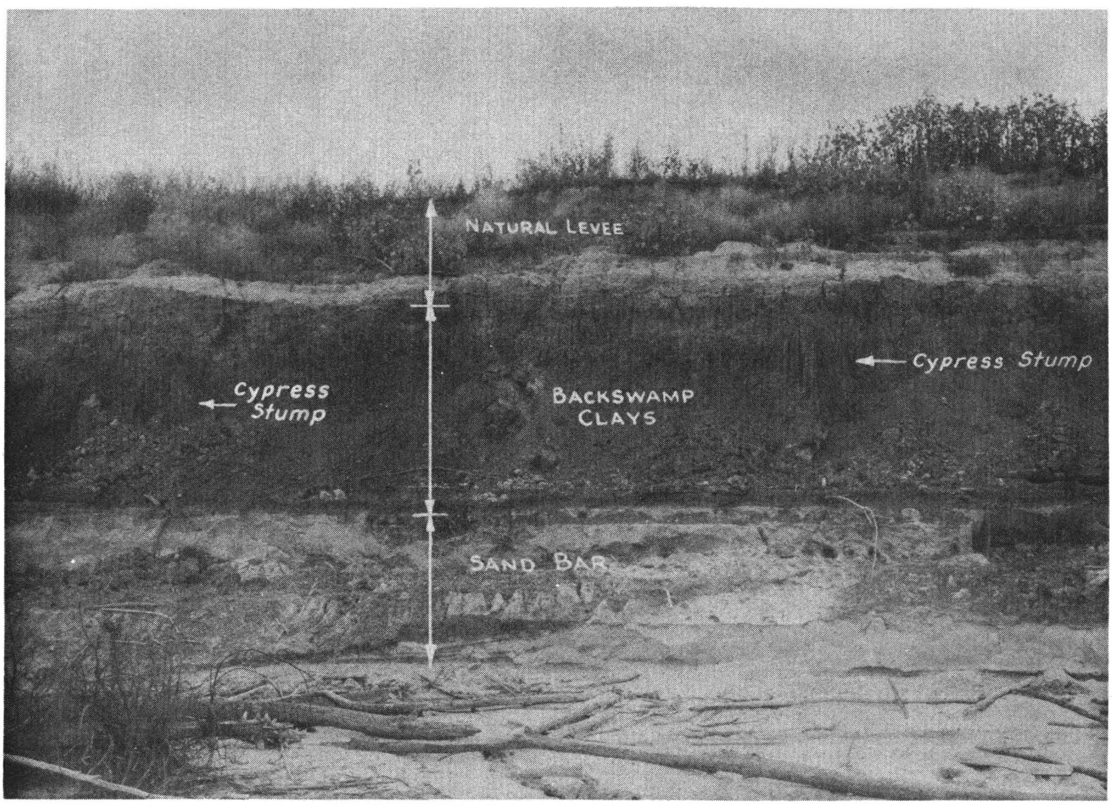



FIG. 17B Natural Levee Sands and Silty Sands Overlying Thin Backswamp Clays which rest on Older Sand Bar Deposits. Note Cypress Stumps in Backswamp Clays. Exposed Section is 35 to 40 Feet Thick. West Bank of River Below Duckport Landing, Mile 594 Below Cairo.

FIGURES 17A & 17B

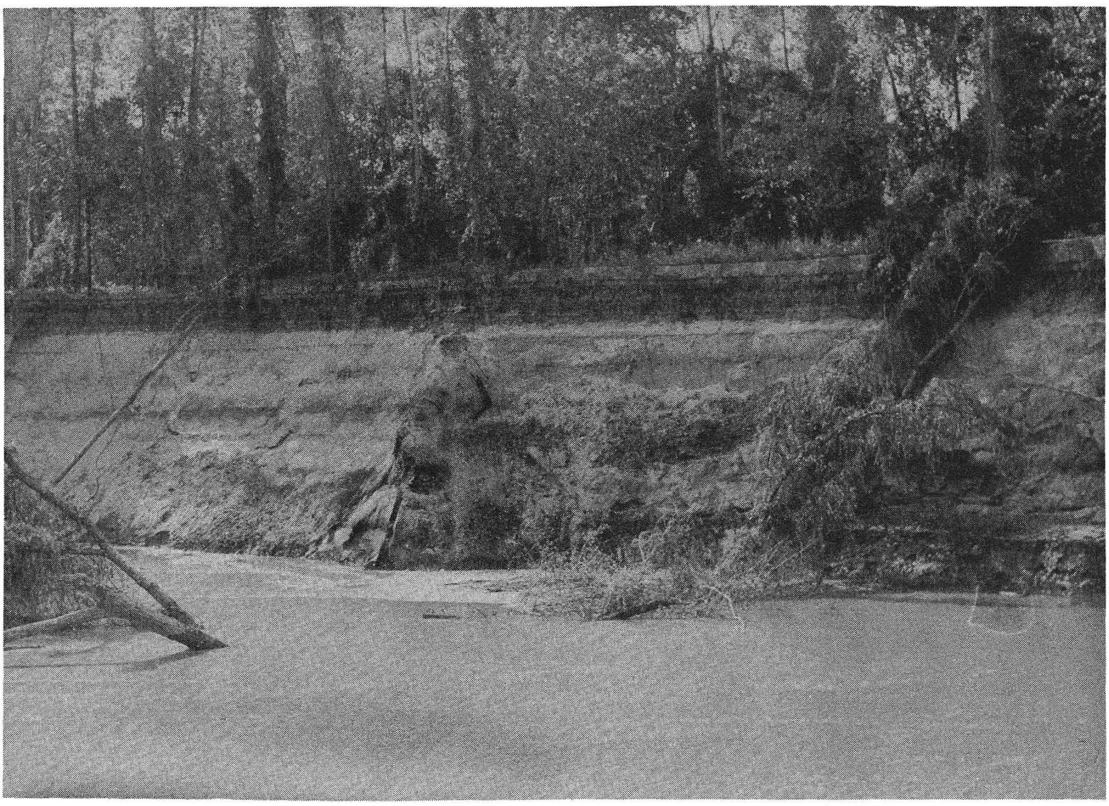


FIG. 18A TOPSTRATUM DEPOSITS OF INTERBEDDED SILTY CLAYS AND SANDY SILTS FORMING THE UPPER PART OF SAND BAR RIDGES AT HEAD OF RACETRACK TOWHEAD, MILE 607 BELOW CAIRO. EXPOSED SECTION IS APPROXIMATELY 30 FEET THICK.

FIG. 18B TOPSTRATUM DEPOSITS OF INTERBEDDED SILTY SANDS AND SILTY CLAYS FORMING UPPER PART OF SAND BAR RIDGES EXPOSED IN PILOT CUT FOR HARDIN CUT-OFF, MILE 293.8 BELOW CAIRO. (MEMPHIS ENGINEER DISTRICT PHOTOGRAPH NO. 45315).

FIG. 19A CLAY PLUG DEPOSITS FILLING ABANDONED RIVER CHANNEL AT NECK OF COWPEN POINT. CYPRESS STUMPS MARKING THE OLD CHANNEL POSITION WERE EXHUMED FROM BENEATH A MANTLE OF SILTS AND CLAYS DURING EXCAVATION FOR GILES CUT-OFF NEAR NATCHEZ, MISSISSIPPI IN 1933. (NEW ORLEANS ENGINEER DISTRICT PHOTOGRAPH NO. 1893).


FIG. 19B CLAYS AND SILTY CLAYS FORMING A PART OF A CLAY PLUG EXPOSED IN THE WEST BANK OF THE RIVER NEAR NEBRASKA LANDING, MILE 595 BELOW CAIRO.

form a thin veneer with the Mississippi River levees only 10 to 15 ft. thick. In the latitude of Baton Rouge, La., however, the natural levees within the meander belt are, in many places, at least 25 ft. thick and everywhere form a ridge standing high above the floodplain level. In the delta region the natural levees are built on soft marsh mucks and subside under their own weight; more of the natural levee material may lie below marsh level than appears above. Levees in the delta continue to sink after the abandonment of the stream channel so that today their surface is considerably below their original elevation.

Differences in thickness of the natural levee deposits also reflect irregularities of the surface upon which they were deposited. The thickest natural levee deposits mantle old channel positions; the thinnest overlie sand bars.

**Topstratum on Sand Bars.** A characteristic topstratum deposit of the floodplain is the alternation of interbedded silty sands and silty clays which form the upper 10 to 15 ft. of sand bar ridges. These extensive deposits mark the accretion topography of the river meander belts, and their local thickness and distribution varies with the nature of development of the sand bar which they blanket.

Rivers on the floodplain constantly migrate within their meander belts and continually shift the position of their channels. Channel shifting within a river bend follows bank recession which takes place on the convex side of the river where water velocity is highest; it is accompanied by contemporaneous sand bar accretion on the inside or concave side of the river where the current is slack. Bank migration is irregular and is conditioned by changes in alinement of the river, by variations in velocity brought about by periodic fluctuations in stage, and by the nature of bank sediments. The irregular nature of channel shifting results in the development of a series of alternating sand bar ridges and sloughs, the shape of which conforms to the curvature of the inside of the bend. Changes in alinement of the river are such that high water sand bar deposits block the lower end of earlier-formed sloughs, and that the upper ends of the succession of sand bar ridges are destroyed by bank caving while new sand bars are forming downstream.

The sand bar deposited during high stage of the river becomes exposed during falling stages (figure 14-A) and generally collects driftwood on its surface (figure 16-B). As the water continues to drop, silty sediments collect at the tail of the bar (figure 15-B) and around the margins of the slough back of the bar. Willow trees start to grow in the silty deposits soon after their deposition and eventually the tail of the bar is covered with a dense growth. Studies[1] have shown that willow growth traps a part of the sediments normally transported over the bar during high river stages. Driftwood in places on the bar surface exerts a similar but less pronounced effect. As the bar increases in height, the current slackens in the shallowing area, and less sands are carried to the bar. After flood crest stages when velocities over the bar are still high, deposits of silty sand are trapped on the bar. As stages continue to fall thinner layers of silty clays are laid down in slack water. The alternation of sediments is pictured in the basal part of the bank section shown in the photographs of figures 18-A and 18-B, and plate 14, diagram 3.

After the bar ridge is removed from the zone of active sedimentation and new bars begin to form in the river, the older feature is generally cloaked with a dense cover of vegetation. The older ridges in the accretion topography become covered with water only during flood stage, when the bar sloughs act as avenues for floodwater release. The vegetation in both bars and sloughs tends to trap the suspended load of sediment in the flood waters and the irregularities in the accretion topography are gradually smoothed by a layer of laminated silty clays which in many places reach a thickness of 5 ft. (see upper part of bank section in photograph, figure 18-A). Bar sloughs act as settling basins for the floodwaters and accumulate thick sections of silty clays (see discussion of clay plugs).

**Channel and Slough Fillings. Clay Plugs.**[2] The term clay plug has been used to designate local bank areas of the Mississippi River which are more resistant to bank caving than surrounding areas. Such areas mark the position of abandoned river channels or of bar sloughs filled with fine-grained topstratum deposits (figures 19-A, 19-B, and 20-A). As used herein clay plugs are not restricted to deposits near the river bank, but include all fine-grained, relatively impermeable sediments which form the filling of abandoned channels and sloughs throughout the alluvial plain.

Both the thickness and composition of clay plugs are highly variable as can be seen on the sections and logs of borings of the clay plugs shown on plate 14. Many abandoned channels are filled with clays and blue mud,[3] others are made up of interbedded clays, silts, silty clays, silty sands, and sandy clays with a few irregular lenticular masses. The plugs vary in thickness from a few feet to a known thickness of over 125 ft. in an abandoned meander loop near Lake Providence, La. The thickest part of each plug is confined to a narrow zone corresponding to the talweg position of an active stream. The shape, thickness, and relationship of the Lake Providence clay plug to the ancient channel is shown by the contour map (plate 14, diagram 4) which shows the elevation of the base of the clay mass.

The nature and extent of the clay plugs are determined largely by the manner in which the channel they fill was cut-off from the river. Natural cut-offs are of either neck or chute type. The neck cut-off is formed when the river is shortened by the coalescence of migrating river bends at the upstream and downstream arms of the meander loop. As the migrating bends approach each other, the intervening neck of land becomes progressively narrower and eventually the river breaks through and establishes a shorter course. Floodwater may scour channels across the neck and hasten the river diversion. A neck cut-off causes the rapid abandonment of an entire meander loop; when such a loop is blocked from the river an ox-bow or cut-off lake is formed (see plate 14, diagrams 2 and 4). Chute cut-offs form when the river establishes a new and shorter course across the point bar on the inside of an enlarging meander loop. A chute cut-off course develops in a slough which crosses the bar inside the bend and gradually enlarges to become the main channel of the river (see plate 14, diagrams 1 and 4). The chute cut-off, in direct contrast with the neck cut-off, is formed slowly and only short segments of the river are abandoned. Chute cut-offs develop slowly because the angle of

[1] Matthes, Gerard H., "Report on Revetments to the President, Mississippi River Commission," October 8, 1941.

[2] The term clay plug is one of a number of localisms used in this report. This term has been in general use by engineers and rivermen for over a century to denote fine-grained, erosion resistant, bank materials which when wet bear a resemblance to clay.

[3] Blue mud is another localism used to denote a clay with a water content equal to over 32 percent of the total weight of the sample or over 47 percent of the dry weight of the sample.

divergence between the branching channels is small and the reduction of flow in the old channel is gradual. Sands, diverted into the old channel during reduction in flow, gradually choke and narrow the upper end of the old channel. Many of these abandoned channels are entirely filled with sands but most have thick narrow talweg fillings at their lower end (see plate 14, diagrams 1 and 4). A thin layer of fine-grained sediments may mask the upper part of the sandy channel filling, but generally sands and gravels are found at the surface near the entrance to the abandoned channel.

Neck cut-offs result in quick abandonment of meander loops because the arms of the old channel generally have a wide angle of divergence with the new river course and the reduction in flow is fast. Sandy sediments are carried within the old channel arms for only a short distance. After most neck cut-offs are formed, the newly established channel generally migrates away from the arms of the abandoned meander loop and the ox-bow lake is removed from the zone of most active sedimentation. The lake receives only fine floodwater clays and silts and very slowly fills with blue mud (see plate 14, diagram 2, and appended logs).

Clay plugs formed in ox-bow lakes present similar variations in the nature of their sediments throughout the alluvial valley. The central part of the mass consists of poorly compacted blue mud with a high water content; the lower part of the mass is "fat" clay, the well compacted equivalent of blue mud; and the upper part of the mass, within the zone of ground-water fluctuation, consists of "buckshot" clay.[1]

Minor clay plugs underlying narrow, elongate, arcuate "lows" or swales in the surface of sand bar accretion areas are very common floodplain features. These plugs are rarely made up of blue mud or clay; most of them consist of silty clays, silty sands, and sandy clays (figures 20-A and 20-B). Most of the plugs are thin and form an insignificant part of the bar accretion but a few are known to be over 60 ft. in thickness. Thick slough fillings are deposited in slack waters "backed up" in the mouths of sloughs opening into the river. Many of the thick deposits, however, are laid down in minor floodplain lakes formed in sloughs which were blocked from the river by growth of sand bars. Only local minor depressions called swales remain to mark the position of most filled sloughs.

The point bar, the composite accretion feature within a bend, consists of an alternation of sand bar ridges, capped with thin topstratum, and swales underlain by clay plugs. The distribution of the topstratum units on a typical point bar, Wilson Point, is shown on plate 14, diagram 3.

**Backswamp Deposits.** The most extensive topstratum deposits of the floodplain are those laid down in the flood basins beyond the natural levees (see plate 1). These deposits mask older strata and consist principally of interbedded, thinly laminated, silty clays and clays with a high organic content (see figures 17-B and 20-B). The backswamp deposits enclose logs, stumps, and roots of trees as well as thin layers of carbonized leaf remains and other comminuted vegetable matter. The deposits are generally slightly oxidized and when dry form typical "buckshot clays."

Backswamp deposits are particularly widespread in the southern parts of the St. Francis and Yazoo basins, and in the Tensas and Beouf basins farther south. They gradually thicken southward and merge with thicker fine-grained deposits of the deltaic plain south of the latitude of Angola, La. At the northern end of the alluvial valley the deposits are thin and discontinuous; in the latitude of Memphis, they reach a thickness of 30 ft.; in the latitude of Vicksburg they are approximately 40 ft. thick; and in the latitude of Angola they reach a maximum thickness of 60 ft.

**Deltaic Plain Deposits.** South of the latitude of Angola the backswamp deposits merge with the topstratum of the deltaic plain and form an extensive "blue clay" mass. The mass thickens gulfward from 60 ft. on the north to 150 ft. in the latitude of Baton Rouge, and to a maximum recorded thickness of 225 ft. near the gulf shore south of Houma. The topstratum also thickens toward the center of the valley; it is generally less than 50 ft. thick between Angola and New Orleans on the eastern valley margin and less than 40 ft. thick along the western valley margin between Opelousas and Morgan City.

The topstratum in the deltaic plain includes a complexly interfingered mass of fine-grained deposits laid down during the period of valley filling, in several near sea-level environments similar to those which characterize the present coastal plain (figures 21-A and 21-B). Silty and sandy sediments mark the natural levee and channel deposits of the rivers and their distributaries and crevasses. On the surface they form long linear units which project finger-like toward the Gulf (see figure 21-B); in the subsurface they are seen as lenticular masses. Lenticular sands and clays containing remains of marine and brackish-water organisms are found scattered throughout the mass. They mark the deposits formed as beaches of the Gulf and of large lakes, the filling of bayous, and the bottom deposits of lakes, bays, and arms of the Gulf. These lenticular deposits are incorporated at different depths in the widespread thick clays and silty clays of the marshes, the principal environment of deposition throughout the history of construction of the deltaic plain.

The marshes generally have a superficial, little-compacted surface layer of muck, ranging up to 20 ft. in thickness, which has an extremely high organic content. In most places these marshes will not support a person's weight and are so poorly consolidated that small boats can be forced through them. (See boat trails, figure 21-A.) The organic mucks generally become compacted with depth and a few feet beneath the surface may show stratification of silty clays and clays.

Because marsh deposits accumulate close to sea level and are poorly consolidated they may be locally destroyed by the growth of "round lakes." Several of these lakes may coalesce while enlarging and form large water bodies, or the growth of a lake may be halted by the spread of marsh vegetation. Lake waters may winnow the finer sediments from the marsh mucks and develop a thin compact silty or sandy layer overlying deeper marsh deposits. If clogged with vegetation, the lake bottoms may become covered by an organic ooze. Some meandering channels and abandoned distributary stream channels in the marshes slowly choke with vegetation (figure 21-A) and, like the lakes, may hold a thick section of organic ooze overlying a relatively compact bottom section of silts and silty clays. Sandy and silty lake bottom sediments, locally holding oyster reefs or other evidences of near shore life, occur throughout the "blue clay" mass as thin, relatively compact, lenticular layers. The organic oozes and thick accumulations of vegetable matter occur as thin, peaty, clay layers.

[1] As used locally "buckshot" clay is a slightly oxidized plastic clay which when dry breaks into small pellets or angular particles.

# Part IV

## THE ALLUVIAL PLAIN

The alluvial plain of the Mississippi Alluvial Valley is the upper surface of the mass of sediments filling the entrenched valley system. It includes the floodplain, the deltaic plain, and the dissected alluvial plains above flood level, and is everywhere a surface of low relief with a gentle slope which decreases seaward. The latest epochs in aggradational history of the valley are recorded in its drainage patterns, distribution of sediments, and erosional features.

Most of the topographic features of the alluvial plain have been fashioned by the depositional activity of running water during valley aggradation. Some are the surface expression of structure; others, near the coast, result from the work of waves. The principal indications of erosional stream activity are found in the dissected alluvial plains.

The general locations of the alluvial plain features are shown on the map, plate 2, and details of the valley surface are shown on the map, plate 15. Reference to these maps and to plate 1 is essential to the clear presentation of alluvial plain features.

**Floodplain Features.** The floodplain is composed of a number of low meander belt ridges and intervening flood basin lowlands. Alluvial ridges of abandoned Mississippi River meander belts may be traced for miles from their position of divergence from the ridge along the present river course south of Cape Girardeau, Mo. They maintain the broad curvature associated with the Mississippi River, are from 10 to 20 miles wide, and rise above the flood basins 10 to 20 ft. Meander belt ridges of tributary streams can also be traced on the alluvial valley surface. Those of the Arkansas and Red rivers are the most extensive and maintain widths of 3 to 5 and 1 to 3 miles, respectively.

Floodbasins are irregular in shape and are flooded by both backwater and overflow waters. During periods of great floods the entire floodplain is under water. Flood basin topography differs from that of other portions of the floodplain mainly in that original erosional and depositional irregularities have been subdued or buried by floodwater sediments (see Upper Tensas Basin, figure 22). Drainage patterns inherited from the original topography are preserved in the swamp networks which are utilized both for distribution and withdrawal of floodwaters.

The deltaic plain portion of the floodplain reflects stream behavior on the low surface slopes which prevail near the coast. Meander belts are less complex, alluvial ridges stand higher above the general surface, and extensive distributary ridges develop (figures 21-B and 23). These distributary ridges are narrow and have a steeper seaward slope than that of the trunk stream. The inter-ridge lowlands which are not much above sea level contain many lakes and carry floodwaters to the Gulf. They give way southward to coastal marshes and bays. Cheniers, narrow beach ridges near the coast line, truncate the ends of the distributary channels and inclose the lowlands. Both the cheniers and the rounded outlines of the lakes are the result of wave action.

The marsh areas of the deltaic plain are characterized by tidal streams (figure 21-A) which in many places exhibit a rectangular drainage pattern. This pattern, together with the distribution and shape of lakes, the pattern of distributary streams, and the trend of the lowlands, closely follows the regional fracture pattern.

**Dissected Alluvial Plain Features.** The dissected alluvial plains are those portions of the alluvial fans of the tributary streams which stand above the general level of the floodplain and which have been eroded by minor streams. They are locally terraced, and their several surfaces are separated by escarpments. Many of the terraces lose their identity within a few miles, the escarpments disappear, and the surfaces merge. Escarpments which separate the dissected alluvial plains from the floodplain also locally disappear and in places the higher surfaces merge with the floodplain.

The cross-cutting relationship of the various stream scars on the local terraces of the dissected plains indicate that the higher surfaces are the oldest. The escarpments between terrace levels are primarily stream-cut bluffs, but they owe at least a part of their height to deposition of natural levees along their crests.

The present drainage lines of the dissected alluvial plains follow surface irregularities which were formed by the activity of streams during the construction of the surface. In most places the dendritic branchwork drainage of the remnant surfaces of the Mississippi, Ohio, and Arkansas alluvial fans is controlled by an anastomosing network of abandoned channels of braided streams (figures 24 and 25).

Three types of channels are distinguishable within the topography left by braided streams: main channels, in which flow was concentrated and which commonly show a slight tendency to develop into meandering courses; dispersal channels, a complex network of small channels which carried water away from the main channels; and gathering channels, in which water from dispersal channels was collected for return to the main channel. A main channel was often formed by the union of several gathering channels. Typical reconstructed braided drainage of the Mississippi River in the region of Weiner, Ark., is shown on plate 16.

Natural levees occur where the main channel of the braided system develops meander-like bends and where the dispersal channels on the outside of bends become partially blocked. Many of the dispersal and gathering channels also possess natural levees.

Elements of the braided stream topography are recognizable in the floodbasins where some have been traced directly from the high dissected alluvial plains, see plate 15. The old channels in the floodbasins are occupied by small streams which form a part of the backswamp network, but subsequent alluviation has largely obliterated the original relief, figure 26.

Faulting has exerted a definite control on the development of the braided streams of the alluvial plains. Individual channels of the braided system parallel the trends of the regional fault system. In some places, notably along Big Creek southwest of Helena, Ark., faulting has considerably disarranged the drainage and formed escarpments which displace the braided stream topography (plate 2). Branchworks draining the braided topography of the plains surface are entrenched where they cross the escarpments. The entrenchment is most evident on the main channels where the present streams have carved narrow valleys.

### Valley Divisions

Alluvial valley features are discussed in relation to three arbitrarily established divisions; northern, central, and southern. The northern division, separated by Crowleys Ridge into the Western and Eastern lowlands, includes all of the valley north of a line drawn along the Mississippi River from Memphis, Tenn., to Helena, Ark., thence to the mouth of the Arkansas River and north along the eastern margin of Grand Prairie Ridge to the valley wall. The central division includes all of the valley south of the above described line and north of a line drawn from the mouth of the Red River westward along Bayou Des Glaises to the Marksville Hills. The southern division consists of the deltaic plain.

## THE NORTHERN DIVISION

### The Western Lowland

The Western Lowland includes extensive remnants of the alluvial fan of the Mississippi River, and the floodplain of the White River and its tributaries. The lowland is connected with the Eastern Lowland by a number of gaps through Crowleys Ridge. It joins the floodplain of the upper Mississippi River near Cape Girardeau, Mo., and is joined by the floodplains of a number of smaller streams along the western valley wall.

The Western Lowland averages less than 5 miles in width between Cape Girardeau and Wappapello, Mo., where it abruptly widens to 20 miles. Near Jonesboro, Ark., it again widens and maintains a width of slightly over 30 miles to its southern margin.

The Ozark Escarpment, which rises 200 ft. above the alluvial valley, forms the northwest boundary of the Western Lowland. The escarpment is straight with a major offset to the east where the White River enters the alluvial plain. It shows little evidence of stream sculpture and is considered to be a fault scarp. The southwestern escarpment along Grand Prairie Ridge, rises 20 to 60 ft. above the White River Lowland and is scalloped by scars of the White River. Crowleys Ridge forms the discontinuous eastern margin of the Western Lowland. The straightness and angularity of the western margin of the ridge are considered to reflect faulting in the area.

#### *Water Gaps Through Crowleys Ridge*

The main water gaps by which the Eastern and Western lowlands are connected are: Bell City-Oran Gap followed by the Whitewater-Little River, the Castor River Gap, the St. Francis River Gap, and the Marianna Gap which is followed by L'Anguille River.

**Bell City-Oran Gap.** The most northerly and widest of the gaps through Crowleys Ridge lies between Bell City and Oran, Mo. It is 10 miles wide but is interrupted by four small upland remnants of Crowleys Ridge; Ringer, Cow, Bird and Lost hills. Bird Hill has an area of slightly over a square mile and stands 250 ft. above the surrounding floodplain. The other knobs are smaller and rise approximately 150 ft. above the floodplain to the general level of Crowleys Ridge. The Whitewater River flowed south through the gap between Bird and Cow hills until recently when it was canalized and diverted into the Mississippi River near Cape Girardeau. Under natural conditions the drainage through the Bell City-Oran Gap was by a plexus of old White River channels into Little River. Mississippi River floodwaters which entered the Western Lowland at Cape Girardeau also flowed into the Eastern Lowland through the gap.

**The Castor River Gap.** Castor River, before its canalization, flowed through a gap in Crowleys Ridge to join Little River near New Madrid, Mo. The valley of the Castor River through Crowleys Ridge is about 10 miles long and varies in width from ¾ of a mile to 1 mile throughout most of its length but narrows to less than ½ mile at its eastern end. The gap, unlike the Bell City-Oran Gap, is not bordered by abrupt escarpments.

The northwestward widening of the valley of Castor River and the northwest-southeast trend of the tributary valleys which join the main valley in the gap indicate that the Castor River reversed the flow in the trunk valley of a minor west-flowing stream system.

**The St. Francis River Gap.** The gap through Crowleys Ridge occupied by the St. Francis River is located where the ridge is low and narrow. The gap is approximately one mile long and a little more than 1,000 ft. wide in its narrowest portion.

The St. Francis River Gap, like the Castor River Gap, is the valley of a beheaded west-flowing stream through which the river was diverted into the Eastern Lowland. Several other similar gaps north of the St. Francis River Gap are also the beheaded valleys of minor west-flowing streams, but most of them are 35 ft. or more above the Eastern Lowland and have no streams.

**The Marianna Gap.** A broad re-entrant of the Mississippi floodplain of the Eastern Lowland now occupies an 8-mile wide gap through Crowleys Ridge north of Marianna, Ark. L'Anguille River enters the Mississippi floodplain just west of the gap. It is entrenched over 20 ft. in the high alluvial plain of the Western Lowland, north of an escarpment which truncates the alluvial plain and limits the northern end of the Marianna Gap. This escarpment is part of the Big Creek fault zone and clearly shows that the gap is of structural origin.

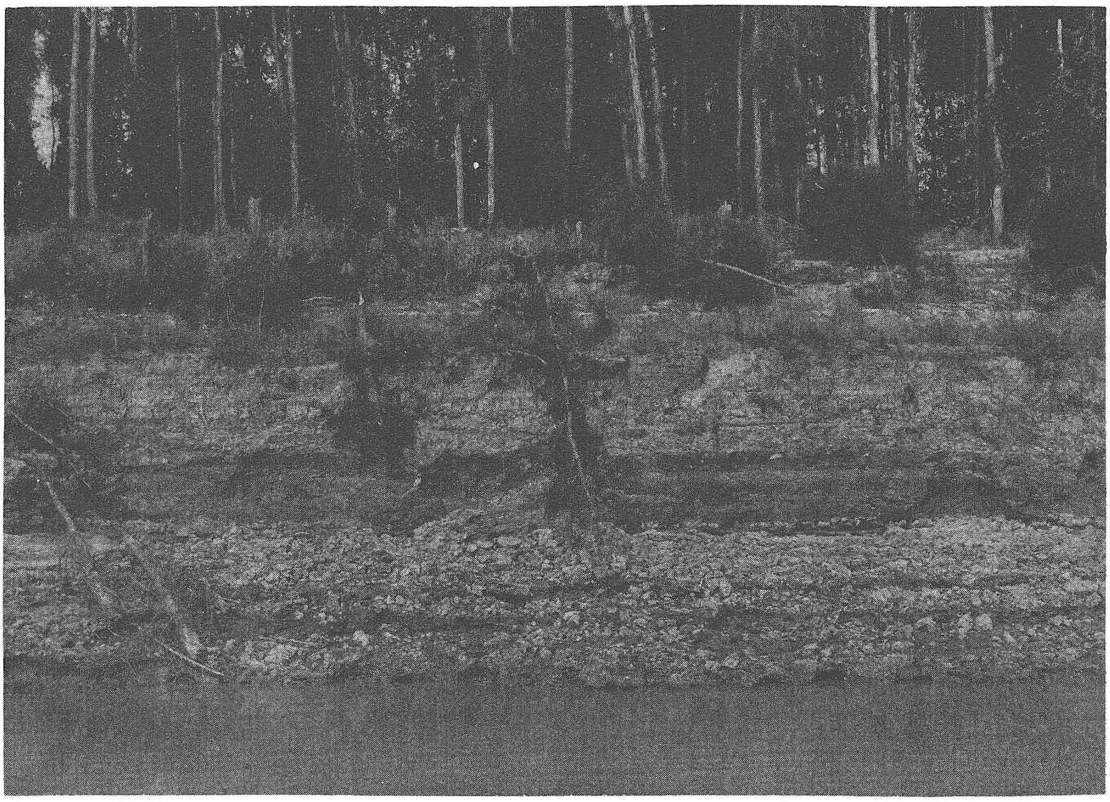


FIG. 20A INTERBEDDED SILTY CLAYS, SILTY SANDS, AND SANDY CLAYS FORMING THE FILLING OF A BAR SLOUGH. EAST BANK OF RIVER SOUTH OF VICKSBURG, MISSISSIPPI, NEAR MILE 605 BELOW CAIRO. EXPOSED SECTION IS APPROXIMATELY 35 FEET THICK.

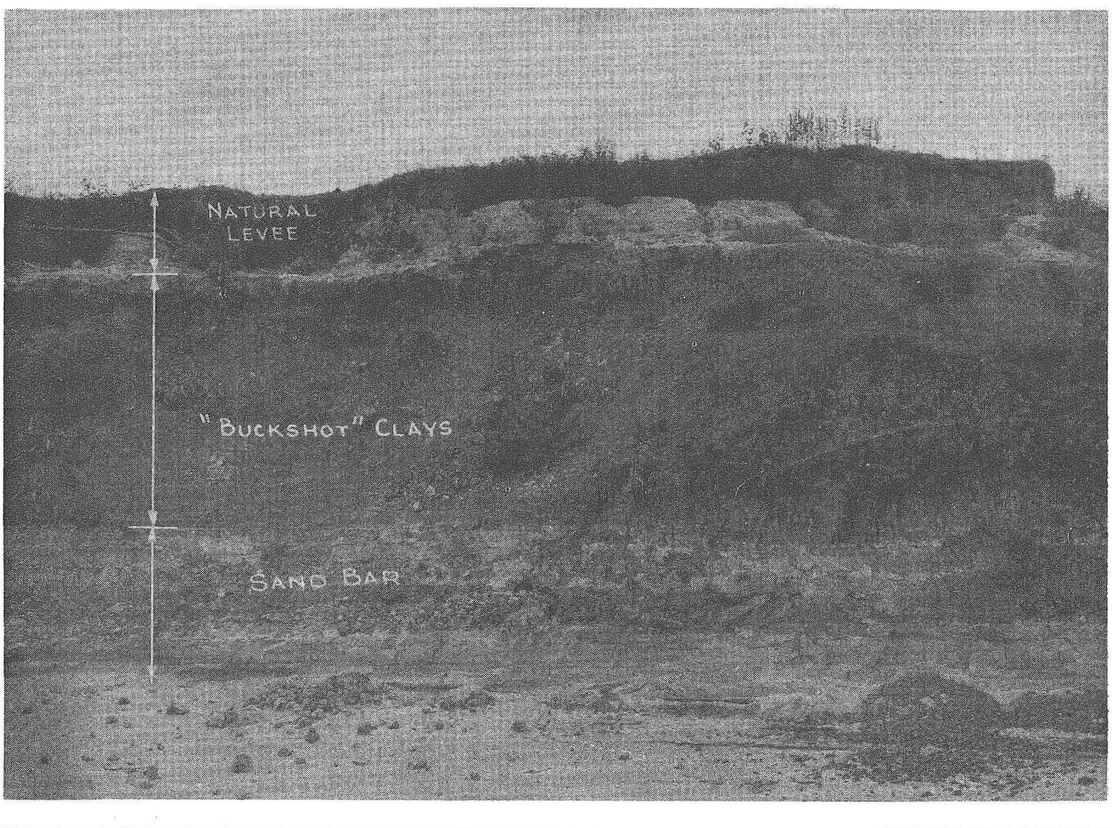
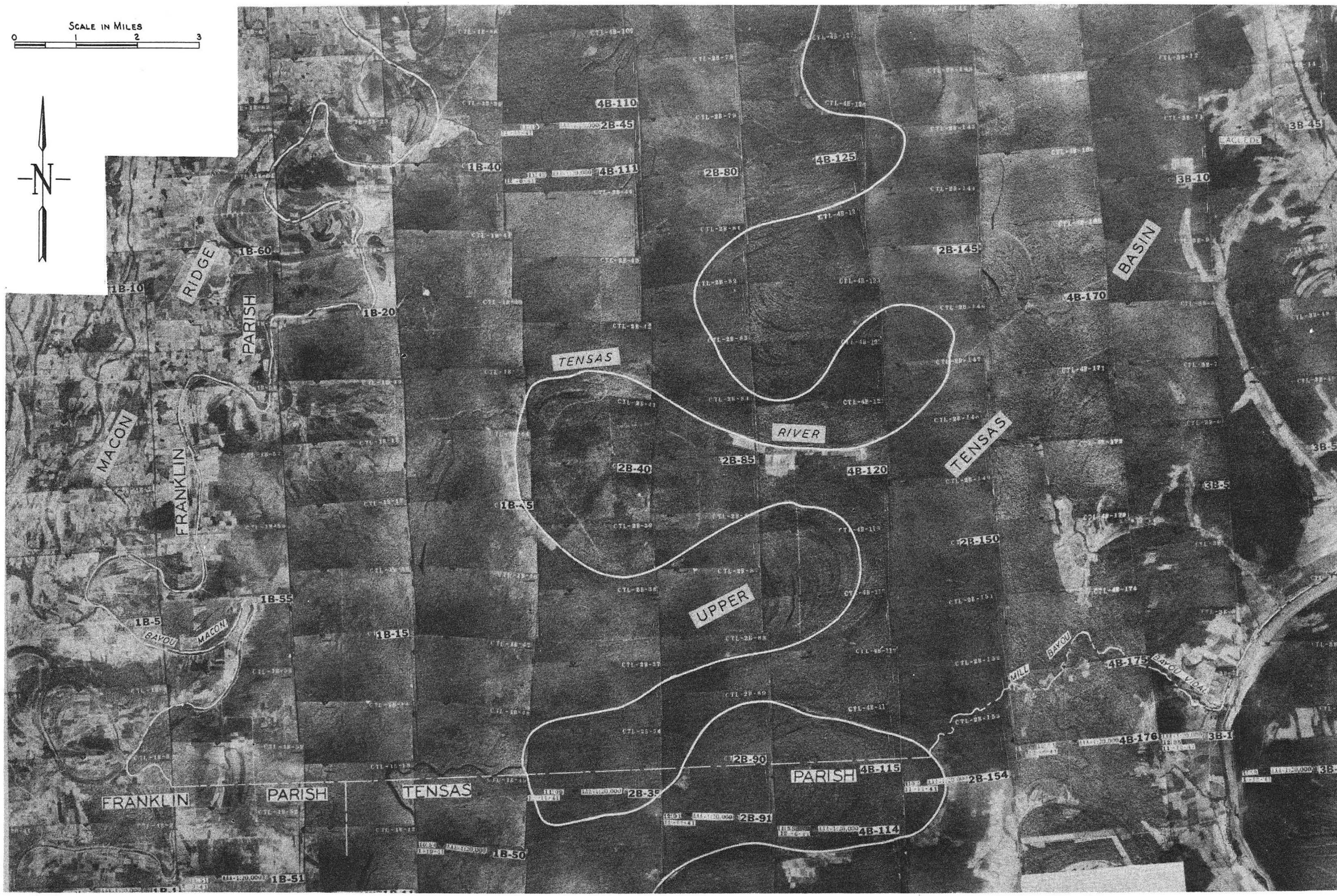



FIG. 20B "BUCKSHOT" CLAYS FORMING A PART OF AN EXTENSIVE BACKSWAMP DEPOSIT. WEST BANK OF RIVER NEAR DUCKPORT LANDING, MILE 593 BELOW CAIRO. THE CLAYS, 20 FEET THICK, ARE OVERLAIN BY NATURAL LEVEE DEPOSITS, 6 TO 8 FEET THICK, AND OVERLIE SAND BAR DEPOSITS.


FIG. 21A Aerial Photograph of Coastal Marshlands of Lafourche Parish, Louisiana, near the Western End of Lake Salvador. Bayou Des Allemands, a Tidal Channel, Connects Lac Des Allemands with Lake Salvador. Other Meandering Channels, Choked with Alligator Grass and Abandoned, are Traceable in the Marshes. Dark Patches within the Marshes are Water Bodies. Narrow Boat Trails Utilized for Oil Exploration and for Trapping Criss-Cross the Area.


FIG. 21B Aerial Photograph of Marshlands near Larose, Lafourche Parish, Louisiana. Cultivated Natural Levees and a Well Defined Channel Mark Bayou Lafourche, an Old Distributary of the Mississippi River. Older Distributary Channels Choked with Vegetation and Sediment can also be Traced in the Marshes. Irregular Dark Patches at Left of Photograph Indicate Burned Marshes.

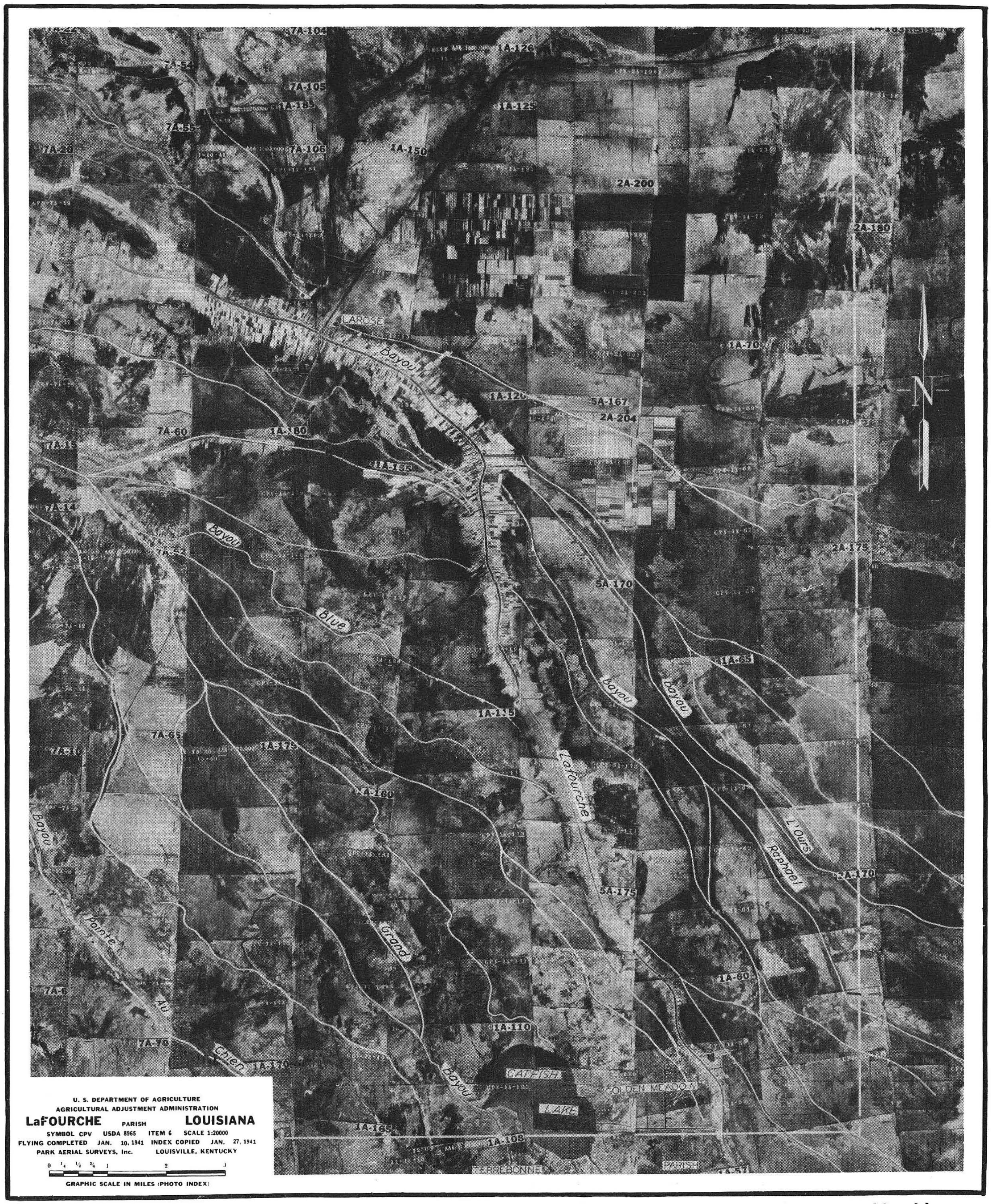
FIGURES 21A & 21B




**Back Swamp Area — Upper Tensas Basin**

Tensas River Follows Upper Tensas Meander Belt, Stage H Course (Mississippi River without Ohio)

FIGURE 22




MINOR DISTRIBUTARIES OF THE BAYOU LAFOURCHE DELTA SYSTEM — STAGES 10 & 11

FIGURE 23

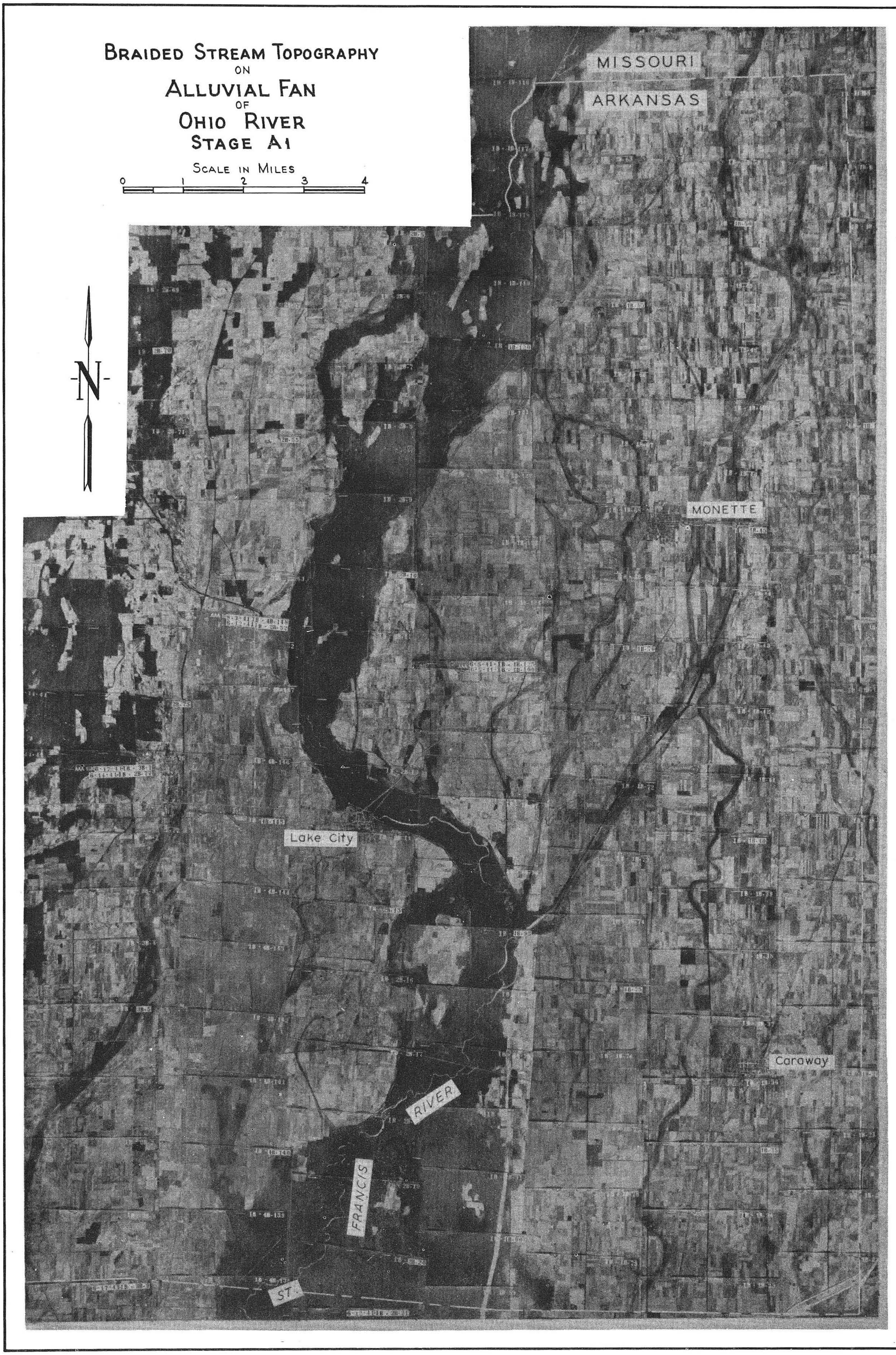

BRAIDED STREAM TOPOGRAPHY
ON
ALLUVIAL FAN
OF
OHIO RIVER
STAGE A1
SCALE IN MILES
0 1 2 3 4
N
MISSOURI
ARKANSAS
MONETTE
Lake City
Caraway
ST. FRANCIS RIVER

FIGURE 24

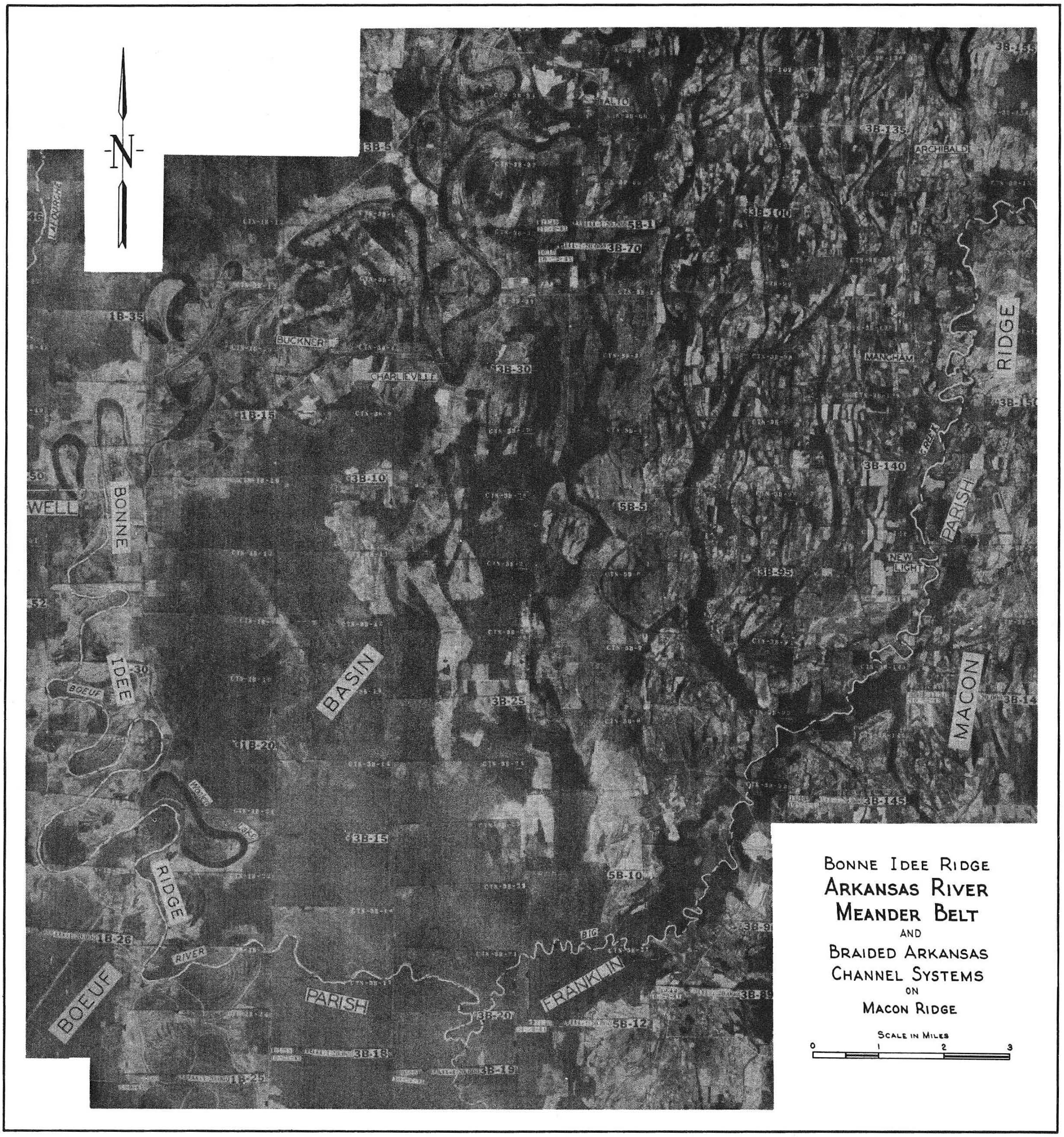

BONNE IDEE RIDGE
ARKANSAS RIVER
MEANDER BELT
AND
BRAIDED ARKANSAS
CHANNEL SYSTEMS
ON
MACON RIDGE
SCALE IN MILES
0 1 2 3
N
BUCKNER
CHARLEVILLE
BALTO
ARCHIBALD
MANGHAM
NEW LIGHT
BONNE
IDEE
RIDGE
BOEUF
RIVER
BASIN
PARISH
FRANKLIN
BIG
MACON
RIDGE
WELL

FIGURE 25

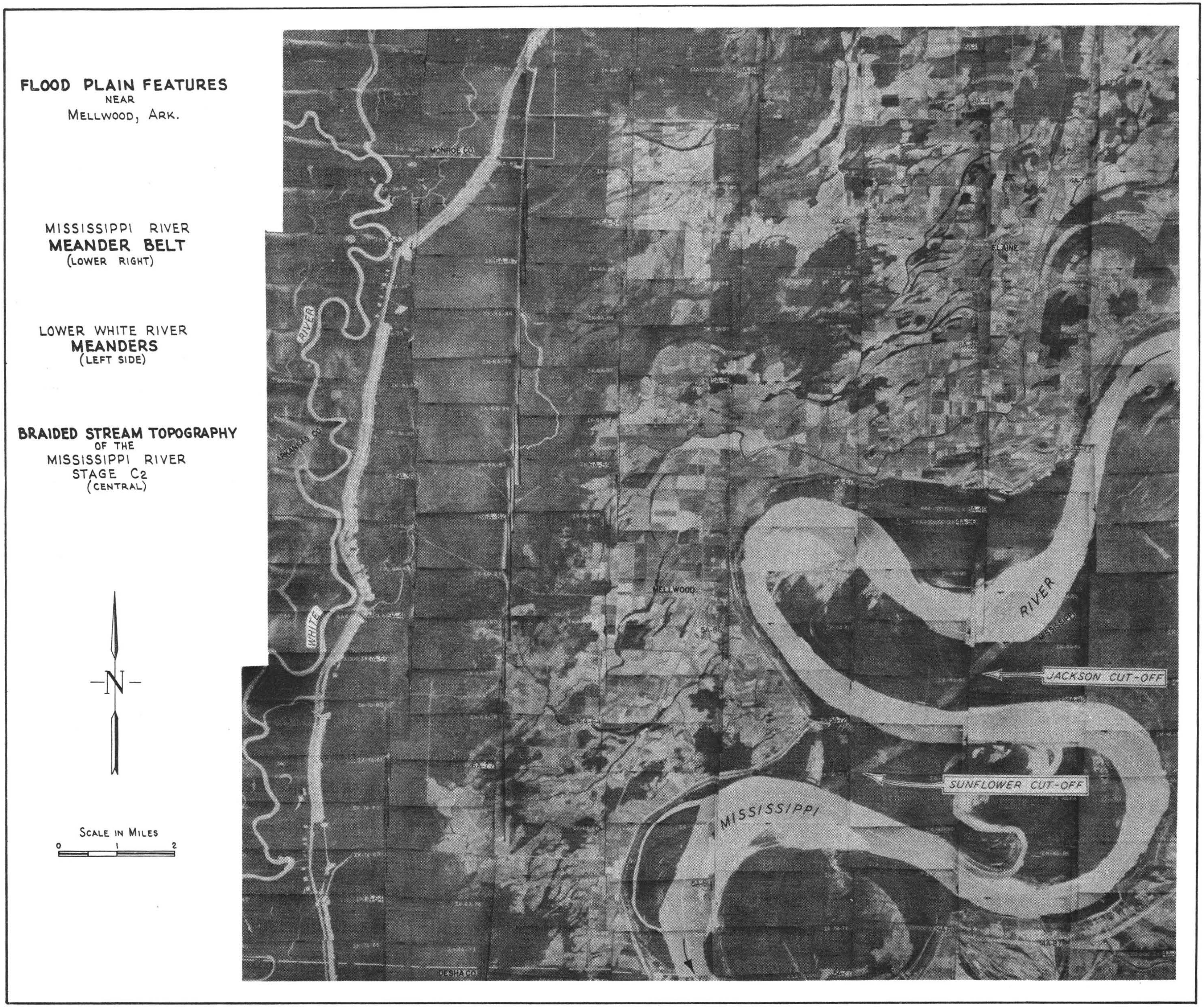

FLOOD PLAIN FEATURES
NEAR
MELLWOOD, ARK.
MISSISSIPPI RIVER
MEANDER BELT
(LOWER RIGHT)
LOWER WHITE RIVER
MEANDERS
(LEFT SIDE)
BRAIDED STREAM TOPOGRAPHY
OF THE
MISSISSIPPI RIVER
STAGE C2
(CENTRAL)
N
SCALE IN MILES
0
1
2
MONROE CO.
ELAINE
MELLWOOD
ARKANSAS CO.
DESHA CO.
WHITE
RIVER
MISSISSIPPI
RIVER
MISSISSIPPI
JACKSON CUT-OFF
SUNFLOWER CUT-OFF

FIGURE 26

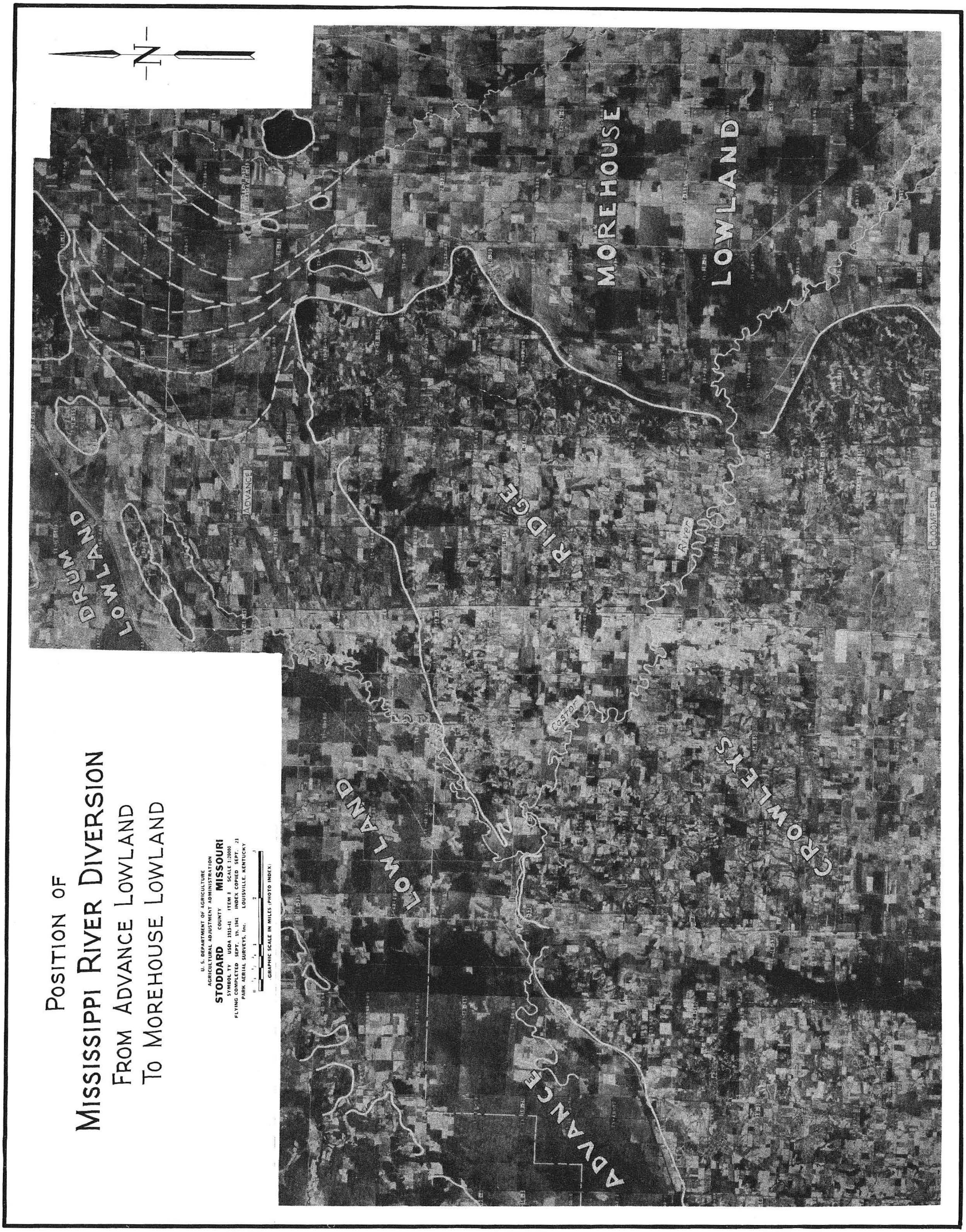

Position of
Mississippi River Diversion
From Advance Lowland
To Morehouse Lowland
U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL ADJUSTMENT ADMINISTRATION
STODDARD COUNTY MISSOURI
GRAPHIC SCALE IN MILES (PHOTO INDEX)
N
MOREHOUSE
LOWLAND
DRUM
LOWLAND
ADVANCE
RIDGE
CROWLEYS
LOWLAND
ADVANCE

FIGURE 27

*Subdivisions of the Western Lowland*

**The Advance Lowland.**[1] The narrow portion of the Western Lowland which extends for 50 miles between Cape Girardeau and Wappapello, Mo., is termed the Advance Lowland. It is 3 miles wide at Cape Girardeau and reaches its greatest width of approximately 8 miles near Advance, Mo., where Hickory Ridge and other small upland remnants set off the narrow, 15-mile long Drum Lowland[2] to the north. West of Drum Lowland the Advance Lowland maintains a width of about 4 miles to Wappapello where it narrows to a width of 2 miles.

The surface of the Advance Lowland, east of Advance, is blocked by a series of low ridges, successive natural levees formed while the Mississippi River occupied the Bell City-Oran Gap. The position of these ridges is indicated by the white lines on photograph, figure 27. The westernmost of the ridges rises 15 ft. above the general level of the alluvial plain; successive ridges diminish in height eastward. The upper end of the Drum Lowland is also blocked by natural levee ridges of the Mississippi River and by the alluvial fan of the Whitewater River.

West of Advance, the lowland surface bears traces of an old braided channel system of the Mississippi River. West of the Drum Lowland the north portion of the Advance Lowland is partially filled by the alluvial fan deposits of the Castor River. These deposits cover and largely obscure the older drainage lines, but traces of the older braided Mississippi channels are retained in the trend of the abandoned Castor River courses.

The southern end of the Advance Lowland was blocked by the alluvial fan of the St. Francis River and the resulting lowland is known as Mingo Swamp. The earlier drainage lines in the Mingo Swamp area have been completely obscured and today the only channels still traceable are meandering courses of the St. Francis and Castor rivers.

**The Alluvial Fans of the Western Lowland.** The Western Lowland is occupied by the huge alluvial fans of the Mississippi River and by smaller fans of the marginal tributaries. The general area of the abandoned Mississippi alluvial fan is shown on plate 2; details of this fan and of the fans of minor streams are shown on plate 15.

**The Mississippi Alluvial Fan.** The alluvial fan deposits of the Mississippi River form most of the surface of the Western Lowland. They can be traced from the Advance Lowland through the wide dissected alluvial plains into the floodplain area of the Mississippi River. The alluvial fan surface consists of a step-like series of seven terraces (figure 28) separated by escarpments. They are designated in order of their development the $A_1$, $A_2$, $A_3$, $B_1$, $B_2$, $B_3$, and $C_1$ stages. The surface of each terrace is covered with many traces of the channels of the braided Mississippi River and smaller streams which were active in constructing the fan.

The Black, White, L'Anguille, and Cache rivers, Bayou De View and Big Creek are all incised within deposits of the Mississippi alluvial fan. The curvature of the valley and the parallelism of these streams with elements of braided stream topography on the adjacent surfaces show that each stream follows the position of an abandoned main channel of the braided Mississippi River. The average slope of the dissected Mississippi alluvial fan is approximately 0.75 ft. per mile, slightly more than the slope of the Mississippi River floodplain in the same latitude; however, local slopes on the fan surface are extremely variable. The down-valley slope of individual terrace surfaces of the fan reaches one foot per mile. Slopes measured along a main channel are locally less than 0.5 ft. per mile and those along dispersal channels are insignificant. Natural levees along the main channel are very narrow and steep with local backslopes of 5 ft. per mile.

**The Big Creek Escarpment.** The Big Creek Escarpment which separates the dissected portion of the Mississippi alluvial fan from its southward continuation on the floodplain extends as a broad arc for 50 miles northeastward from the southern end of Grand Prairie Ridge to West Helena, Ark., where it stops at the foot of Crowleys Ridge (plate 2). The escarpment has an average height of about 30 ft. and reaches a maximum height of 60 ft. near West Helena. It is named after Big Creek, a tributary of the White River, which flows at its base for several miles. A portion of the escarpment east of the White River is shown on figure 4.

Scars of braided Mississippi channels on the dissected alluvial plains are abruptly downdropped to the south of the Big Creek Escarpment. This displacement of the surface features definitely establishes the fact that the escarpment is the result of faulting. A few borings in the vicinity of Barton (8 miles west of West Helena), show a displacement of the alluvium and valley floor sediments at the foot of the escarpment. The displacement at depth is greater than that of the surface and shows that movement along the fault zone started before the deposition of the Recent alluvium.

The Big Creek Escarpment is jagged and notched by stream valleys. Many of the streams crossing the escarpment are deflected southwestward and tend to follow minor faults which are en echelon to the trend of the Big Creek fault zone. The total displacement of the surface as indicated by the height of the escarpment has been distributed locally to movement along parallel minor faults each with a throw of several feet. The diagram, figure 29, shows the complex nature of faulting in the central part of the escarpment south and west of Marvell.

Slow movement along the faults of the Big Creek fault zone is indicated by the fact that traces of braided courses of the Mississippi River all turn southwestward and paralled the trend of the escarpment (see figure 29 and plate 15). This phenomenon indicates that movement was occurring when the river occupied the Western Lowland. Slow and continued fault movement permitted the Mississippi River to slowly incise earlier formed portions of its alluvial fan and to develop the step-like sequence of terraces north of the fault zone. The long continued nature of the faulting is shown by a greater displacement of the valley floor sediments than is shown at the surface and by a somewhat thicker section of alluvium recorded in borings made at the foot of the escarpment.

[1] Marbut, C. F., "The Evolution of the Northern Part of the Lowlands of Southeastern Missouri," Univ. of Missouri Studies, vol. 1, no. 3, p. 4, 1902.
[2] Marbut, C. F., Idem., p. 7.

Local movement along the Big Creek fault zone was sufficiently great to cause a northward tilting of the alluvial fan surface between Helena and Marvell, Ark. Drainage following abandoned braided channels of the Mississippi River in this area has been reversed and now flows northward toward Marianna.

**Alluvial Fans of Tributary Streams.** Each of the major tributaries entering the Western Lowland, the Whitewater, Castor, St. Francis, Black, White, and Little Red rivers, has developed an alluvial fan. The general outlines of these alluvial fans are shown by the distribution of abandoned stream courses on plate 15. The largest of these fans is that of Little Red River. Part of this fan lies above floodplain level and was evidently formed when the Mississippi River occupied the Western Lowland. All other fans were constructed subsequent to the shift of the Mississippi River to the Eastern Lowland.

**Floodplains within the Western Lowland.** The principal floodplains within the Western Lowland are those of the Black and White rivers; Cache River, Bayou De View, Big Creek, and L'Anguille River have minor floodplains.

The floodplains of the Black and White rivers make up a continuous lowland which extends the entire length of the Western Lowland, south of the Advance Lowland. This lowland narrows to 0.75 mile at the western valley wall near Pocahontas, Ark. (figure 30), but elsewhere it is 4 to 8 miles wide. It is separated from the Mississippi alluvial fan surface by escarpments which average less than 15 ft. high but which reach a maximum height of almost 50 ft. near St. Charles, Ark.

The floodplain bears traces of several older meander belts of the Black and White rivers. Meander scars of a stream larger than the present Black River are also found in the Black River lowland. The size of these scars indicates that they were formed by a much larger stream, one which probably carried the combined flow of Castor, Whitewater, St. Francis, and Black rivers.

South of De Valls Bluff, Ark., the White River lowland contains the scars of the youngest braided Mississippi system in the Western Lowland. This system occurs on the $C_1$ surface which merges with the White River floodplain (plate 15).

A series of large meander scars similar to and older than the large scars in the Black River lowland forms a part of the $C_2$ surface bordering the Cache River lowland (figure 30). These large scars make up a meander belt which can be traced from the Black River escarpment near Knobel, Ark., along the present Cache River valley to its junction with the White River floodplain. Throughout this distance the meander belt is slightly above floodplain level of the Cache River. It parallels the trend of the braided stream scars on the higher Mississippi $C_1$ surface.

Earlier meander belts of the White River lie to the east of the small outlying Mississippi alluvial fan remnants known as the Surrounded Hills. The lowland to the west of these hills was initially developed by the Little Red River and was not occupied by the White River until a much later date. In the lowland to the east of the Surrounded Hills, the White River was joined by the Black River in its Cache River $C_2$ course (plate 15).

The only part of the Mississippi River floodplain in the Western Lowland lies between the Big Creek escarpment and the present Arkansas and Mississippi rivers. The southern edge of the floodplain is part of the Mississippi meander belt. The remainder of the area is part of the White River basin which includes most of the White, Cache, De View, and Big Creek floodplains. Several meander belts of the White River lie at the western edge of this portion of the Mississippi floodplain. Irregular ridges and swales in the eastern part of the floodplain mark braided channel positions of the Mississippi River. These braids are a continuation of the braids on the dissected plain surface north of the Big Creek Escarpment.

### *Influence of Regional Structure in the Western Lowland*

In addition to active faulting which has displaced the surface along the Big Creek fault zone, there is a marked correlation between the trend of the escarpments, the trend of the alluvial fan drainage, and the regional structural pattern. The prominent escarpment between $A_1$ and $B_2$ surface in the vicinity of Weiner, Ark., parallels the trend of the Ozark Escarpment fault zone. It also forms the continuation of the trend of the western side of Crowleys Ridge north of Jonesboro, Ark. This escarpment, like most other escarpments in the area, turns abruptly to the southeast and parallels the trend of the White River fault zone, figure 6.

The drainage of the dissected alluvial plain forms a roughly rectangular pattern with the dominant directions corresponding to the major fault directions, northeast-southwest and northwest-southeast (plate 15).

The gaps in Crowleys Ridge also correspond with the position of the major fault zones.

## The Eastern Lowland

The Eastern Lowland contains that part of the Mississippi meander belt north of Helena, the St. Francis Basin, and extensive remnants of the old alluvial fan of the Ohio River. The lowland maintains a width of 40 to 50 miles from the northern end to the latitude of Osceola, Ark., and narrows southward toward its southern boundary, the Mississippi River, which crosses the lowlands diagonally between Memphis and Helena.

The general surface of the Eastern Lowland is lower than that of the Western Lowland, and the escarpments are higher. These escarpments are but slightly modified by scallops of the major streams, the Ohio and Mississippi rivers. They form a series of straight bluffs whose short segments are alined with the trend of the major regional fault system.

The Eastern Lowland connects with the Western Lowland by the several water gaps through Crowleys Ridge and with the upper Mississippi Alluvial Valley by Thebes Gap through which the Mississippi River flows. They connect with the upper Ohio Alluvial Valley by the Metropolis Lowland, followed by the Ohio River, and by the Cache Lowland of southern Illinois which was previously occupied by the Ohio.

**Thebes Gap.** The narrow gorge of the Mississippi River which separates the Benton or Commerce Hills from the highlands of southern Illinois (figure 31) is named for Thebes, Ill., where it is less than 3,000 ft.

FIGURE 28

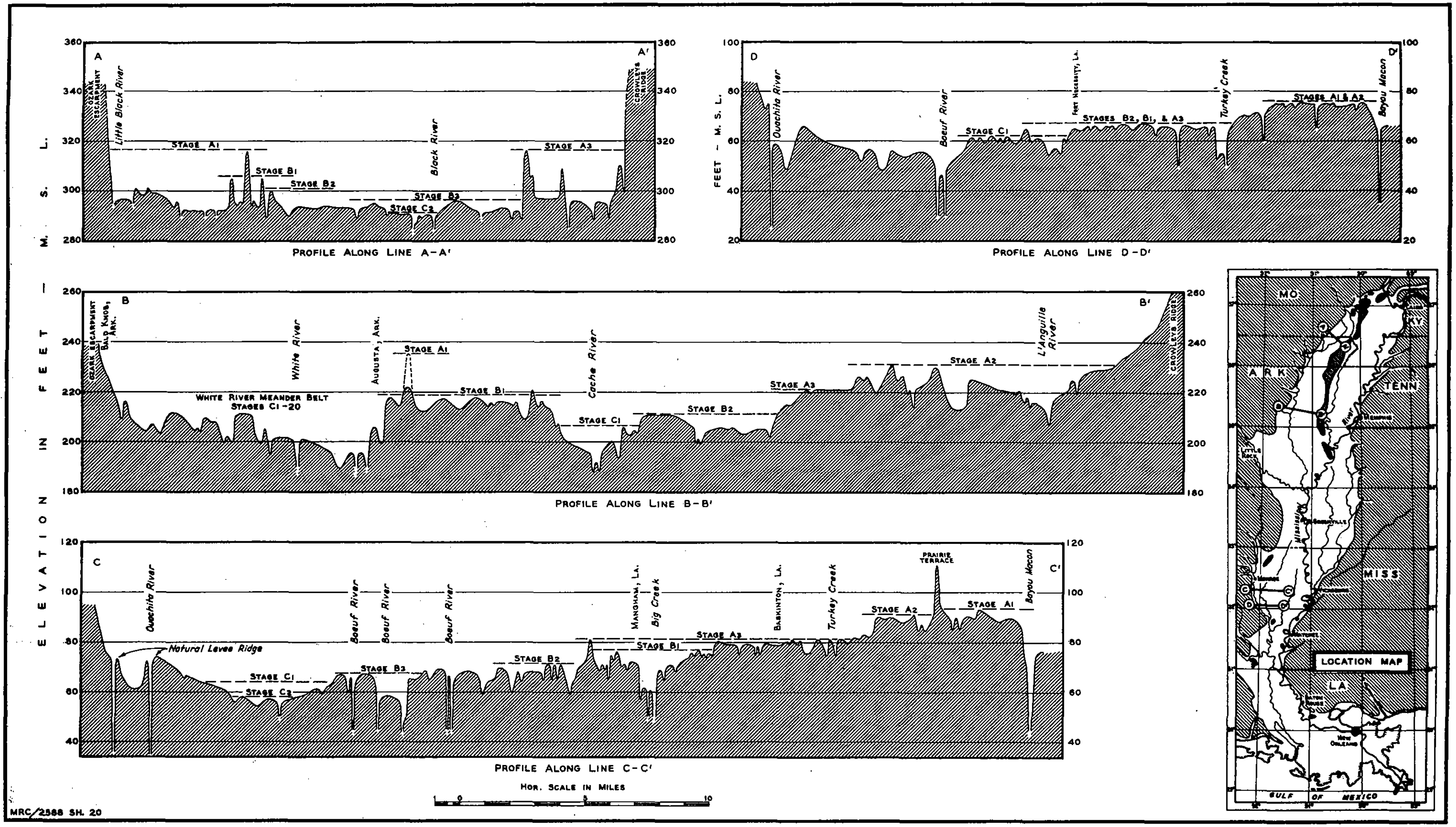
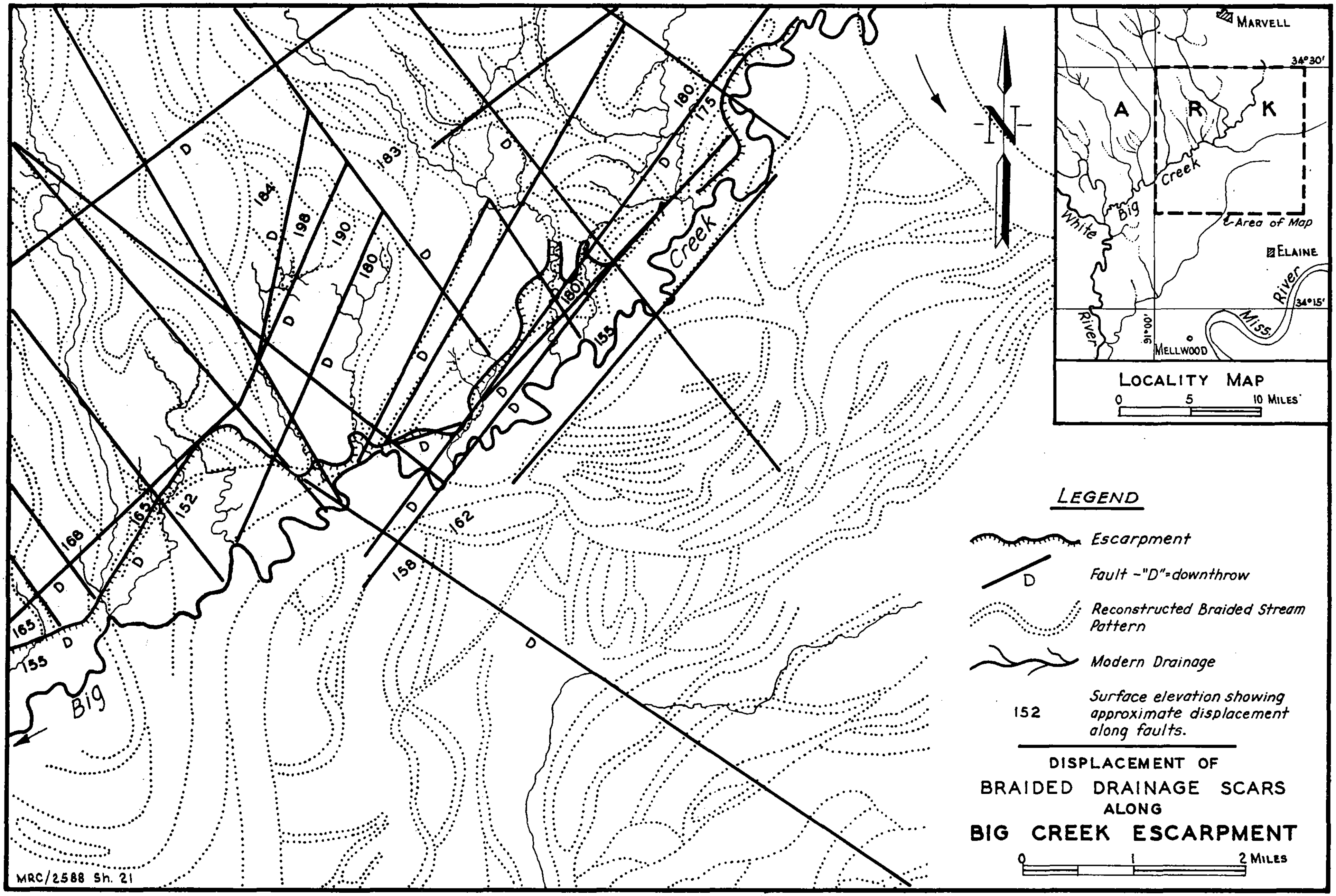



FIGURE 28 STEP – LIKE PROFILES OF DISSECTED ALLUVIAL PLAINS

FIGURE 29




DISPLACEMENT OF BRAIDED DRAINAGE SCARS ALONG BIG CREEK ESCARPMENT

Bell City-Oran Gap was so complete that the whole upland is below the level of Sikeston Ridge. Degradation was less complete in the Cairo Lowland, and isolated remnants of the original surface co-extensive with Sikeston Ridge remain above floodplain level.

Scars of the braided channel of the Ohio River can be traced on the surface of Sikeston Ridge. A small gap in the north end of Sikeston Ridge, 3 miles south of the Commerce Hills, marks the position of a braided channel of the Ohio River which later functioned as a dispersal channel of the Mississippi River while it occupied its Morehouse Lowland course.

**The Morehouse Lowland.** The Morehouse Lowland,[1] named after the centrally located town of Morehouse, Mo., lies between two remnants of the Ohio alluvial fan, the Malden Plain to the west and Sikeston Ridge to the east. To the north the Morehouse Lowland connects with the upper end of the Western Lowland by the Bell City-Oran Gap; to the south it is continuous with the Little River Lowland with which it merges in the latitude of New Madrid, Mo. The Morehouse Lowland is slightly more than 30 miles long and increases from 10 miles in width at its northern end to almost 20 miles at its southern end.

The drainage pattern of the Morehouse Lowland (figures 27 and 31 and plate 15) is determined by an anastomosing network of old Mississippi River braided channels. Smaller streams, such as the Castor River and Little River (named Whitewater River on old maps), flow in these old braided courses and have modified the original channels. The cross-cutting relations of the braided channel scars indicate the eastern part of the Morehouse Lowland was the last to be abandoned by the Mississippi River.

**Little River Lowland.** The Little River Lowland, 20 miles wide and 80 miles long, forms the central part of the St. Francis Basin and is the southward continuation of the Morehouse Lowland. It is bounded on the west by the Malden Plain, on the east by the Mississippi River, and on the south by the abandoned St. Francis segment of the Mississippi River meander belt. The topography of this lowland differs from that of the Morehouse Lowland mainly in that scars of braided Mississippi courses have been largely destroyed by erosion or burial. Before canalization of the region, drainage in the northern part of the Eastern Lowland was collected by the Pemiscot Bayou-Left Hand Chute of the Little River system which joins the St. Francis River at Marked Tree, Ark.

The Little River Lowland is obliquely crossed at its southern end by the meander belt ridges of the Pemiscot Bayou-Left Hand Chute of Little River and of their older counterpart, Tyronza River. Meander loops within these ridges were formed by a stream larger than any draining the region today, but they are smaller than those of the Mississippi or Ohio rivers. The stream which constructed these ridges received much of its volume from Mississippi overflow near Cape Girardeau, which entered the system by way of the Morehouse Lowland. Other sources of water were the Castor, St. Francis, and Whitewater rivers and the drainage of the Eastern Lowland collected by Little River and St. Francis Bay.

**The Malden Plain.** The Malden Plain is that portion of the abandoned alluvial fan of the Ohio River lying between Crowleys Ridge and the Morehouse-Little River lowland belt. The plain is separated from the neighboring lowland by a 15 to 20 ft. escarpment at the north. The slope of the plain, however, is greater that that of the lowlands, and the escarpment loses in height southward where the alluvial fan surface merges with the floodplain in the vicinity of Marked Tree, Ark.

Braided stream patterns of the Ohio alluvial fan are well preserved on the Malden Plain which is largely undissected. Only a few streams are incised below the general surface level. The St. Francis River follows an abandoned main channel of the braided Ohio system across the plain and has but slightly modified original channel features. Both the braided Ohio channel and the St. Francis River are shown on the photographs of the area around Monette, Ark. (figure 24). Fans of small streams draining eastward from Crowleys Ridge coalesce to form an alluvial apron overlapping the western margin of the Malden Plain. They obscure features of the Ohio alluvial fan.

**The Lower St. Francis Basin.** The lower St. Francis Basin (figure 34) is the southernmost part of the Eastern Lowland. It includes that portion of the present meander belt of the Mississippi River south of Richardsons, Tenn., the abandoned St. Francis segment of the Mississippi River meander belt, and the area between the two meander belts.

The St. Francis meander belt segment extends in an 80-mile arc from west of Richardsons, Tenn., to near Helena, Ark. The two ends of the arc merge with the present Mississippi meander belt, but at the center of the segment the two meander belts are more than 20 miles apart. The meanders of the St. Francis segment are similar in size and shape to those of the present Mississippi River; but the characteristics of the meander belt are better reflected in the cut-offs marginal to the belt than in the last channel, because the latter has been greatly modified by subsequent stream activity. Since it was abandoned by the Mississippi River, the St. Francis segment has been occupied by the St. Francis River and by the southerly continuation of the stream which constructed the Pemiscot Bayou meander belt system. Another stream which modified the St. Francis segment was the Fifteen Mile Bayou diversion channel (figure 34) which forms a short arc from near Memphis, Tenn., to near Helena, Ark., and truncates the older St. Francis segment. It functioned as a by-pass channel of the Mississippi River and is named from the largest stream occupying the channel.

## THE CENTRAL DIVISION

The principal elements of the central division are the floodplain of the Mississippi River and the great alluvial fan of the Arkansas River. The floodplain is separated by the present river into the Yazoo Basin on the east and the Tensas Basin on the west. The Tensas Basin is further divided into an upper and lower portion by the constriction in the valley between Sicily Island, La., and Natchez, Miss.

The Arkansas fan includes Grand Prairie Ridge to the north, the Arkansas Lowland between Grand Prairie Ridge and the Arkansas River, the Boeuf Basin, and parts of Macon Ridge to the south. Sicily

[1] Marbut, C. F., op. cit., p. 8.

wide. It is 7 miles long and at no place exceeds a mile in width. The hills flanking the gap rise as much as 300 ft. above river level.

The general slope and drainage of the Commerce Hills and of the marginal eastern uplands is to the north, and the stream divides lie near the southern margins of the hills. Minor streams draining into the Mississippi River in the gap are "barbed" tributaries and point upstream where they enter the master valley. These facts indicate that Thebes Gap once formed the valley of a minor northflowing stream.

**The Cache Lowland of Southern Illinois.** The Cache Lowland is a gently sinuous valley 2 to 5 miles wide (figures 31 and 32) which extends 40 miles from the Ohio River south of Golconda, Ill., to the head of the Eastern Lowland northwest of Cairo. The lowland surface is at the same level as the Ohio floodplain near Golconda but at its western end it is some 15 ft. higher than the Mississippi River floodplain.

The two principal streams flowing within the Cache Lowland today are the Cache River and Bay Creek. Both streams head in the uplands of southern Illinois, enter the Cache Lowland from the north, and follow an abandoned channel of the Ohio River. Bay Creek, however, flows east to join the Ohio and reverses the original direction of flow.

The old Ohio River channel followed by the Cache River is shown on figure 32. Bars, chutes, and islands similar to those of the present Ohio River are preserved along this channel. Its Ohio origin is further indicated by its width, general configuration, and by the associated accretion scars and chute cut-off channels.

**The Metropolis Lowland.** The lowland through which the present Ohio River[1] flows south from the mouth of Bay Creek near Golconda is named for the town of Metropolis, Ill., which lies in its narrowest portion. In this lowland the Ohio floodplain is 1 to 3 miles wide but it widens where it joins the Eastern Lowland near Cairo.

*Divisions of the Eastern Lowland*

Most of the area of the Eastern Lowland is made up of the St. Francis Basin and the Mississippi River meander belt. The lowlands, however, include dissected alluvial plains (remnants of the Ohio alluvial fans) which stand as ridges, and meander belt ridges divide the basin into separate lowlands. Sikeston Ridge, a narrow alluvial fan remnant at the north end of the basin, separates the Cairo Lowland from the Morehouse Lowland to the west. The Morehouse Lowland is bordered on the west by the Malden Plain, remnant of the Ohio alluvial fan, and on the east by the Mississippi meander belt ridge. The southern end of the Little River Lowland is separated from the lower St. Francis Basin by an old Mississippi meander belt ridge, the St. Francis segment.

Minor features east of the Mississippi River meander belt are the Reelfoot Lake Basin, the Tiptonville Dome, and the Obion-Forked Deer Basin.

**The Cairo Lowland.**[2] The Cairo Lowland is a basin bounded on the west by Sikeston Ridge and on the north and east by the valley walls. It includes that portion of the Mississippi meander belt between Commerce and New Madrid, Mo. It also includes eroded remnants of the Ohio alluvial fan in the area near Charleston, Mo., and braided Mississippi channels near the eastern edge of Sikeston Ridge. The northern end of the Cairo Lowland south and west of Commerce, Mo., is characterized by highly irregular erosional and depositional topography developed where the Mississippi River has cut across and reworked alluvial deposits of the Ohio fan. Where sands occur at the surface they form irregular hummocks which in many ways resemble sand dunes.

**The Reelfoot Lake Basin and Tiptonville Dome.** Tiptonville Dome,[3] south of the Cairo Lowland, is an uplifted area which lies opposite the southern end of Sikeston Ridge but is not a continuation of that feature. It is separated from the adjacent Reelfoot Lake Basin on the east by a fault escarpment along which earth movement has taken place during the construction of the alluvial plain surface. Maximum uplift of the Tiptonville Dome amounts to at least 15 ft. judging from the displacement of stream profiles, and the Reelfoot Lake Basin is downfaulted by at least 25 ft.; hence the total displacement is as much as 40 ft. The meanders marked 10 and 12 on figure 33 are cut by the escarpment and part of them have been downdropped into the Reelfoot Lake Basin from an elevation of 315 ft. M. S. L. to an elevation of 290 ft. M. S. L. east of Cronanville.

Displacement along the fault has been very recent and probably slight movement occurred as recently as 1812, the time of the New Madrid earthquake. Borings east of Cronanville show a displacement of 50 ft. in the Tertiary beds underlying the Recent alluvium. This sub-surface displacement is greater than exists at the surface and indicates that movement along the fault was probably slow and long continued.

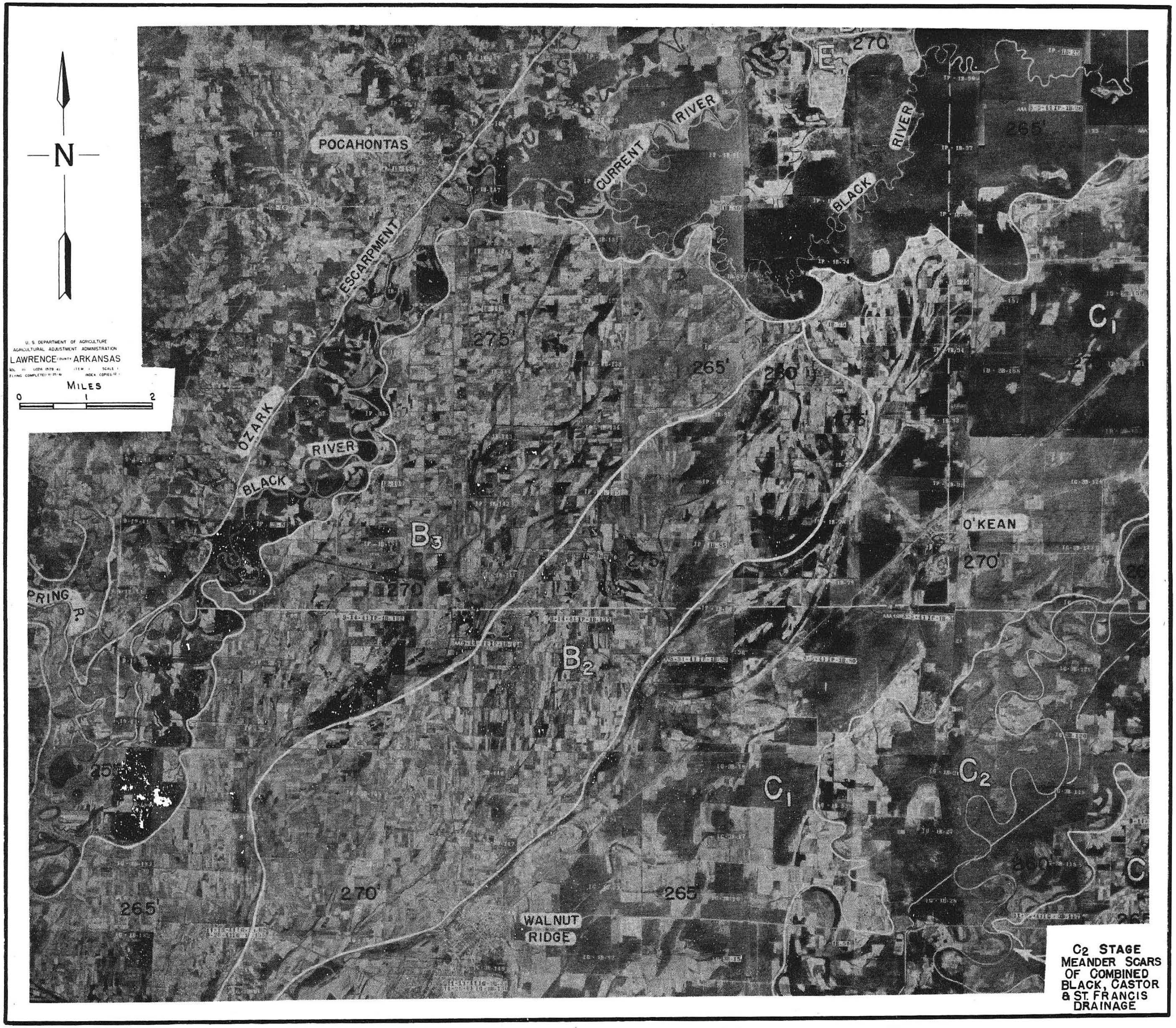
**Obion-Forked Deer Basin.** The small basin herein designated the Obion-Forked Deer Basin lies between the Mississippi River meander belt and the eastern valley wall. Besides the floodplains of the Obion and Forked Deer rivers, it contains two small remnants of the Ohio alluvial fan. The remnant on the north lies between Obion River and Running Reelfoot Bayou, the other is between Rock Slough and Forked Deer River.

**Sikeston Ridge.** The low alluvial ridge which extends southward for 35 miles from the Commerce Hills to New Madrid is named for its principal town, Sikeston, Mo. It is between 2 and 3 miles in width throughout most of its length but flares to almost 5 miles at its southern end. At its north end the ridge rises 40 ft. above the bordering lowlands; but, inasmuch as its slope is considerably greater than the slope of the neighboring floodplain, the ridge descends nearly to floodplain level at New Madrid.

The escarpments bordering the ridge were cut by comparatively straight braided Mississippi River channels. In the Morehouse Lowland, degradation by the braided Mississippi stream flowing through the

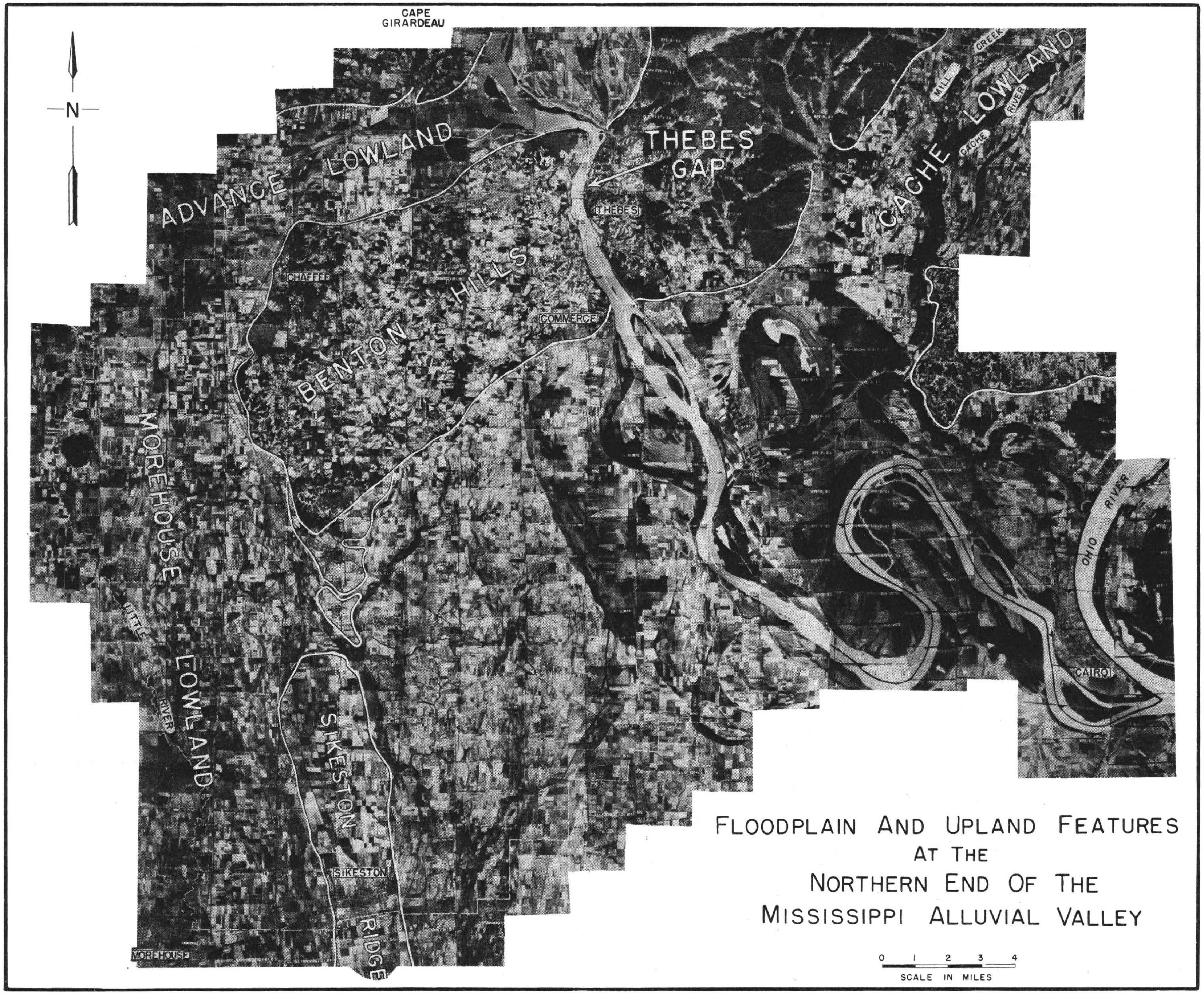
[1] Fowke, Gerard, "Evolution of the Ohio River," Hollenbeck Press, Indianapolis, Ind., 1933. A general discussion of the Ohio River evolution.
[2] Marbut, C. F., op. cit., p. 8. Marbut used Cairo Lowland for the entire northern part of the Eastern Lowland. His term Charleston Lowland is synonymous with Cairo Lowland of this report.
[3] Fuller, M. L., "The New Madrid Earthquake," U. S. Geol. Survey Bull. 494, 1912.

FIGURE 30




BRAIDED STREAM TOPOGRAPHY OF THE MISSISSIPPI RIVER
STAGES B AND C

FIGURE 31




FLOODPLAIN AND UPLAND FEATURES AT THE NORTHERN END OF THE MISSISSIPPI ALLUVIAL VALLEY

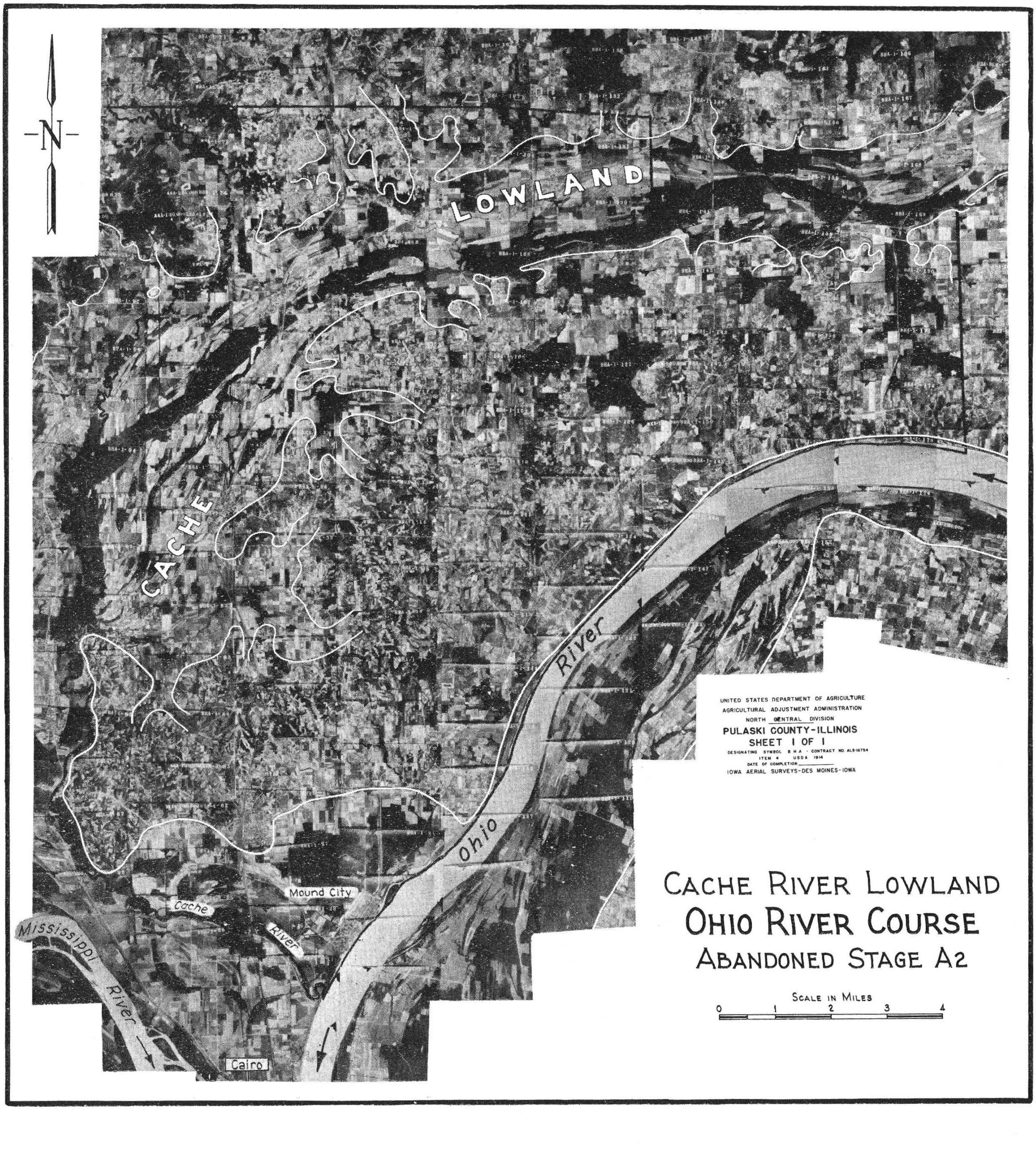
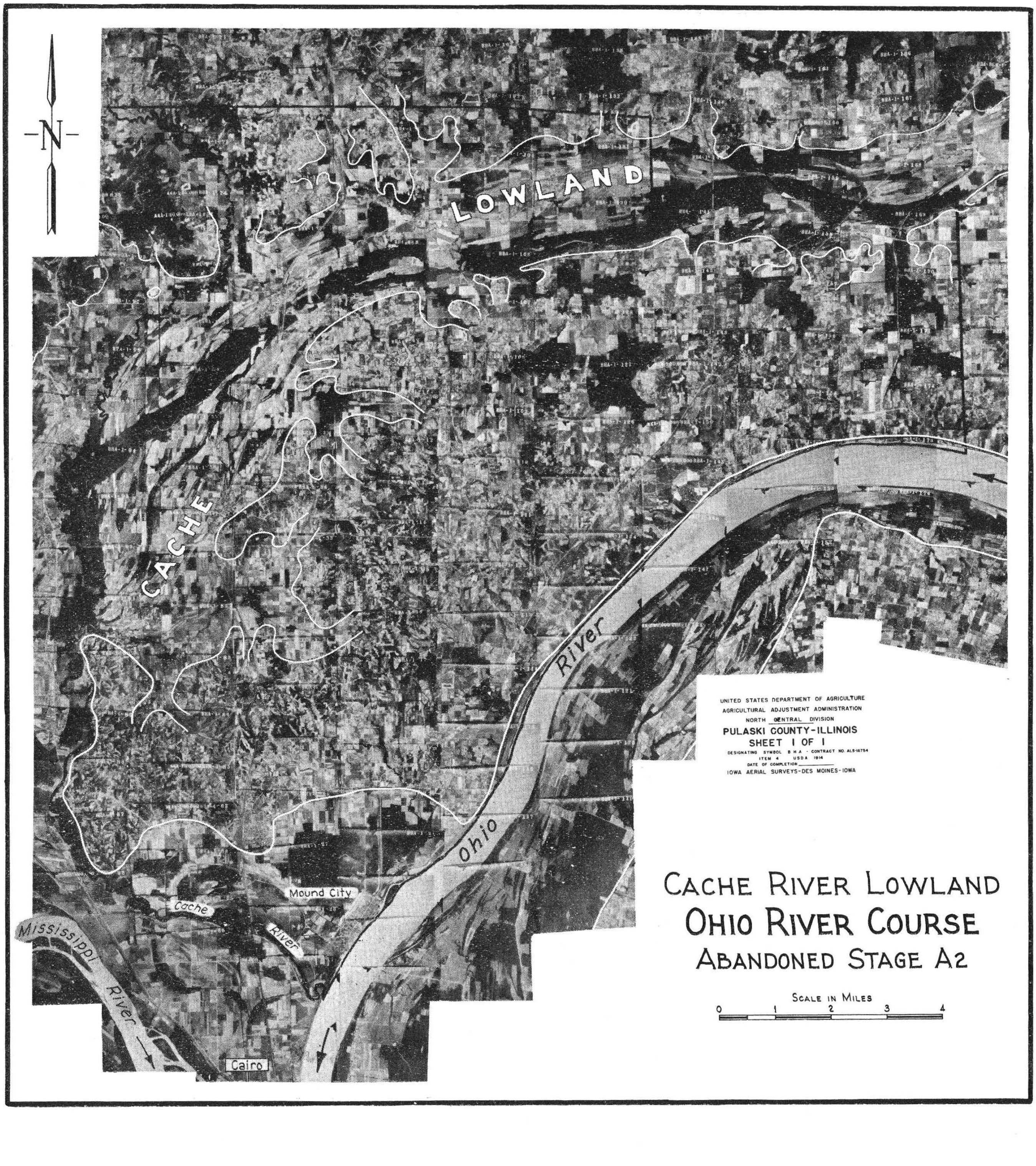

N
LOWLAND
CACHE
River
Ohio
UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL ADJUSTMENT ADMINISTRATION
NORTH CENTRAL DIVISION
PULASKI COUNTY-ILLINOIS
SHEET 1 OF 1
DESIGNATING SYMBOL B H A - CONTRACT NO. ALS-16754
ITEM 4 USDA 1914
DATE OF COMPLETION
IOWA AERIAL SURVEYS-DES MOINES-IOWA
Mound City
Cache
River
Mississippi
River
Cairo
CACHE RIVER LOWLAND
OHIO RIVER COURSE
ABANDONED STAGE A2
SCALE IN MILES
0
1
2
3
4

FIGURE 32


N
LOWLAND
CACHE
Ohio River
Mound City
Cache River
Mississippi River
Cairo
UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL ADJUSTMENT ADMINISTRATION
NORTH CENTRAL DIVISION
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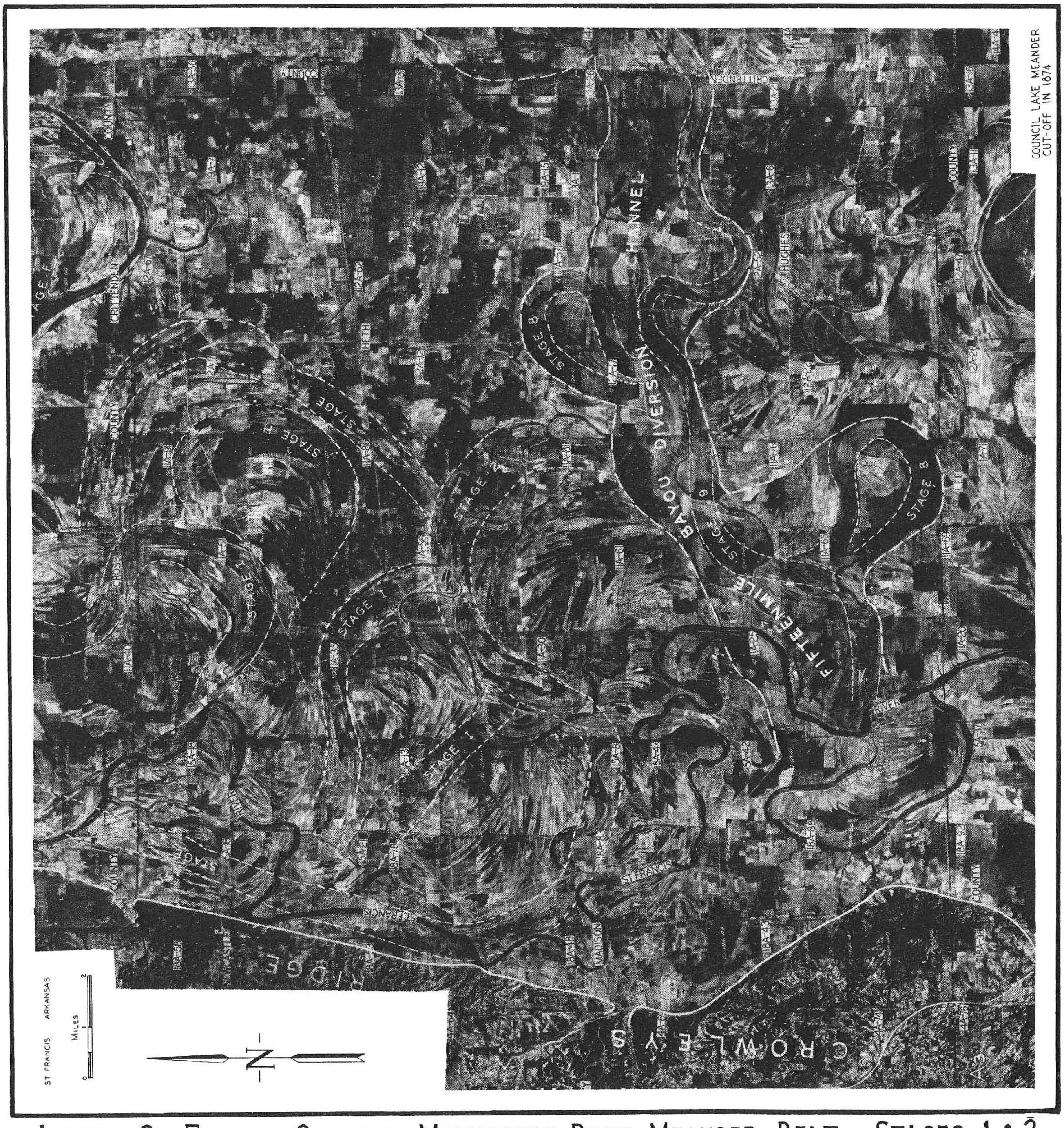
DESIGNATING SYMBOL B H A - CONTRACT NO. ALS-16754
ITEM 4 USDA 1914
DATE OF COMPLETION
IOWA AERIAL SURVEYS-DES MOINES-IOWA
CACHE RIVER LOWLAND
OHIO RIVER COURSE
ABANDONED STAGE A2
SCALE IN MILES
0 1 2 3 4

FIGURE 32


FAULTING AT REELFOOT LAKE

DISPLACEMENT OF MISSISSIPPI RIVER MEANDER SCARS PERMITS DATING OF FAULT MOVEMENT AS SUBSEQUENT TO 1500 A.D. SEQUENCE OF RECONSTRUCTED MEANDER SCARS IS INDICATED BY 1 (OLDEST) TO 15. MAPPED COURSES SHOWN BY DATES.

FIGURE 33




**LOWER ST. FRANCIS SEGMENT MISSISSIPPI RIVER MEANDER BELT – STAGES 1 & 2**
LITTLE RIVER SEGMENT MISSISSIPPI RIVER STAGES C2-J – FIFTEENMILE BAYOU DIVERSION CHANNEL STAGES 6-9

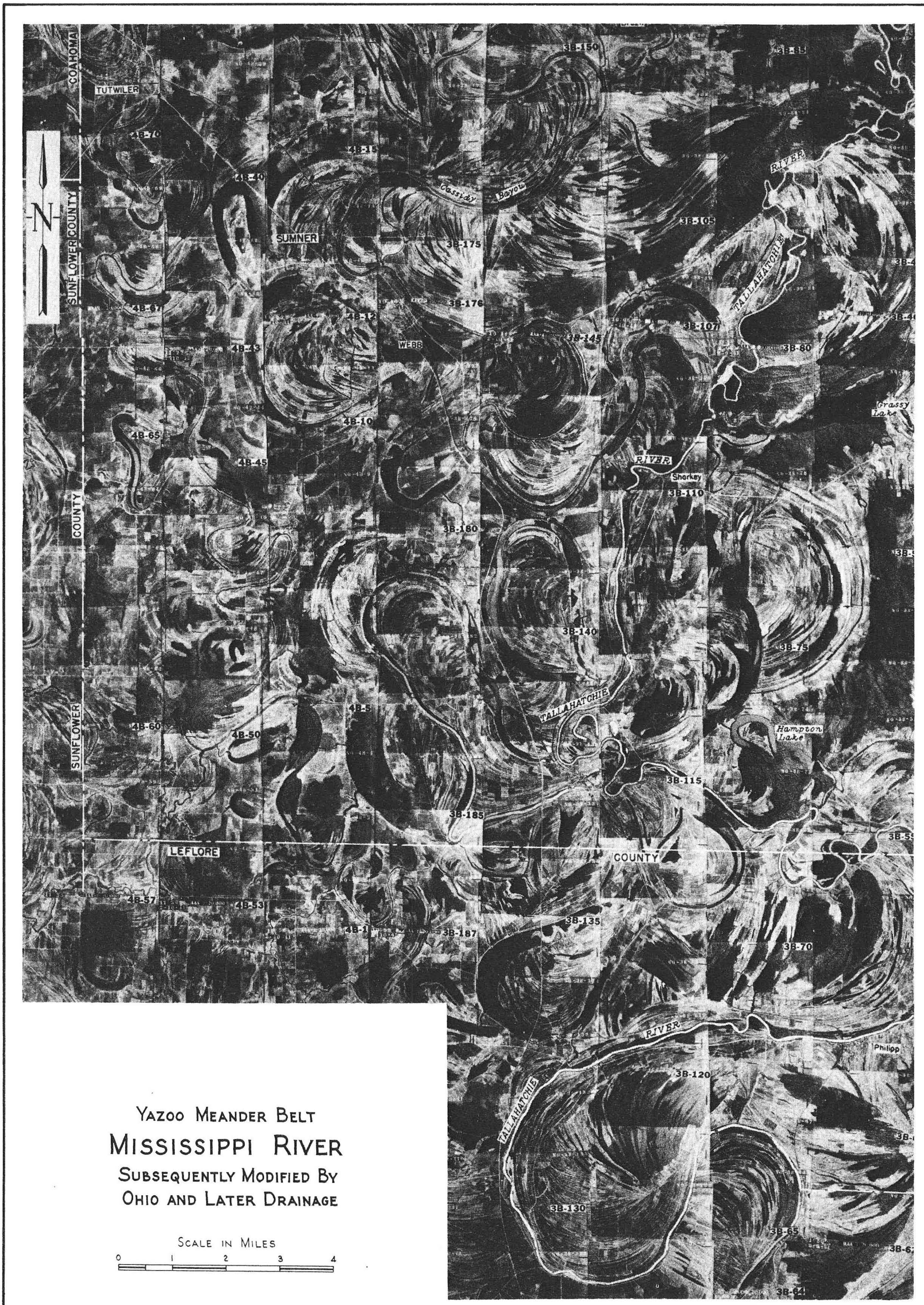

YAZOO MEANDER BELT
MISSISSIPPI RIVER
SUBSEQUENTLY MODIFIED BY
OHIO AND LATER DRAINAGE
SCALE IN MILES
0 1 2 3 4
N
COAHOMA
TUTWILER
SUNFLOWER COUNTY
SUMNER
WEBB
Cassidy Bayou
TALLAHATCHIE
RIVER
Sharkey
Grassy Lake
Hampton Lake
SUNFLOWER
COUNTY
LEFLORE
COUNTY
Philipp
3B-150
3B-175
3B-176
3B-145
3B-105
3B-107
3B-80
3B-110
3B-180
3B-140
3B-75
3B-115
3B-185
3B-135
3B-187
3B-70
3B-120
3B-130
3B-65
4B-70
4B-15
4B-40
4B-67
4B-12
4B-43
4B-10
4B-65
4B-45
4B-60
4B-50
4B-57
4B-53

FIGURE 35

Island, an upland remnant, lies at its southern tip. The fan is separated from the Mississippi River floodplain by the eastern escarpment of Macon Ridge, which extends from Sicily Island northward to Eudora, Ark. North of Eudora, the edge of the Arkansas alluvial fan corresponds to the western edge of the Mississippi meander belt as far as the mouth of the Arkansas River.

The eastern bluffs of the central division are similar to those of the northern division and rise 100 to 150 ft. above the floodplain. They are slightly scalloped by the activity of the Mississippi River in places, but most of the segments of the bluff line are straight, reflecting their structural origin. There is no continuous alluvial apron along the foot of the bluffs, but many small streams entering from the east have low alluvial fans. The surfaces of these fans form a belt of fertile farm land along the eastern margin of the valley.

The western escarpment of the valley in the central division is generally far less precipitous than the eastern one. Much of the area rimming the west side of the valley is a low Pleistocene terrace which rises slightly more than 40 ft. above the floodplain level. The only higher bluffs are found north of Pine Bluff, Ark., and near Sicily Island, La.

### The Yazoo Basin

The Yazoo Basin extends for 200 miles from Memphis to Vicksburg; it is 60 miles wide opposite Arkansas City, Ark., from which point it narrows to north and south. The Yazoo Basin is divided into smaller basins by a number of low meander belt ridges. These ridges are from east to west, the abandoned Yazoo meander belt of the Mississippi and Ohio rivers, the abandoned Sunflower meander belt of the Mississippi River, and the Deer Creek meander belt. The basin between the Yazoo and the Sunflower meander belts is drained by the Quiver River, that between the Sunflower meander belt and Deer Creek by Bogue Phalia, and that west of Deer Creek by Steele Bayou. The Tallahatchie Basin lies between the Yazoo meander belt and the eastern valley wall. It is drained by the Tallahatchie River and Tippo Bayou.

**The Yazoo Meander Belt Ridges.** The Yazoo meander belt is a complex group of minor ridges and basins. At its northern end it is composed of two ridges which converge near Tutwiler, Miss., and define a slightly lower area east of Dundee, Miss., drained by the headwaters of the Yazoo River. South of Tutwiler the meander belt ridge again divides, and the short Bear Creek segment leaves the main Yazoo meander belt near Schlater, Miss., and rejoins it some 45 miles farther south near Belzoni, Miss. The two meander belt ridges in this section are so close together that there is no well-defined intervening lowland.

The Yazoo meander belt has been occupied in successive periods by the combined Mississippi-Ohio River which left large scars between Tutwiler and Tchula, Miss.; by the full flow of the Ohio River as shown by smaller scars between Memphis and Tutwiler; and by only part of the Ohio River flow as indicated by smaller scars between Coahoma and Vicksburg, Miss. The flow of eastern marginal streams, such as the Coldwater, Tallahatchie, and Yalobusha rivers, has modified these older scars. A portion of the meander belt is shown on figure 35.

The Bear Creek meander belt segment cuts across scars of the combined Mississippi-Ohio River and is cut by the youngest Ohio scars. The size of its meanders indicates that it was formed by the Ohio River.

**The Tallahatchie Basin.** Faint traces of the braided drainage of the Ohio alluvial fan can be discerned in the lowlands of the Tallahatchie Basin although they are partially mantled by deposits of the Tallahatchie, Yocona, and Yalobusha alluvial fans. The basin also includes a low, 3-mile wide, meander belt ridge between Crenshaw and Marks, Miss., the South Lake meander belt. The scars of the South Lake meander belt are truncated by the Yazoo-Ohio system scars north of Tutwiler and hence are dated as older than the Yazoo meander belt. This meander belt was formed by a stream which carried all the eastern drainage of the valley at a time when the Ohio River flowed along the eastern side of Crowleys Ridge.

**The Quiver River Lowland.** The lowland between the Yazoo and Sunflower meander belts is mainly a backswamp area. The only features which interrupt the nearly level backswamp surface are the narrow meander belts now occupied by a minor floodplain stream known as Quiver River. This meander belt is a southwest continuation of the South Lake meander belt.

**The Sunflower Meander Belt Ridge.** The abandoned Mississippi River Sunflower meander belt bisects the Yazoo Basin and extends as a 10-mile wide low ridge for 120 miles south from the Mississippi River near Helena to its junction with the Yazoo meander belt near the eastern valley wall near Yazoo City, Miss. This meander belt (figure 36 and plate 15) is comparable in size and complexity to that of the present Mississippi River. The height of the ridge decreases southward and in the southern part of the Yazoo Basin it lies close to backswamp level.

The Sunflower meander belt takes its name from the Sunflower River, the largest stream in the area today. The Sunflower, however, nowhere follows the last channel position of the Mississippi River for more than 20 miles, and it occupies only 42 of the 315 miles of abandoned Mississippi River channel mapped in this area. The rest of the channel is followed by over 60 other streams of various sizes.

**The Bogue Phalia Basin.** The principal stream between the Sunflower meander belt and the present Mississippi River is Bogue Phalia. This stream drains the area which has a network of channels determined by the braided topography of part of the old Mississippi alluvial fan (plate 15). Bogue Phalia is a true floodplain stream and follows a succession of topographic lows related to older stream courses.

**The Deer Creek Meander Belt Ridge.** Deer Creek (figure 37) is unique in the Mississippi Valley. It has angular bends and a deep, narrow channel, but its natural levees are almost as wide and high as those of the Mississippi River. Deer Creek was a long-lived crevasse stream or distributary which carried Mississippi floodwaters long enough to build up its own meander belt. The angularity of its meanders apparently is the result of scouring action limited to high water when the attack was directed toward the lower end of each bend. Deer Creek first functioned as a crevasse channel very early in the history of the present meander belt. It carried floodwaters from the Mound Crevasse opposite Arkansas City, Ark., as recently as 1927.

The Deer Creek meander belt forms a ridge which occupies the approximate center of a larger basin area located over the axis of the Mississippi Structural Trough. Backswamps of this basin comprise the main backwater area of the Yazoo Basin. They bear faint traces of several pre-Sunflower meander belts (plate 15).

### The Tensas Basin

The Tensas Basin is an extensive lowland area lying west of the Mississippi River between the latitude of Eudora, Ark., and the mouth of Old River, near Angola, La. It lies east of Macon Ridge and east of the western uplands between Sicily Island and Marksville, La. It is north of the alluvial ridge which marks the northern limit of the deltaic plain. The Tensas Basin varies in width between 25 and 45 miles from the latitude of Vicksburg to its southern boundary. North of the latitude of Vicksburg the basin narrows to near Eudora, where the Mississippi meander belt nearly touches the northern end of Macon Ridge. The basin is slightly constricted to a width of 25 miles between Natchez and Sicily Island and widens to 45 miles in the latitude of Acme.

The part of the lowland lying south of the constriction between Natchez and Sicily Island is termed the lower Tensas Basin. This widest part of the basin is periodically flooded by backwater from the Red and Mississippi rivers. The upper Tensas Basin is less completely flooded.

Stream networks which drain the lowland or distribute floodwaters, depending on the stage of the master stream, include both through-flowing streams and streams which start on the floodplain. The Red River crosses the southern part of the lower Tensas Basin from Moncla, La., to its junction with Old River near Red River Landing. The Red follows in part old channels established by the Mississippi River and is joined at Acme by Black River which also follows an abandoned Mississippi channel. The Black River is formed by the junction of the Ouachita and Tensas rivers 60 miles north of Acme.

The major tributary of the Tensas River in the upper Tensas Basin is Bayou Macon which drains the area west of the Tensas. A plexus of bayous, some of which follow abandoned Mississippi channels, drains the area east of the Tensas.

The lower Tensas Basin west of Black River is drained by a complicated network of streams which follow abandoned meandering channels of the Arkansas River and old braided channels of the Mississippi River. This network is connected with the Red River by Saline Bayou. East of Black River another network drains into Bayou Cocodrie which follows abandoned meander channels of the Mississippi River. The lowland south of Red River, called the upper Atchafalaya Basin, is drained by a swamp network which flows into Bayou Natchitoches and the Red River.

The principal features of the Tensas Basin are the low meander belt ridges which separate the lowland into a series of basins. The Walnut Bayou meander belt ridge separates the Catahoula Lake Basin from the Dismal Swamp Lowland in the lower Tensas Basin. The swamps of the upper Tensas Basin are crossed by the upper Tensas and Bayou Macon meander belt ridges which delimit minor unnamed lowlands. The low Cocodrie meander belt ridge lies at the north end of the Dismal Swamp Lowland between the Walnut Bayou meander belt and the meander belt of the present Mississippi River.

**The Walnut Bayou Meander Belt Ridge.** The Walnut Bayou meander belt ridge[1] merges with the present meander belt of the Mississippi River at both its upper and lower ends. It extends for over 100 miles in Louisiana from Tallulah to near the mouth of Red River. The meander belt receives its name from Walnut Bayou (figure 38), a small stream which occupies a portion of the last channel position east of Tallulah. The general continuity of the last channel position of the Mississippi is traceable except near St. Joseph, La., where it is cut out by the present Mississippi River meander belt. At the southern end of the Walnut Bayou meander belt the Mississippi channel was occupied and much modified by the Black, Tensas, Red, and Atchafalaya rivers. The lower portion of the Mississippi channel, now occupied by Bayou Des Glaises, is the southern boundary of the central division (figure 39 and plate 1).

In its southern portion, the Walnut Bayou meander belt ridge is separated from the present Mississippi River by a lowland occupied by the Cocodrie meander belt and Dismal Swamp. Cut-off meanders along the Walnut Bayou meander belt retain characteristics exhibited by cut-off channels along the present river. The last channel of the Walnut Bayou meander belt, in contrast to the cut-offs, has lost many of its original characteristics through occupation by smaller streams. Reworking of point bar deposits by these later streams, shifting of their courses into the shorter chute channels, and a general change in channel alinement has resulted.

**The Cocodrie Meander Belt Ridge.** The Cocodrie meander belt ridge[2] lies between the Walnut Bayou and the present Mississippi River meander belt. It receives its name from Bayou Cocodrie, a small floodplain tributary of the Red River. Accumulation of backswamp clay in the lower Tensas Basin has been sufficient to largely bury the Cocodrie meander belt ridge, and only crests of natural levees rise above swamp level (figure 18). The continuity of the meander belt is evident more from the control which it exerts on the drainage pattern than from its topographic expression as a ridge.

**The Dismal Swamp Lowland.** The lowland between Walnut Bayou and the present Mississippi River meander belt south of the Cocodrie meander belt is herein designated the Dismal Swamp Lowland after its greatest feature, Dismal Swamp. It is crossed by the present course of the lower Red River below the mouth of Black River and by traces of an unnamed pre-Cocodrie meander belt. Neither the Red River levees nor those of the older Mississippi meander belt rise appreciably above swamp levels. A series of shallow lakes of very irregular outline fill parts of the lowland.

**The Catahoula Lake Basin.** The Catahoula Lake Basin lies south of Sicily Island between the Walnut Bayou meander belt and the western valley wall. It takes its name from the ephemeral Catahoula Lake

[1] The position of the Walnut Bayou meander belt now occupied by the Black and Tensas rivers has long been recognized as an old Mississippi course but has usually been correlated with the upper Tensas meander belt. Cross-cutting relations of old channel scars clearly date the upper Tensas as an older system.

[2] The Cocodrie meander belt was previously mapped with a slightly different continuity by the writer (Fisk, H. N., "Geology of Avoyelles and Rapides Parishes, Louisiana," Louisiana Dept. Cons., Geol. Bull. No. 18, p. 27, 1940).


BOBO
N
FINAL COURSE STAGE D
Note Older Meander Scars
BIG SUNFLOWER RIVER
ABANDONED
SUNFLOWER MEANDER BELT
OF THE
MISSISSIPPI RIVER
STAGE D
0
1/2
1 MILE

FIGURE 36


N
SUNFLOWER
RIVER
BELT
Nitta Yuma
MEANDER
Creek
Anguilla
Sunflower
MEANDER
BELT
ROLLING FORK
CREEK
Deer
BIG
SWAMP
DEER
BACK
DEER CREEK MEANDER BELT
IN THE
LOWER YAZOO BASIN
SCALE IN MILES
0 1 2 3 4

FIGURE 37

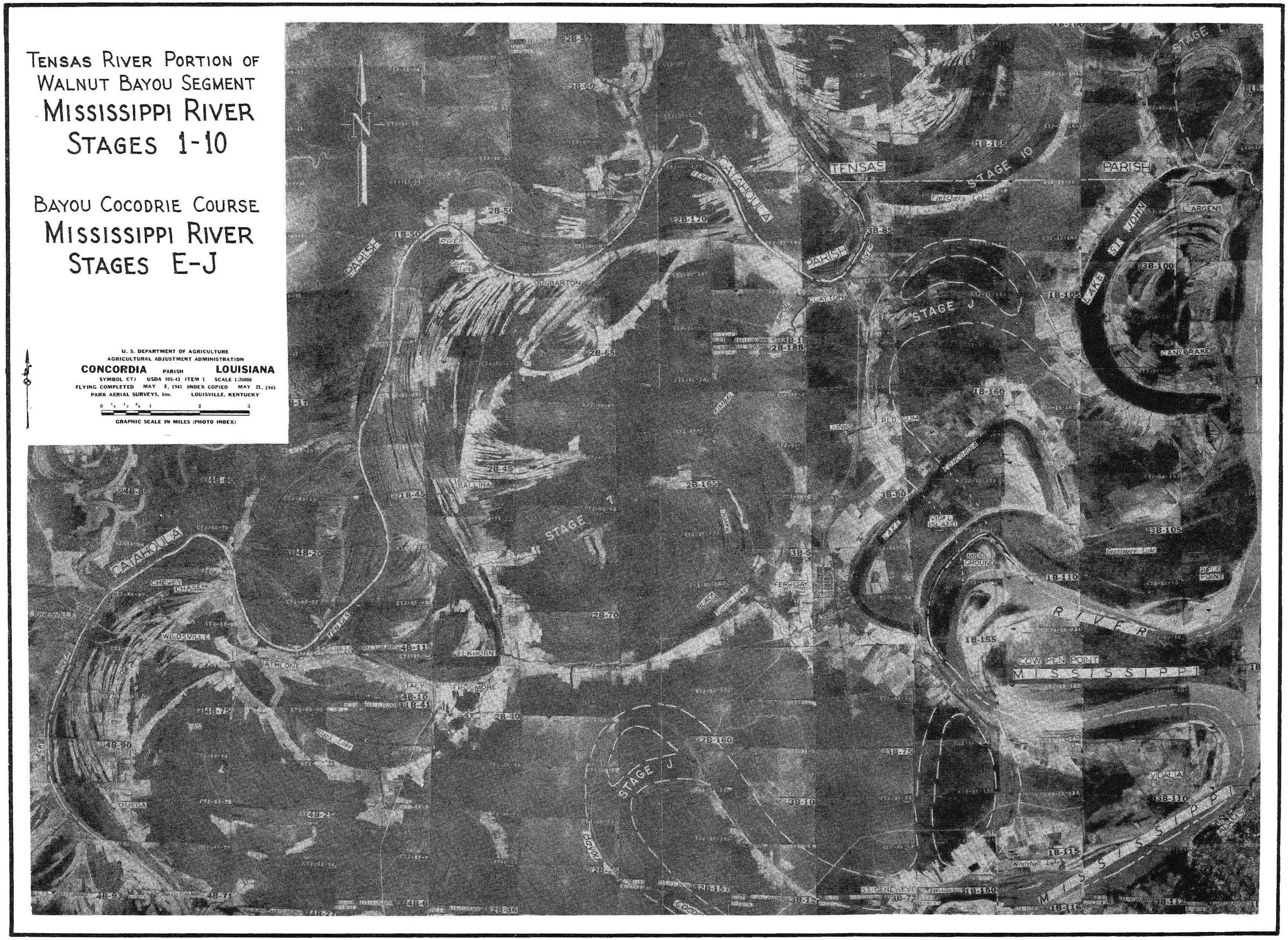

TENSAS RIVER PORTION OF
WALNUT BAYOU SEGMENT
MISSISSIPPI RIVER
STAGES 1-10
BAYOU COCODRIE COURSE
MISSISSIPPI RIVER
STAGES E-J
U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL ADJUSTMENT ADMINISTRATION
CONCORDIA PARISH LOUISIANA
SYMBOL CTJ USDA 905-41 ITEM 1 SCALE 1:20000
FLYING COMPLETED MAY 8, 1941 INDEX COPIED MAY 21, 1941
PARK AERIAL SURVEYS, Inc. LOUISVILLE, KENTUCKY
GRAPHIC SCALE IN MILES (PHOTO INDEX)
N
TENSAS
PARISH
CATAHOULA
STAGE 10
STAGE J
STAGE 7
LAKE ST. JOHN
CANEBRAKE
CLAYTON
DUNBARTON
BALLINA
FERRIDAY
ELKHORN
FROGMORE
ATHLONE
WILDSVILLE
CHEVEY CHASE
JONESVILLE
COW PEN POINT
MISSISSIPPI
RIVER
VIDALIA
ST. GENEVIEVE

FIGURE 38

FIGURE 39


MONCLA
MONCLA GAP
PARISH
RIVER
RED
MARKSVILLE
TECHE MEANDER BELT
COCODRIE MEANDER BELT
WALNUT BAYOU MEANDER BELT
MARKSVILLE HILLS
MANSURA
RAPIDES
RED
RIVER
Bayou
Boeuf
ALLUVIAL
PLAIN
PARISH
BUNKIE
Lake Pearl
RIDGE
HUFFPOWER
EVERGREEN GAP
EVERGREEN ISLAND
BAYOU
DES
GLAISES
SIMMESPORT
RIVER
ATCHAFALAYA
PARISH
COUPEE
TECHE MEANDER BELT
GUM RIDGE
RIDGE
Features of the Mississippi and Red River Alluvial Plains near the Marksville Hills
Scale in Miles
0 1 2 3 4

near the westernmost point of the western valley wall at the mouth of Little River. During high water, the lake is about 12 miles long and 3 to 4 miles wide; at low water, it largely dries up and its bottom is pastured. Catahoula Lake has been shut off from active Mississippi River sedimentation since the abandonment of the Walnut Bayou meander belt by the river and now receives only backwater floods. Strand line beaches marking various levels are characteristic of the slopes which lead to the flat lake bottom. They result from the considerable wave action developed in such a large lake.

The only important perennial tributary of Catahoula Lake is Little River which drains much of central Louisiana east of Red River and has built an extensive delta into the lake. The surface of the delta reaches the general high-water lake level but has extensions at levels corresponding to low-water stages.

Saline Bayou and French Fork of Little River also connect with Catahoula Lake. The direction of flow is these two streams depends upon the relative stage of the lake, and of the Red and Black rivers. When the rivers are high; the lake fills; when they are low, the flow is reversed, and they drain the lake basin. French Fork of Little River has a fairly straight channel with wide natural levees and a plexus of distributary channels. The levees gradually decrease in height from the Ouachita River toward Catahoula Lake, indicating that they were formed while the stream was acting as a distributary for waters from the east. The channel of Little River connects with French Fork of Little River by a meandering channel which crosses the lake bottom.

The French Fork of Little River flows between two of the series of three partially buried meander belt ridges constructed by the Arkansas River. The meander belts are locally obscured by the French Fork natural levees, and their continuity is recognizable mainly from soils and drainage patterns. The third Arkansas meander belt is traced through the swamps south of French Fork. All three meander belts turn southward in the latitude of Archie, La., and have been traced to the Red River at the south end of the Catahoula Lake Basin.

The drainage of the western and northern parts of Catahoula Lake Basin is controlled by abandoned braided channels of the Mississippi River. These channels are followed by streams in the swamps of the Bushley Creek drainage near Rhinehart, La., and in the area west of Muddy Bayou south of Catahoula Lake.

**Catahoula Lake Fault Zone.** Catahoula Lake occupies a graben bounded by faults of the Catahoula Lake fault zone. Surface displacement of 5 to 10 ft. occurs where some of the faults of this zone cross the dissected surface of the Arkansas alluvial fan south of the town of Sicily Island. The graben-like character of the Catahoula Lake depression is illustrated on the structure section of plate 4.

**The Upper Tensas Meander Belt Ridge.** The upper Tensas meander belt ridge extends southward from near Alsatia, La., for 40 miles to the latitude of Newellton, La. The meander belt ridge is low and rises only 5 to 10 ft. above the adjacent backswamps. It holds traces of a meandering stream comparable in size to the upper Mississippi.

The meander belt is followed by several streams, the most important of which is the upper part of the Tensas River. It extends southward for 50 miles from Alsatia to Newlight, La., where it is intersected by the Walnut Bayou meander belt.

**The Bayou Macon Meander Belt Ridge.** A segment of an abandoned meander belt of the Arkansas River follows the lowland at the foot of Macon Ridge for 70 miles from Lake Providence, La., to near Tensas Lake in the latitude of Sicily Island. The low alluvial ridge averages 3 miles in width and holds meander loops slightly larger than those normally found in Arkansas River meander belts. It is possible that during their formation the Arkansas River flow was augmented by that of the White River.

Bayou Macon enters the meander belt at Delhi, La., midway between Lake Providence and the southern end of the belt. North of Delhi the meander belt is followed by Joes Bayou.

**Swamps of the Upper Tensas Basin.** Small swamps flank the upper Tensas and Bayou Macon meander belt ridges. Their drainage is controlled by the abandoned braided channels of the Mississippi River which cover them. Bayou Macon follows a system of these braided channels scars north of its junction with Joes Bayou.

### The Arkansas Alluvial Fan

The Arkansas alluvial fan is a belt of Arkansas River sediments, 20 to 40 miles wide, extending in a great arc for over 200 miles along the western valley wall between Little Rock, Ark., and Sicily Island. The entire surface of the fan is covered with a network of abandoned Arkansas River courses, both meander belts and braided channels, which radiate away from the apex of the fan at Little Rock. These old drainage lines are reflected in the existing drainage and topography of the area. The fan properly includes the flood basin of the Arkansas River south of Little Rock and floodplains of minor streams which merge with the Mississippi River floodplain. The dissected alluvial plains, Grand Prairie Ridge and Macon Ridge, are older and higher parts of the fan.

#### *Upland Remnants*

Within the limits of the Arkansas alluvial fan are incorporated upland remnants, Sicily Island, isolated islands on the crest of Macon Ridge, and the Bastrop Hills.

**Sicily Island.** Sicily Island is an island-like outcrop of Tertiary beds mantled with Quaternary deposits entirely surrounded by the floodplain. The island is located between Harrisonburg and the town of Sicily Island, La., and is separated from the western valley wall by the 1.5-mile wide floodplain of the Ouachita River. It rises 200 ft. above the floodplain.

Sicily Island is roughly equidimensional and nearly five miles in diameter. The highest parts of the island are near its northern edge. Most of the drainage is toward Big Creek which flows westward into the Ouachita River; a very minor amount flows down the south and northwest slopes. Veatch[1] pointed out from drainage studies that Sicily Island was not separated from the western uplands until early Quaternary time.

[1] Veatch, A. C., "Geology and Underground Water Resources of Northern Louisiana," Louisiana Geol. Survey Bull. No. 4, pp. 52-56, 1905.

**Macon Ridge Islands.** A few small and irregular areas of late Pleistocene deposits rise above the general level of Macon Ridge which is primarily a part of the alluvial fan of the Arkansas River (plate 1). The several Pleistocene remnants are alined in a southwesterly direction between Eudora, Ark., and Bakers, La. (plate 2). The "islands" vary in length up to 18 miles and in width from 0.5 to 2.5 miles, and stand from 10 to 20 ft. above the surrounding surface from which they are separated by poorly defined escarpments.

The Pleistocene remnants occupy the crest of the divide between the Arkansas and Mississippi trenches. The Bastrop-Yazoo City transvalley cross section (plate 5-A) crosses one of the "islands" at Oak Grove and shows the character of the upland surface and of the underlying Pleistocene deposits.

**The Bastrop Hills.** The Bastrop Hills are located near the western valley wall from which they are separated by the gap occupied by Bayou Bartholomew and the Ouachita River. The abrupt eastern escarpment of the Bastrop Hills rises as much as 70 ft. above the neighboring floodplain. The hills are 17 miles in length and a little over 5 miles wide at their widest part. They slope westward toward Bayou Bartholomew and the Ouachita River, and most of the streams head near the eastern escarpment and flow west.

Most of the northern portion of the Bastrop Hills consists of late Pleistocene deposits of the Prairie formation. The profile of the hills and the nature of the underlying deposits are shown on plate 5. The southern portion of the hills is a lower Recent terrace developed from deposits of the alluvial fan of the Ouachita River (plate 15). This terrace has been referred to as the "Flatwoods Terrace" by Fergus,[1] who considers it to be of Pleistocene age.

*Divisions of the Arkansas Alluvial Fan*

**The Grand Prairie Ridge.** The Grand Prairie Ridge is the northernmost part of the Arkansas alluvial fan. The ridge starts at the valley wall northeast of Little Rock, Ark., and trends southeast for 72 miles to the Arkansas River at Arkansas Post, Ark. It averages 15 miles in width but narrows toward the southern end. Its northern edge, the boundary between the northern and central divisions, is an escarpment which has been scalloped by the Little Red and White rivers and rises from 20 to 30 ft. above the floodplain of these streams. A western escarpment separates Grand Prairie Ridge from the Arkansas River Lowland. It is both lower and less clearly defined than the eastern escarpment along the White River Lowland. The western escarpment is in places scalloped by the Arkansas River, but elsewhere it is straight as a result of faulting which has cut across meander scars.

The surface of the ridge is drained by a series of dendritic branchworks, the positions of which were determined by the initial depositional irregularities of the fan surface, and by a system of faults which break the surface into rectangular tilted blocks.

The eastern part of Grand Prairie Ridge bears traces of old braided channel scars of the Mississippi River and is mapped as part of the Mississippi alluvial fan (plate 2).

Grand Prairie Ridge is shown on the geologic map of Arkansas (1939) as being underlain by Pleistocene deposits. Detailed logs of borings (shown on plate 6) clearly indicate that these sediments constitute a part of the Recent alluvium filling the entrenched valley system.

**The Arkansas River Lowland.** The lowland of the Arkansas River is bounded on the north by the Grand Prairie Ridge and on the south by the Arkansas River. It reaches a maximum width of 20 miles and extends from Little Rock to Arkansas Post, a distance of 72 miles. A series of nearly parallel meander belt ridges radiate from the mouth of the narrow upland valley at Little Rock (figure 40) to cross the lowland. Each of the abandoned meander belts has been slightly obscured by subsequent activities of minor streams.

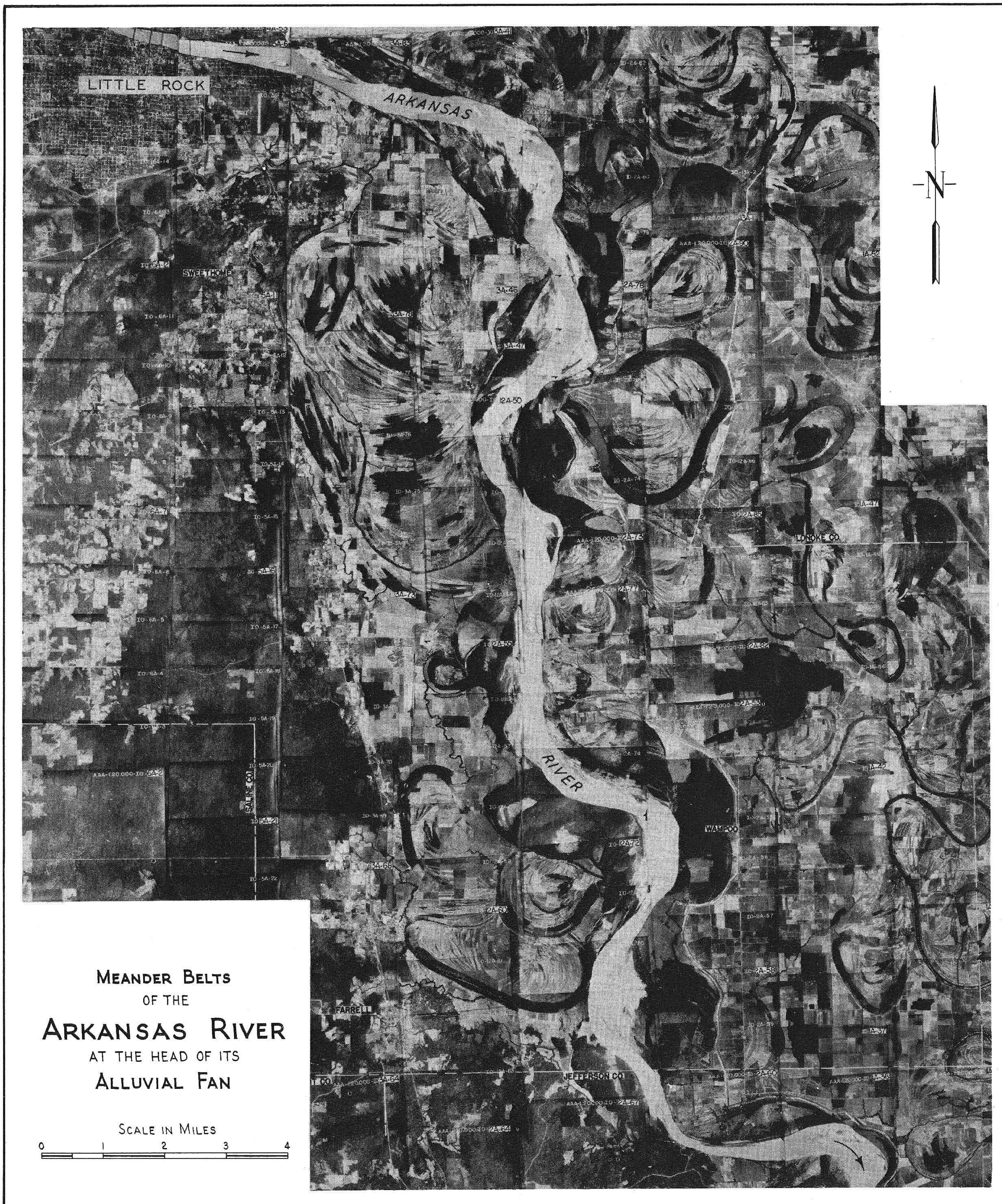
Several older meander belts exhibit less pronounced topographic expression. These include the belts followed by Cypress Creek and Oak Log Bayou south of the Arkansas River; that followed by Crooked Slough east of Lake Village, Ark.; that followed by Bayou Lafourche east of the northern end of Macon Ridge; and the belts followed by various streams just east of the Bastrop Hills in Louisiana. Many other traces of braided channels of the Arkansas River are also preserved at floodplain level in the Boeuf Basin. The largest area showing the braided pattern lies between the Bastrop Hills and Rayville, La.

**The Boeuf Basin.** The Boeuf Basin which lies south of the Arkansas River Lowland is bounded on the west by the valley wall from Pine Bluff, Ark., to the Bastrop Hills in Louisiana. The eastern boundary is marked by the Mississippi River from the mouth of the Arkansas River to the north end of Macon Ridge and extends southward along the western edge of the ridge to Sicily Island. The basin is connected with the Ouachita Lowland through the Bayou Bartholomew Gap and merges with it at its southern end. It connects with the upper Tensas Basin by the narrow lowland which lies between the north end of Macon Ridge and the Mississippi River and is occupied by Bayou Macon.

Numerous meander belts abandoned by the Arkansas River are observable in the Boeuf Basin. A recently abandoned one, Bayou Bartholomew Ridge, can be traced near the basin's western margin for more than 100 miles from Pine Bluff to the gap west of the Bastrop Hills through which it enters the Ouachita Lowland. It has been modified by Bayou Bartholomew which now follows it. About 10 miles to the east is the Choctaw meander belt which parallels the Bayou Bartholomew meander belt for 35 miles before bifurcating 5 miles south of Dumas, Ark. Its younger branch trends east to the Mississippi River and is followed by Amos Bayou; the older branch is followed southeastward by Bayou Macon to near Eudora, Ark. Another Arkansas meander belt ridge can be traced southward for 130 miles from near Dermott, Ark., to the gap west of Sicily Island (figure 25). No important streams occupy its northern portion, but it is followed by Bayou Bonne Idee from Bonita, La., to the Boeuf River which occupies the lower 50 miles of the belt. This Bayou Bonne Idee meander belt and the younger Bartholomew meander belt merge near Dermott.

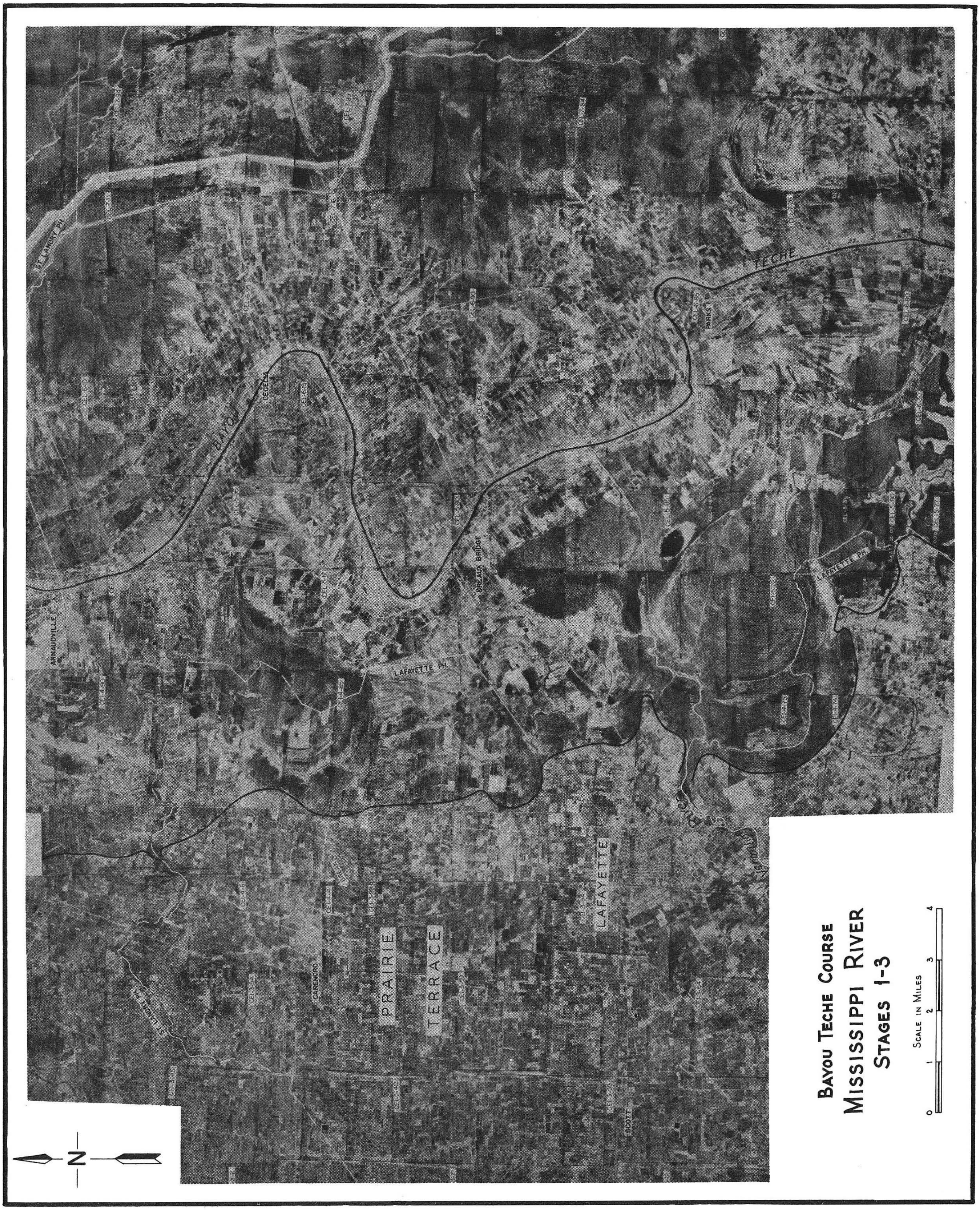
**Macon Ridge.** The dissected alluvial plain of the Arkansas alluvial fan surrounds the Pleistocene "islands" and forms the greater part of Macon Ridge. It extends from Eudora, Ark., 100 miles south to the town of Sicily Island and reaches a width of approximately 25 miles near the latitude of Winnsboro, La.

[1] Fergus, P., "Monroe Gas Field, Louisiana," Geol. of Natural Gas, Amer. Assoc. Petrol. Geologists, p. 746, 1935.



LITTLE ROCK
ARKANSAS
RIVER
SWEETHOME
WAMPOO
LONOKE CO.
SALINE CO.
JEFFERSON CO.
FARRELL
N
Meander Belts
of the
Arkansas River
at the Head of its
Alluvial Fan
Scale in Miles
0
1
2
3
4


FIGURE 40



Bayou Teche Course
Mississippi River
Stages 1-3
Scale in Miles
0
1
2
3
4
N
Bayou
Teche
St. Landry Ph.
Lafayette Ph.
Arnaudville
Breaux Bridge
Parks
Cecelia
Carencro
Prairie
Terrace
Lafayette
Scott


FIGURE 41

Its eastern margin is fairly straight and abrupt, and rises 20 ft. above the neighboring Tensas Basin on the east. Its western margin is poorly defined and merges with the Boeuf Lowland.

The surface of the dissected alluvial plain descends by a series of step-like escarpments to the general level of the Boeuf Basin. The escarpments separate low terrace surfaces upon which are preserved traces of braided drainage of the Arkansas River (plate 15). The step-like nature of the surfaces is shown on the profiles (figure 28), and the braided stream pattern is shown on the photograph (figure 25).

## THE SOUTHERN DIVISION

The deltaic plain, formed as the Mississippi River shifted its delta positions, extends from the head of the Atchafalaya River to the coast and is limited on the east by the mouth of Pearl River and on the west by the mouth of Vermilion River. The marginal escarpments of the central division continue to the south but gradually decrease in height with the elevation of the uplands. The eastern upland surface slopes beneath the Recent alluvium of the coastal marshes in the latitude of Donaldsonville, La. The western upland surface slopes beneath marsh level at Franklin, La.

### The Lower Red River Alluvial Plain

The lower Red River alluvial plain lies wholly in Louisiana and merges with the northwest part of the deltaic plain. It is considered in this section of the report because abandoned Red River courses, leading from the Red River floodplain, follow and intertwine with old Mississippi River channels in the deltaic plain. This plain extends for 50 miles southwestward from Alexandria. Throughout this distance it maintains an average width of 8 to 10 miles. The present Red River meander belt follows the eastern wall of its valley for 20 miles below Alexandria and then turns abruptly to the northeast, leaving the alluvial plain through a narrow gap in the uplands at Moncla. South of this gap, the divide between the Mississippi and Red River valleys consists of a series of low remnants of the late Pleistocene Prairie terrace. The principal terrace outliers are the Avoyelles or Marksville Hills to the north, and the smaller Evergreen Island and Gum Ridge to the south (plate 15). The gaps between the outliers of the terraces connect the Red and Mississippi floodplains.

South of the present course an abandoned Red River meander belt, Huffpower Ridge, is followed by Bayous Robert, Huffpower, and Rouge from Alexandria through Evergreen Gap which lies between the Marksville Hills and Evergreen Island (figure 39). A lowland lying between this meander belt ridge and the Red River is occupied by Chatlin Lake and carries traces of older meander scars of the Red River. South of Huffpower Ridge are a number of other low Red River meander belt ridges occupied by Bayous Boeuf, Wauksha, Petite Prairie, Cocodrie and Mariecroquant. These meander belts were formed by the Red River at a time when it flowed directly to the deltaic plain of the Mississippi River.

### The Deltaic Plain

The deltaic plain of the Mississippi River lies wholly in Louisiana and includes three types of land: natural levee ridges which are slightly raised above surrounding levels, forested swamps, and the coastal marshes whose vegetation is chiefly sedges and grasses. The main natural levee ridges include the ones along the present Mississippi River, Teche Ridge, Lafourche Ridge, and the Atchafalaya Ridge. They divide the deltaic plain into a number of lowlands, the more important of which are the Atchafalaya Basin, Lake Pontchartrain Basin, Lake Borgne Depression, and the Barataria Depression. Shore features, such as cheniers, off-shore bars and round lakes, are best developed along the Louisiana coastwise plain in Cameron and Vermilion parishes to the west and along the Mississippi coast to the east of the deltaic plain. A few cheniers occur in the deltaic plain, and off-shore bars are well developed in the 60-mile arc of the Chandeleur Islands southeast of the deltaic plain.

#### *The Alluvial Ridges of the Deltaic Plain*

Some of the alluvial ridges of the deltaic plain were formed as meander belt ridges, other as levee ridges along important distributary channels.

**Teche Ridge.** The Teche Ridge is a well-defined abandoned meander belt ridge of the Mississippi River.[1] It can be traced southward from Marksville, where it branches from the Walnut Bayou meander belt, to the head of the Teche Delta at Houma. It is named for Bayou Teche which occupies it from Opelousas to Morgan City.

The part of the ridge followed by Bayou Teche was initially developed as a Mississippi River meander belt, but subsequent to its abandonment by the Mississippi River it was followed by the Red River. Two sets of natural levees flank Bayou Teche: the outer, broad, and gently sloping set formed by the Mississippi River has characteristic black and gray soils; and the inner, narrower, and steeper set formed by the Red River has red and brown soils.

The Teche meander belt is flanked by many old Mississippi cut-off meanders (figure 41) which are similar to those flanking the present Mississippi River. Although the continuity of the final Teche-Mississippi channel is interrupted in many places, the meander belt can be traced by means of the cut-off loops.

Bayou Courtableau and the Bayou Petite Prairie, which follow old Red River courses, break across the Teche Ridge at Port Barre and Palmetto, respectively, and flow into the Atchafalaya Basin. The ridge has been breached at Morgan City where the ponded waters of the Atchafalaya Basin spill southward through Berwick Bay into the lower Atchafalaya River.

[1] Darby, W., "A Geographical Description of the State of Louisiana," Philadelphia, John Melis, 1816. (Darby was apparently the first to recognize the Mississippi origin of the Bayou Teche course.)

The uppermost portion of the Teche meander belt is followed by Bayou Avoyelles and Old Red River near Marksville. It is obscured by the natural levees of the Huffpower meander belt ridge, but south of Cottonport, the continuity of the last channel is by way of Bayou Chopique, Bayou Jack, Bayou Rouge, Bayou Negro Foot, Bayou Wauksha, and by Bayou Courtableau to Bayou Teche.

**The Atchafalaya Ridge.** The natural levee of the Atchafalaya River, the most important distributary of the Mississippi River, bisects the upper end of the Atchafalaya Basin. This ridge is broadest and stands highest above the neighboring basins at its northern end. It tapers to the south and loses its significance at Krotz Springs near the center of the basin. South of Krotz Springs, the Atchafalaya River divides, and levees of the various branches become of decreasing importance as the river loses its identity in the swamp network.

**The Grosse Tete Ridge.** An alluvial ridge comparable in importance to that of the Atchafalaya Ridge lies along Bayous Grosse Tete and Fordoche. The size of the natural levees which make up the ridge indicates that it was formed by a major Mississippi distributary. The levees decrease in importance downstream and disappear near the junction of Bayou Grosse Tete and Bayou Plaquemine.

**The Lafourche Ridge.** The Lafourche Ridge extends from Donaldsonville to the head of the Lafourche Delta at Thibodaux and is made up of two parts. The inner narrow ridge about 15 ft. high represents the natural levees of Bayou Lafourche when it was an active distributary of the Mississippi River. Flanking the inner levees are the lower and wider levees built by the Mississippi River when it occupied the Lafourche meander belt.

*The Basins of the Deltaic Plain*

The basins of the deltaic plain lie between the low alluvial ridges. The Atchafalaya Basin and the Lake Pontchartrain Basin are inclosed by ridges; the Barataria and Lake Borgne depressions open to the Gulf of Mexico.

**The Atchafalaya Basin.** The Atchafalaya Basin, under natural conditions, received water not only from the Atchafalaya River but also from various crevasse and distributary channels of the Mississippi and Red rivers. The upper end of the basin is divided into four minor backswamp basins by the Atchafalaya and Grosse Tete ridges. The central part of the basin is a plexus of interconnecting streams which distribute the Atchafalaya waters through the swamp and ultimately drain into the system of lakes which occupies the lower end of the basin. These lakes, representing water impounded behind the barrier of Teche Ridge, are from west to east: Lake Fausse Point, Grand Lake, Six Mile Lake, Flat Lake, Lake Palourde, and Lake Verret. They are all shallow and irregular in outline, though wave action has locally rounded the shoreline in many places. The northern parts of Lake Fausse Point (figure 41) and Grand Lake are partially filled by deltas of Atchafalaya distributaries. The delta in Grand Lake has enlarged considerably within historic times. The pattern of the swamp drainage of much of the lower Atchafalaya Basin is like that of the lake-filling delta systems, indicating that lakes were formerly more extensive.

**The Lake Pontchartrain Basin.** The Lake Pontchartrain Basin lies between the uplands to the north and the alluvial ridge of the Mississippi River. The southeastern margin of the basin is Metairie Ridge, a low alluvial ridge marking the position of the trunk courses of an old subdelta of the Mississippi River east of New Orleans. The basin is 70 miles long, reaches a maximum width of 30 miles, and includes Lake Maurepas at its western end. It collects the drainage of most of Louisiana east of the Mississippi River and from a considerable area in southern Mississippi. Under natural conditions, it received overflow from the Mississippi River; and Bayou Manchac and New River, abandoned distributary channels, formerly carried Mississippi River waters directly to the basin.

The lake from which the basin takes its name measures 25 miles from north to south and 40 miles from east to west. The outlines are smoothly rounded by wave action, and the lake is in places rimmed by a ridge-like beach of sand winnowed from the deposits of its shore and bottom. The lake is very shallow, averaging about 12 ft. in depth with a very small area deeper than 16 ft. The modification in size and shape of the lake by wave action and alluviation has been measured.[1] The shoreline east of New Orleans receded at a rate of 8 ft. a year in the period of 1870-1917.

Tidal flow in and out of Lake Pontchartrain through the Rigolets has deepened the Rigolets channel to more than 70 ft., and a subaqueous tidal delta has been built out into the lake near the passage. The small daily tide of the Gulf is of less importance in effecting changes in the lake than the occasional hurricanes which have been known to have raised the lake level as much as 13 ft.

Lake Maurepas is very similar to Lake Pontchartrain but smaller. Water flows from Lake Maurepas to Lake Pontchartrain by two tidal channels, North Pass and Pass Manchac. The deep meandering channel of North Pass is typical of the tidal streams of the Lake Pontchartrain Basin. Similar tidal channels are those of the Tickfaw, Natalbany, Amite, and Tangipahoa rivers. The deep, clay-banked, tidal channels are in marked contrast to the sandy, shoal channels along the upper courses of these rivers.

**Relation of Lake Pontchartrain Basin to Regional Structure.** The Lake Pontchartrain Basin is bounded by faults of the Red River and Lake Borgne fault zones (plate 17). Recent depression of the basin may be measured by subsidence of an Indian village site at the north end of the lake to 14 ft. below sea level.[2] The area has been actively subsiding along a fault system bordering the northeast margin of the lake since Miocene time. Geophysical data and deep borings indicate local displacement of over 2,000 ft.

**The Barataria Depression.** The lowland between the Lafourche Ridge and the Mississippi River is herein termed the Barataria Depression. This lowland connects with the Gulf of Mexico at its open southern end. It contains a series of interconnecting water bodies whose salinity gradually decreases northward from the Gulf.

[1] Steinmayer, K. A., "Bottom Sediments of Lake Pontchartrain, Louisiana," Amer. Assoc. Petrol. Geologists, vol. 23, pp. 1-23, 1939.
[2] Russell, R. J., "Quaternary History of Louisiana," Geol. Bull., Soc. America, vol. 51, p. 1211, 1940.

The southernmost of these water bodies is Barataria Bay, a typical coastal lagoon with a discontinuous bar separating it from the Gulf and an irregular embayed inland margin. Barataria Bay which has salt water at its lower end and brackish water to the north, connects with Hackberry Bay. The latter is linked with the slightly brackish waters of Little Lake by Grand Bayou. Little Lake is linked with the comparatively fresh waters of Lake Salvador and Lake Cataouache by Bayou Perot. The northernmost of the lakes is Lac des Allemands.

The entire depression is a complicated maze of interconnecting lakes and waterways. Outlines of most of the lakes have been somewhat rounded by wave action, and numerous "round lakes" occur. The larger water bodies, however, are much less regular in outline than those of Lake Pontchartrain Basin to the north.

**Relation of Barataria Depression to Regional Structure.** The northwest-southeast trend of the Barataria Depression corresponds to the trend of the Red River fault zone. The elongation and shape of its lakes indicate that they originated through the enlargement of tidal channels by wave action. The tidal channels were controlled by the position of the ancient Mississippi River distributaries and other streams with courses determined by the regional fault pattern.

The eastern margin of the depression is the straight southeast-trending Mississippi River course between Myrtle Grove (Mile 60) and Head of Passes (Mile 0). The major Mississippi River crevasses, Davis and Hymelia, are alined along this trend. The depression is outlined on the west by a similar trending discontinuous ridge marking the eastern margin of the Lafourche Delta. This ridge extends southward along the Vacherie crevasse ridge from the present Mississippi River (Mile 150) to the town of Bayou Boeuf, on the southern shore of Lac des Allemands. From Bayou Boeuf it extends southeastward east of Bayou Lafourche along Petite Bois Bayou, Bayou Raphael, and Mink Bayou to Caminada Bay. This western margin of the depression was the site of faulting observed at Vacherie.

The Barataria Depression is a lowland developed in a series of tilted fault blocks which fan out from the Red River fault zone. The Vacherie fault, on the west, controlled the eastern margin of the Lafourche Delta and directed deposition of sediments into the Gulf. The area to the west did not receive as much sediment and receded under wave attack to form the many lakes of the Barataria Depression.

**The Vacherie Fault.** A slight earthquake took place along a fault zone near Vacherie, La., between April 12 and 15, 1943. Displacement of the ground surface was evident over a distance of almost a mile. The fault zone maintained a general south-southeasterly trend and consisted of a series of nearly parallel open cracks and minor fault offsets en echelon fashion. A maximum displacement of 8 inches was observed near the center of the fault zone.

The fault is situated on the southeast flank of the Vacherie salt dome. (See location map, plate 17.) Localization of the observed fault movement to the vicinity of the salt dome probably reflects local structural conditions, but the fault can be traced as a part of the Red River fault zone as far north as Kleinpeter. Of particular interest is the fact that faulting occurred at a place along the river where repeated crevassing took place. The ridge which runs landward from the present artificial levee to Lac des Allemands bears traces of the channel developed by these repeated crevassings (plate 17).

Borings show a greater displacement of the shallow Prairie deposits than were observed on the surface, indicating recurrent movement along the fault. Plate 17 shows a section across the fault and the relation of the fault to the regional structure and the Barataria Depression.

**Lake Borgne Depression.** Mississippi Sound and its southwestward continuation, Lake Borgne, occupy a southwest-northeast depression between Metairie Ridge on the north and the marsh lands of St. Bernard Parish on the south. The water-filled portion of the depression is from 10 to 15 miles wide and extends for over 50 miles east of the Mississippi River. The outlines of Lake Borgne indicate that it originated from the coalescence of several smaller round lakes alined with the depression.

**Relation of Lake Borgne Depression to Regional Fault Pattern.** Major faults of the Lake Borgne fault zone can be traced westward from Mobile Bay, Ala., to Caillou Bay in southern Terrebonne Parish, La., a distance of approximately 200 miles (plate 17). The Lake Borgne Depression is located in a graben within the fault zone and includes parts of Mississippi Sound and Lake Borgne east of the Mississippi River, and Lake Salvador and a number of alined smaller lakes west of the river. The graben, which also holds the anomalous bend of the Mississippi River, English Turn, is approximately 17 miles wide throughout most of its length. It is complex structurally and contains small faults which define minor horsts and grabens.

A cross section drawn from Lake Pontchartrain southward across the northern fault of the graben (plate 17) shows the offsetting of the late Pleistocene beds in the subsurface. It also shows offsetting of sedimentary zones overlying the Pleistocene beds and a thickening of the marsh deposits on the downthrown sides of the faults.

## The Mississippi Delta System

The term "delta" has been used in a variety of ways, and has been recently restricted in the Mississippi River region[1] to follow the original definition of Herodotus, in which a delta is designated as a triangular-shaped tract of land at the mouth of a river, limited by the outermost distributaries of the stream. The Mississippi River Delta by this definition extends from the head of the Atchafalaya River to the Gulf of Mexico, and from the mouth of Vermilion River to the outermost edge of the Chandeleur Island arc. The definition coincides essentially with the usage of the deltaic plain in this report.

The northern limit of the Mississippi River Delta has been placed as far north as Keokuk, Iowa, and as far south as Fort St. Philip, slightly above the Head of Passes, by different authors. Delta is used herein to refer to a group of subdeltas related to a common trunk course. The present active bird foot distributary

[1] Russell, R. J., "Physiography of the Lower Mississippi Delta," Louisiana Dept. Cons., Geol. Bull. No. 8, 1936. This work is the only complete and authoritative compilation of the data on the Mississippi Delta within Plaquemines and St. Bernard Parishes, La. It includes much information on the details of the physiography, subsidence, and rate of delta growth.

system south of Fort St. Philip is the active subdelta of the river. This subdelta, called the Balize subdelta,[1] is the most recent of a series of subdeltas of varying size which have been developed and abandoned by the trunk Mississippi course south of Kenner (mile 110). The latest Mississippi delta complex, the Plaquemines-St. Bernard Delta[1] includes the Balize, Bayou Cheniere, Barataria,[2] River aux Chenes (Forts),[1] St. Bernard,[1] and Metairie[1] subdeltas.

The deltaic plain contains five delta complexes in addition to the Plaquemines-St. Bernard Delta. Each of the deltas is made up of a number of subdeltas which radiate from a different trunk course of the Mississippi River. The deltas are, from oldest to youngest, Bayou La Rose, Maringouin, Cocodrie, Teche, and Lafourche. They are named for present streams occupying the old trunk channel position, or for streams in the position of the major tributaries.

### *The Plaquemines-St. Bernard Delta*

This delta includes all the land of Plaquemines and St. Bernard parishes and large parts of Orleans and Jefferson parishes to the northeast and southwest of the present river. The position of each of the subdeltas is shown on plate 15.

**The Balize Subdelta.** The Balize subdelta includes all the active passes of the Mississippi River. Balize refers to the largest settlement near the Head of Passes, but the location of this settlement has varied as the individual passes enlarged or deteriorated. Pilottown is but the latest in a succession of settlements bearing the name Balize.

The Balize subdelta is commonly referred to as the "bird foot" delta of the Mississippi. The distributary channels or passes with their flanking levees form the claws of the bird foot, and the main channel and levees form the legs. The inter-tributary lowlands between adjacent claws are the bays of the Gulf. Bays not receiving large quantities of river sediments, such as Redfish Bay, are increasing in size because of active subsidence and wave action. Other bays, such as Garden Island Bay, have been rapidly filled within recent years and are decreasing in size.

**Subsidence.** Sinking of bench marks, buildings, cemeteries and engineering works in the Balize subdelta has impressed many observers with the activity of subsidence in the Mississippi Delta. There is, however, a wide variation in the amount and rate of observed subsidence, and it is difficult to determine whether the local depression results from local compaction of sediments or from regional depression under the weight of the deltaic mass. Local settlement of the land surface takes place elsewhere in the deltaic plain when marsh sediments are drained and thus compacted. Subsidence of parts of New Orleans, of the Little Woods area east of New Orleans, and of farmed areas within the coastal marshes has occurred following the establishment of drainage systems in the areas.

Natural levees built on soft marsh deposits sink under their own weight. This foundering goes on as the levee is constructed and may continue after abandonment of the stream course because of lag in adjustment. As a result of such subsidence, the levee deposits in the lower delta are usually thicker below marsh level than above. The low areas landside of the levees which have been dragged down by the foundering levees are called levee-flank depressions.[3]

Estimates of regional subsidence, based on sinking of objects upon the natural levees, are rendered unreliable by the foundering of levee. Yet all data[3] suggest that appreciable depression is going on in the delta region.

**The Bayou Cheniere Subdelta.** The Bayou Cheniere subdelta lies between Barataria Bay and the Mississippi River in southwestern Plaquemines Parish. It includes a number of old Mississippi distributary channels, among the most important of which are Bayou Grand Cheniere and Grand Bayou. The present channel as far south as Buras was part of the complex of distributaries forming the Bayou Cheniere subdelta. The Balize subdelta represents a seaward growth of the Bayou Cheniere subdelta.

Much of the subdelta area consists of lakes and bays well rounded by wave action. The levees of the Bayou Cheniere system can be traced from the Mississippi River to a beach ridge near the Gulf which truncates them.

**The Barataria Subdelta.** The Barataria subdelta is a complex of old distributary channels lying north and east of Bayou Cheniere subdelta in Jefferson Parish. Bayou Barataria occupies a portion of one large channel.

The system starts at Marrero as a natural levee ridge which leads south to join Bayou Barataria Ridge a few miles east of Lafitte. The main channel branches below Lafitte Village, with small distributaries radiating in the manner of the passes of the Balize subdelta.

The pattern of channels and bends in the Barataria subdelta suggest that the system was short lived and did not receive the full discharge of the Mississippi River but that it was of considerable importance.

**The River aux Chenes Subdelta.** The name River aux Chenes subdelta is herein given to the complex distributary channels lying north of the Mississippi River in the "River aux Chenes delta-flank depression."[4] The southward continuation of these distributaries is found south of the Mississippi River in the neighborhood of Ft. Jackson and Ft. St. Philip, the region of Russell's Forts subdelta.

The subdelta consists of a series of nearly parallel, locally anastomosing, distributary channels. The subdelta lies so close to sea level on the southwest that the only trace of old distributary channels is found in the paired islands and in the longitudinal "grain" of the hydrographic system.

The River aux Chenes levees are low in comparison with those of the Mississippi on the south and the levees of the St. Bernard subdelta to the north but no lower than the levees in the distal fringe of the St. Bernard subdelta.

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[1] Russell, R. J., op. cit., p. 41.
[2] Viosca, Percy Jr., "Bayoulands of Jefferson," Jefferson Parish Yearly Review, pp. 42-58, 1943.
[3] Russell, R. J., op. cit., p. 45.
[4] Russell, R. J., op. cit., p. 105.

**The St. Bernard Subdelta.** The largest of the abandoned subdeltas of the present Mississippi River Delta is located in St. Bernard Parish. The main channel of the subdelta followed eastward along Bayou La Loutre and constructed an alluvial ridge. At a later date this channel functioned as a distributary while the main flow followed Terre aux Boeufs and constructed an alluvial ridge which trends southward from the Bayou La Loutre Ridge at Reggio away from the main St. Bernard subdelta.

The distal portion of the St. Bernard subdelta is the type example of drowned topography in the delta region. The marsh is at or near sea level, and many round lakes have developed. Enlargement of many adjacent lakes has caused them to coalesce. The scalloped outlines of their coalescing water bodies are typical of the region. Many of the lakes have become connected with the Gulf and today form bays. Old distributary channels are preserved mainly in the "grain" of the drainage and in double islands representing remnants of old levees flanking abandoned channels. This "grain" is closely alined with the regional fault systems. The subdelta may have extended as far south and east as the Chandeleur Islands.[1]

Indian mounds with bases as much as 9 ft. below the present sea level and tree stumps in areas now invaded by salt-water vegetation have been cited as evidence of subsidence in the distal portion of the St. Bernard subdelta.[2] Likewise the 0.5 ft. per mile slope of natural levee crests has been pointed out as evidence of eastward tilt.

The great bend in Bayou La Loutre represents an anomalous feature in the main channel of the St. Bernard system which corresponds to English Turn in the present river. Like English Turn, the great turn in Bayou La Loutre may be the result of faulting.

**The Metairie Subdelta.** The Metairie subdelta is named from Metairie Ridge which leaves the Mississippi River near Kenner, La., and trends eastward to New Orleans. The subdelta lies in Orleans Parish, east of New Orleans, and the stream in its main channel flowed eastward to its "head of passes" at the Rigolets. The main channel followed the position of Gentilly Ridge and the ridge of Bayou Sauvage east of New Orleans.

That the Metairie subdelta probably was short lived is indicated by its small area and thin deposits. Borings in this area encounter oxidized Pleistocene deposits at depths of approximately 40 ft. in the vicinity of New Orleans and at shallow depths to the east.

Between Lake Pontchartrain and Bayou Sauvage is a row of Indian mounds which stand slightly above swamp level. These mounds appear to rest on an old chenier ridge. Mollusca, found at 11 ft. in bore holes through the marsh muck into the clays beside the mounds, indicate conditions more saline than in Lake Pontchartrain today. Shells of **Rangia cuneata,** a common brackish-water clam, are included in the Indian mounds and indicate the existence of a nearby brackish water body.

### *The Lafourche Delta*

At Thibodaux, La., the Lafourche meander belt ridge divides into a true delta system of distributaries which outline a great triangular area. A portion of this distributary complex is shown on the photograph, figure 23.

The important distributary ridges of the delta system include those of Bayous Lafourche, Black, Terrebonne, Grand Caillou, Petite Caillou, Point au Chien, and Blue, as well as Little Bayou, Eagle Island Bayou, and Petite Bois Bayou. The distributaries of anastomosing channels are grouped to form a series of unnamed subdeltas, indicated on plate 15.

The Lafourche Delta is marginal on the north and west to the older Teche Delta which it overlaps on the south and east. Reoccupancy and reversal of flow in the abandoned Teche Mississippi channel above Houma by a distributary of the Lafourche Mississippi is indicated by the westward slope of the Bayou Black levees between Houma and Gibson, La.

The distal portion of the Lafourche Delta is salt marsh in which many round lakes have developed. Several of its subdeltas are rimmed to the south by ridges either of chenier or off-shore bar type. Most conspicuous of these ridges are the Isle Derniere, Timbalier Island and the ridge which trends westward from Grand Isle. Some distributaries are truncated by cheniers whereas others turn and parallel the cheniers. This relationship indicates that the channels and cheniers are contemporaneous and that the subdeltas did not extend far beyond the present shoreline.

Bayou Lafourche continued to act as a Mississippi distributary until long after the main flow of the river shifted to the east. It was artificially closed in 1903-04. The channels and levees of the present Bayou Lafourche are those of the historic distributary channel rather than those of the trunk Lafourche-Mississippi course.

### *The Teche Delta*

The Teche Delta has a typical triangular shape with the apical angle considerably wider than that of the younger Lafourche Delta. Its older distributary channels are traced with increasing difficulty to the south. None of the channels have been traced more than 20 miles south of Houma where they die out in the coastal marshes. The shortness of the Teche-Mississippi distributary channels indicates either that the delta did not extend farther south than mapped on plate 15 or that the distal portion of the delta has subsided below marsh level.

The distributary channels of the Teche Delta include Bayou Mauvais Bois, Bayou du Large, Small Bayou, Bayou La Cache, and Bayou Chauvin. The continuity of these distributaries is shown on plate 15. Separation of the Teche Delta into subdeltas is difficult because it is masked in part by the subsequent Lafourche deposits.

[1] Russell, R. J., op. cit., p. 71. [2] Russell, R. J., op. cit., pp. 162-174.

### *The Cocodrie Delta*

The Cocodrie Delta is named for its trunk stream, Bayou Cocodrie, which follows a meander belt within the Tensas Basin. The meander belt has been traced southward through the Atchafalaya Basin to the Lafourche Ridge near Labadieville. East of the Lafourche Ridge, the trunk course divides into a series of poorly defined distributaries which trend west-east across the upper end of the Barataria Depression. The eastward traces of the Cocodrie Delta system are located near New Orleans (plate 15).

### *The Maringouin Delta*

The Maringouin Delta lies north and east of the Teche Delta. It is crossed by streams of the younger Lafourche, Teche and Cocodrie deltas, and its outlines are retained only in the drainage pattern of the Atchafalaya Basin.

The delta receives its name from Bayou Maringouin, a small stream west of Baton Rouge which occupies a portion of the main channel. After abandonment of the Maringouin Delta, Bayou Maringouin functioned as a branch of the Grosse Tete distributary system. The levees along the bayou were formed during a later epoch in its history.

### *The Bayou La Rose Delta*

The oldest recognized delta system is the Bayou La Rose Delta in the western part of the Atchafalaya Basin. It is named for Bayou La Rose, a larger distributary of the present Atchafalaya system. Bayou La Rose follows one of the main channels of a delta system whose trunk course was in a meander belt with an axis close to the present Atchafalaya River.

# Part V

# RECENT GEOLOGICAL HISTORY

## INTRODUCTION

The Recent[1] history of the Mississippi Alluvial Valley covers the time during which the late glacial (late Wisconsin stage) entrenched valley system was filled and the present hydrographic system evolved. The history has been reconstructed from an interpretation of the alluvium filling the entrenched valley system and from the traces of old stream channels which cover the alluvial plain. It is the record of the shifts in position of the master stream and its principal tributaries and of the changes in valley slope, stream load, and nature of the streams which took place during and subsequent to the rise in sea level.

**Stages in the Drainage History.** The Recent history of the valley has been divided into a series of stages constituting two major epochs in the evolution of the drainage. The history of the early epoch, that of rising sea level, has been developed from a study of the subsurface alluvium and has been divided into stages which correspond to positions of sea level, the —300, —200, —80, and —55 foot stages. Traces of the —20 foot stage, or $A_1$ stage, are preserved in the northern end of the valley but are buried in the deltaic plain region.

The history of the late epoch, that of standing sea level, has been reconstructed from traces of stream activity exposed on the surface of the alluvial plain. The late stages are separated on the basis of such major changes as a shift in the position through which the stream enters the valley, an abandonment of a segment of a meander belt, or a shift in delta position. The drainage stages are designated by letters from A to J and by numbers from 1 to 20. The $A_1$ stage is the oldest of which traces are still preserved and stage 20 is the present drainage. Stages from $A_1$ through J are of unequal length and cover an interval of approximately 4,000 years; those from 1 to 20 are approximately equal in length and cover a period of 2,000 years. Separation of stages 1 to 20 is based on analogy to known migration of bends of the present river. Stages 17 to 20 correspond to mapped historic courses of 1765, 1820, 1880, and 1940. Stage 1 represents the time when the Mississippi and Ohio rivers first joined near Cairo, Ill. The designation of this and succeeding stages by numbers and the earlier stages by letters is largely a matter of convenience, used because it sets apart stages related to the modern meander belts from those related to earlier stages of drainage evolution.

### *Valley Alluviation*

The rise of sea level and the development of the alluvial fans about the mouths of the tributary valleys are the two principal factors which have controlled valley alluviation. Rise in sea level initiated the filling of the valley and controlled the speed of alluviation, but the form of the filling and the distribution of the deposits were controlled by alluvial fan disposition. A third factor, regional structure, controlled the position of many streams on the alluvial fans and has been indirectly responsible for modifications of the alluvial mass.

**Rising Sea Level and Valley Alluviation.** The rise in sea level produced by the melting of the late Wisconsin continental ice caps forced aggradation of the Mississippi valley. Alluviation took place because this rise in baselevel decreased the over-all slope of the valley and not because of the increase in amount of sediment brought to the valley. There is no evidence to indicate any great change in stream discharge during the period of valley alluviation. Streams entering the valley from non-glaciated regions carried as coarse a load as did streams draining the glaciated areas (see Appendix, pp. 67-70).

The rise in sea level caused a decrease in stream slope which was reflected in a progressive upstream loss in carrying power of both master and tributary streams. Alluviation, therefore, gradually worked upstream, and the site of deposition of a given grain size of sediment likewise shifted upstream.

The gradational nature of the sediments throughout the valley and the occurrence of coarse clastics at depth at the present coast line indicate that alluviation kept pace with the rise in sea level throughout most of the Recent epoch. The development of a shallow estuary which extended inland as far as the latitude of Lafayette, La., late in the history of valley filling, may have coincided with rapid rise in sea level corresponding to the recognized final rapid melting of the ice caps.[2]

**Alluvial Fans and Valley Alluviation.** That the filling of the entrenched valley system consists largely of the alluvial fan deposits of tributary streams is indicated by the configuration of the top of gravels in the subsurface (plate 12), the local slope of the present valley surface away from the mouths of tributary valleys, and the fan-like pattern of abandoned stream channels around the mouths of tributary valleys. The upward decrease in coarseness of the fan deposits reflects the progressive upstream shift of alluviation as controlled by rise in sea level. The shape and slope of the alluvial fan, however, result from the inability of a tributary stream to carry its floodwater load in the wide alluvial valley of the master stream.

Alluvial fans characteristically develop a steep slope on the face of the out-building fan in an open valley, as deposition is localized around the mouth of the tributary valley. Upstream above the apex of the fan, the slope is flattened because the sediment dropped near the narrow valley mouths acts as a dam across the tributary valley. All slopes within the alluvial valley are gentle and only in a few places exceed a foot per mile. For example, the front of the Ohio alluvial fan within the Eastern Lowland had a slope of 0.9 ft. per mile; the top slope within the Cache Lowland was only 0.2 ft. per mile; and the valley slope below the face of the fan was less than 0.6 ft. per mile.

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[1] The Recent epoch covers approximately the last 25,000-30,000 years of earth history. It starts with the waning of the last continental ice sheet, the late Wisconsin stage of glaciation (see Appendix, p. 67).

[2] Daly, R. A., "Changing World of the Ice Age," Yale University Press, p. 56, 1934.

All tributary valleys have steeper slopes than the master valley, excepting the Ohio and Ouachita rivers. This relationship has been maintained throughout the alluvial history of the valleys. Each shift of stream position during aggradation of the alluvial valley took place because a temporary gradient advantage was provided. Such an advantage was furnished by an upstream shift of the junction position with a stream of lower gradient. The Ohio River with its low gradient has served throughout valley history as the master stream of the northern part of the valley. The Mississippi River has progressively shifted its junction with the Ohio River northward. The final shift diverted the Mississippi River into the north end of the Eastern Lowland and provided a sufficient gradient advantage to enable it to entrench early-formed portions of the Ohio alluvial fan by 15 ft. in the latitude of Cairo, Ill. The present Mississippi River meander belt is from 20 to 40 ft. below the highest level of the Mississippi alluvial fan of the Western Lowland.

**Regional Structure and Valley Alluviation.** The principal influence exerted by movement along regional structures has been a control of the drainage pattern, which in turn has determined the local pattern of alluviation. Stream shifts accompanying alluviation resulted primarily from alluvial fan aggradation, but the location of each shift and the trend of each new course were in places determined by faults of the regional system. Periodic entrenchment of the alluvial fan deposits of the Ohio, Mississippi, Arkansas, and Ouachita rivers has been the direct result of uplift along the Big Creek and Catahoula Lake fault zones. Thickening of the alluvial mass in structural depressions along these fault zones, as well as in the Lake Borgne fault zone, is known (plate 17).

The effect which the active subsidence of the Mississippi Structural Trough has had upon the thickness of the alluvial mass is not known because the thickest alluvium overlies the entrenched master valley. Subsidence in the Gulf Coast Geosyncline, however, has caused a thickening of the alluvial section underlying the deltaic plain far greater than necessary to fill the valleys cut during late Wisconsin time.

## Epoch of Rising Sea Level

**Initial Fill of the Valley.** During the late Wisconsin entrenched stage when the streams were actively down-cutting, coarse sediments as well as fine debris were swept to the Gulf of Mexico. The position of the shore line during this stage is not known, but projection of the slope of the entrenched master valley indicates that sea level was at least 400 ft. lower than at present. (See Appendix for additional data.) The shore line must have been near the present edge of the continental shelf. It is possible that the Mississippi River may have entered the Gulf of Mexico near the head of the submarine canyon (plate 3).

**—300 Foot Stage.** When sea level had risen to a level 300 ft. lower than at present, the Mississippi River was still carrying gravels to the Gulf (plate 18) and both the river and its tributaries were still confined within their entrenched valleys. During this stage, all streams were continuing to entrench their valley floors within the marginal uplands above the fall-line.

**—200 Foot Stage.** Aggradation following the —300 foot stage buried the lower ends of divides in the entrenched valley system south of the latitude of Natchez, Miss. Streams widened their valleys by this alluviation, locally flattened their gradients, and started the development of alluvial fans near their valley mouths.

By the time sea level has risen to an elevation of —200 ft. (plate 18) the Ohio and Mississippi tributary streams had alluviated their valleys to the gradient of the bedrock above the fall-line. By the end of this stage the Ohio and Mississippi tributary streams were no longer confined within their entrenched valleys south of the fall-line but could shift their courses easily. Throughout the —200 foot stage, however, the Mississippi River was still capable of carrying gravels as far south as the present shore line.

**Period of Gravel Alluvial Fan Growth, —80 and —55 Foot Stages.** As sea level rose above the —200 foot stage, the decrease in gradient prevented the master stream from carrying gravels to the Gulf of Mexico, but the tributaries continued to bring gravel to the valley. The upper surface of buried gravel fans of the Mississippi and Red River valleys indicates that these streams carried gravel until sea level reached the —80 foot stage (plate 18). The Arkansas and Ohio rivers, farther removed from the sea than the Red River, and with slightly steeper slopes, were able to carry gravel until the —55 foot stage of sea level (plate 18).

The lenticular nature of the gravels and the poorly sorted character of the deposits indicate that the streams throughout the early stages of valley aggradation were overloaded and braided and had shallow channels constantly in flood. During the building of the gravel fans, some of the inter stream divides, like Macon Ridge, still stood above the alluvial surface and served as guides for the development of lobes of gravel fans (plate 12). During late stages in gravel fan growth most of the divides became buried with alluvial deposits, and upon leaving their narrow, rock-walled, tributary valleys the overloaded streams were able to migrate widely and to drop their load. As a result, the alluvial fans grew rapidly in late stages of gravel deposition and developed steep fronts into the alluvial valley.

Upbuilding and outbuilding of a gravel fan at the mouth of a tributary valley lowered the slope upstream within the valley, decreased the carrying power of the stream, and thereby shut off the supply of gravel being brought to the alluvial fan. Today the only streams bringing gravel to the Mississippi valley are minor tributaries, such as Thompson Creek, north of Baton Rouge. These streams derive their gravels from the graveliferous Quaternary terraces of the uplands.

**Construction of Highest Fan Surface, $A_1$ or —20 Foot Stage.** Lack of coarse gravel particles did not stop the growth of alluvial fans. The tributary streams continued to contribute sand and the gravel fans were gradually buried as the slope of the master stream decreased. Successive stages of upbuilding of the fans were marked by a decrease in size of particles; eventually silt constituted the main deposit. Remnants of the great mantle of sands and silts deposited above the gravels of the alluvial fans are found in many parts of the alluvial plain. They mark the $A_1$ stage of alluvial valley development.

The $A_1$ stage surface is everywhere marked by the depositional pattern of braided streams overloaded with silty sediments. In the northern part of the valley the $A_1$ surface constitutes the highest portion of the dissected alluvial plains. Remnants of the $A_1$ surface are found as far south as the Catahoula Lake area, La Salle Parish, La., in the south-central part of the valley where the ancient braided stream pattern controls the present drainage. Farther south, the old surface is buried beneath younger deposits. The reconstructed drainage of the valley during $A_1$ stage is shown on figure 42, and the profiles of the Ohio and Mississippi rivers during this stage are shown on plate 19. These profiles indicate that during $A_1$ time, sea level was 20 ft. lower than at present.

The significant features of the $A_1$ drainage are as follows: The $A_1$ Ohio River followed braided courses through the Cache Lowland in southern Illinois and constructed an alluvial fan which extended as far south as the latitude of Charleston, Miss. It flowed southward across the eastern side of the valley and joined the Mississippi River near Simmesport, La.

The Mississippi River followed a braided course through the Western Lowland in which it had constructed its alluvial fan. Pronounced southwestward swings in the Mississippi course near the present mouth of the White River and south of Sicily Island are attributed to deflection of the river along structural depressions in the active Big Creek and Catahoula Lake fault zones. Streams entering the valley from the east combined and flowed along the eastern margin of the Ohio alluvial fan to the latitude of Helena, Ark. The Arkansas River flowed almost parallel with the Mississippi in the Macon Ridge area and joined it slightly north of Sicily Island, La. The Arkansas was meandering near the apex of its alluvial fan but braided to the south in the Macon Ridge area, where active faulting uplifted the region. The meandering Ouachita River also joined the Mississippi north and east of Sicily Island. The position of the Red River is not definitely known inasmuch as traces of the $A_1$ stage channels have been buried or cut out by stream action.

**The $A_2$ Stage.** The $A_1$ stage ended while sea level was still rising when the Mississippi and Ohio rivers were diverted to new braided-course positions near the apex of their alluvial fans. These stream diversions were about contemporaneous and were the most important of a series of changes on the alluvial fans because they shifted the junction of the Ohio and Mississippi rivers upstream more than 100 miles.

The $A_2$ positions of the major streams are shown on figure 42. The Mississippi River occupied a course in the Western Lowland and the Ohio River entered the Eastern Lowland by its course through the Cache Lowland. The valley slope profiles of the Ohio and Mississippi rivers are shown on plate 18. As indicated on the profile, the Ohio during $A_2$ stage was flowing on a low slope within the Yazoo Basin area and had, for the first time, started to develope a meandering course. Its course continued to braid upstream on the steep frontal slope of its alluvial fan. The Mississippi River may also have started to meander south of the Ohio junction, but all traces of this stage course have been destroyed.

The $A_1$ stage alluvial fans of the Mississippi and Arkansas rivers were entrenched by their respective rivers as a result of faulting. The $A_2$ surface of the alluvial fan of the Mississippi River lies below the $A_1$ surface from the mouth of the Advance Lowland to the Big Creek Escarpment. Just north of the Big Creek Escarpment, the $A_2$ surface is 10 ft. lower than the $A_1$ surface, but the interval between the two surfaces gradually decreases northward. The relationship of the drainage to the Big Creek Escarpment shows that the entrenchment of the $A_1$ surface was initiated by the active upward movement along the Big Creek fault zone.

The alluvial fan of the Arkansas River in the Macon Ridge area was entrenched as a result of movement along the Catahoula Lake fault zone. The braided course of the $A_2$ Arkansas River follows a surface which is 5 ft. lower than the $A_1$ surface near the southern end of Macon Ridge. The $A_2$ surface is entrenched within the $A_1$ surface as far north as Forest, La., near the head of Macon Ridge.

## Epoch of Standing Sea Level

**The $A_3$ Stage.** The $A_3$ stage marks the time when sea level first reached its present position. The $A_2$ stage is regarded as having ended when the Ohio River was diverted from its Cache Lowland position to the Metropolis Lowland in southern Illinois. The conditions which made this diversion possible are shown on plate 20. The Metropolis Lowland was once occupied by a minor drainage system tributary to the Ohio River in the Eastern Lowland near Cairo, Ill. The headwater streams of this west-flowing tributary system headed in the uplands south of the Metropolis Lowland and their principal branchworks drained the widespread late Pleistocene Prairie Terrace, which rises 20 to 40 ft. above the present Ohio floodplain. A low divide on the Prairie Terrace, Metropolis Gap, separated the west-flowing system from an east-flowing minor stream system tributary to the Tennessee River which then flowed northward to join the Ohio River. Floodwaters from the Tennessee River poured westward through the low Metropolis Gap and in time scoured a channel sufficiently deep to permit the diversion of the entire low-water flow of the Tennessee-Cumberland-Ohio trunk stream from the Cache Lowland. (See point of diversion, plate 20.)

The diversion of the Ohio River from the Cache Lowland to the Metropolis Lowland was a slope adjustment which provided the Ohio system with a steeper course to the Eastern Lowland. The diversion resulted from the lowering of the slope of the master streams brought about through the upbuilding of the alluvial fan of the Ohio River which had its apex at the mouth of the Cache valley. Growth of the alluvial fan caused the aggradation of the Cache-Ohio valley and caused the lowering of the slopes of the Ohio and lower Tennessee-Cumberland rivers. It is probable that flood stages were increased as the valley slopes decreased and an increasing discharge passed through the gap. Diversion of the entire system through Metropolis Gap resulted in the entrenchment of the former floodplain deposits between Paducah, Ky., and Golconda, Ill. (plate 20).

The elevation and slope of the $A_2$ stage floodplain provide data for the interpretation of the flood stage necessary for overflow to pass through Metropolis Gap. Between Paducah and the head of the Cache Lowland where the Tennessee and Ohio joined, the northward slope of the Tennessee-Cumberland floodplain was slightly less than 0.2 ft. per mile. The southward slope of the present Ohio floodplain in the same region is nearly twice as great. The elevation of the terrace at the margins of the Metropolis Gap is slightly over 360 ft. M. S. L. and the elevation of remnants of the floodplain of the north-flowing Tennessee-Cumberland system is approximately 350 ft. A stage of only 10 ft. greater than bank-full stage in the Tennessee River would have permitted flood-waters to pour through Metropolis Gap into the trunk stream of the west-flowing tributary. The flood stage on the present Ohio River is over 20 ft. and it seems probable that equally high stages were present on the lower slopes of the $A_2$ stage.

$A_3$ stage drainage of the alluvial valley is indicated on figure 43, and profiles of the valley surface along the Mississippi and Ohio river channels are shown on plate 19. The Ohio River maintained a meandering channel south of Memphis, Tenn., and occupied a position near the eastern valley wall to a junction with the Mississippi River near Tutwiler, Miss. During $A_3$ time the Mississippi had been diverted from the Western Lowland to the Eastern Lowland by way of the Marianna Gap. Diversion of the Mississippi through the Marianna Gap was the direct result of active uplift along the Big Creek fault zone near Helena, Ark. This uplift forced the Mississippi to concentrate its flow in a gathering channel which had started to function in the gap during $A_2$ time.

Below the Ohio-Mississippi junction the Mississippi River meandered and formed the Yazoo meander belt. These meanders are similar in every respect to those within the present meander belt. They are traceable as far south as Tchula, Miss.; in the lower end of the valley they have been destroyed or buried. The profiles of the $A_3$ stage valley surface indicate that the shore line extended inland to the latitude of Lafayette, La., and formed a shallow Mississippi estuary. Marine shells found at shallow depths in this region indicate the extent of the estuary. Following $A_3$ time, the history of shore line alluviation has been one of deltaic masses building outward toward the edge of the continental shelf.

**The B Stages.** At the end of $A_3$ stage, the Mississippi River was diverted from the Drum Lowland to the Advance Lowland at the north end of the valley. This shift caused a westward diversion of the river at the apex of its alluvial fan near Wappapello, Mo. This upstream shift diverted the Mississippi from its course through Marianna Gap to a course along the central part of the valley in the same latitude (figures 43 and 44). The B stages cover the time between the abandonment of the Drum Lowland and the construction of the oldest known delta system, the Bayou La Rose Delta.

Successive westward shifts of the Mississippi in $B_1$, $B_2$, and $B_3$ stages were the result of continued uplift along the Big Creek fault zone. During each stage a low terrace was formed (plate 15). The successive terraces mark the entrenchment of the $A_3$ stage alluvial fan and resulted in a progressive narrowing of the zone in which the stream braided.

While the Mississippi River was being incised during the $B_3$ stage, the Arkansas River was shifting westward and was being incised within its alluvial fan. The Ohio River maintained essentially its $A_3$ position throughout the B stages. The Mississippi and Ohio rivers joined near the center of the Yazoo Basin and meandered in a channel similar to that of the present Mississippi River.

**The C Stages—The Abandonment of the Western Lowland.** There is no sharp break between the B and C stages. Rather, $C_1$ stage may be regarded as the culmination of developments which started in the A stages and went on all through the B stages. The C stages offer the earliest good evidence of deltaic and coastal features and are regarded as marking the time when the oldest mappable Mississippi delta was constructed.

The drainage of the valley in $C_1$ stage, just before the occurrence of the Morehouse diversion, is shown on figure 45; the valley slope is given on the profile (plate 19). In this stage the Mississippi was braiding in a trench cut in the deposits of the earlier A and B stages. This trench was less than 5 miles wide throughout most of its length from Cape Girardeau, Mo., to St. Charles, Ark., but locally it had a width of 12 miles between Knobel and Newport, Ark. (plate 15). Below the Big Creek Escarpment the $C_1$ stage Mississippi continued to braid in the wide alluvial flats of the present Yazoo and Tensas basins. The abandoned meander belt ridge of the $B_3$ stage Ohio-Mississippi River separated the $C_1$ stage Ohio and Mississippi rivers throughout the lower Yazoo Basin region as far south as St. Joseph, La. In this stage the Ohio was maintaining a meandering channel along the eastern margin of the valley in the Bear Creek segment of the Yazoo meander belt.

The diversion of the Mississippi River through the Morehouse Lowland has been recognized by several writers. Both Matthes[1] and Marbut[2] have directed attention to the Morehouse Lowland, but both considered the diversion to be of Pleistocene age. Marbut believed the diversion to be the result of capture of the Mississippi River by headward erosion of a small Ohio tributary in the Eastern Lowland. Matthes considered the diversion to be the result of the narrowing of the divide between the Mississippi and Ohio rivers by active lateral erosion of Crowleys Ridge by the Ohio River.

The diversion of the Mississippi River into the Eastern Lowland through the Morehouse Lowland was initiated between $C_1$ and $C_2$ stages of the Recent epoch. Mississippi scars through the Morehouse Lowland truncate older scars which can be traced down the Western Lowland where they overlie the late Wisconsin Mississippi trench (plate 21).

The diversion took place because of the gradient advantage afforded by the course into the Eastern Lowland. A factor which facilitated diversion was the progressive reduction in flood storage area as the Mississippi entrenched its alluvial fan. Flood stage heights were increased upstream, and an increasingly greater overflow passed through the Bell City-Oran Gap. A possible additional factor, faulting across the Advance Lowland near the point of diversion, may have reduced the local slope of the Mississippi upstream from Advance and thus favored diversion.

Following the Morehouse diversion, many readjustments took place in the drainage of the valley. The initial slope through the Bell City-Oran Gap was steep, almost 2 ft. per mile. The Mississippi River entrenched

[1] Matthes, F. E., "The Pleistocene Diversion of the Mississippi River across Crowleys Ridge, Southeastern Missouri," Science, New Series, vol. 77, pp. 459-460, 1933.

[2] Marbut, C. F., "The Evolution of the Northern Part of the Lowlands of Southeastern Missouri," University of Missouri Studies, vol. 1, no. 3, pp. 18-33, 1902.

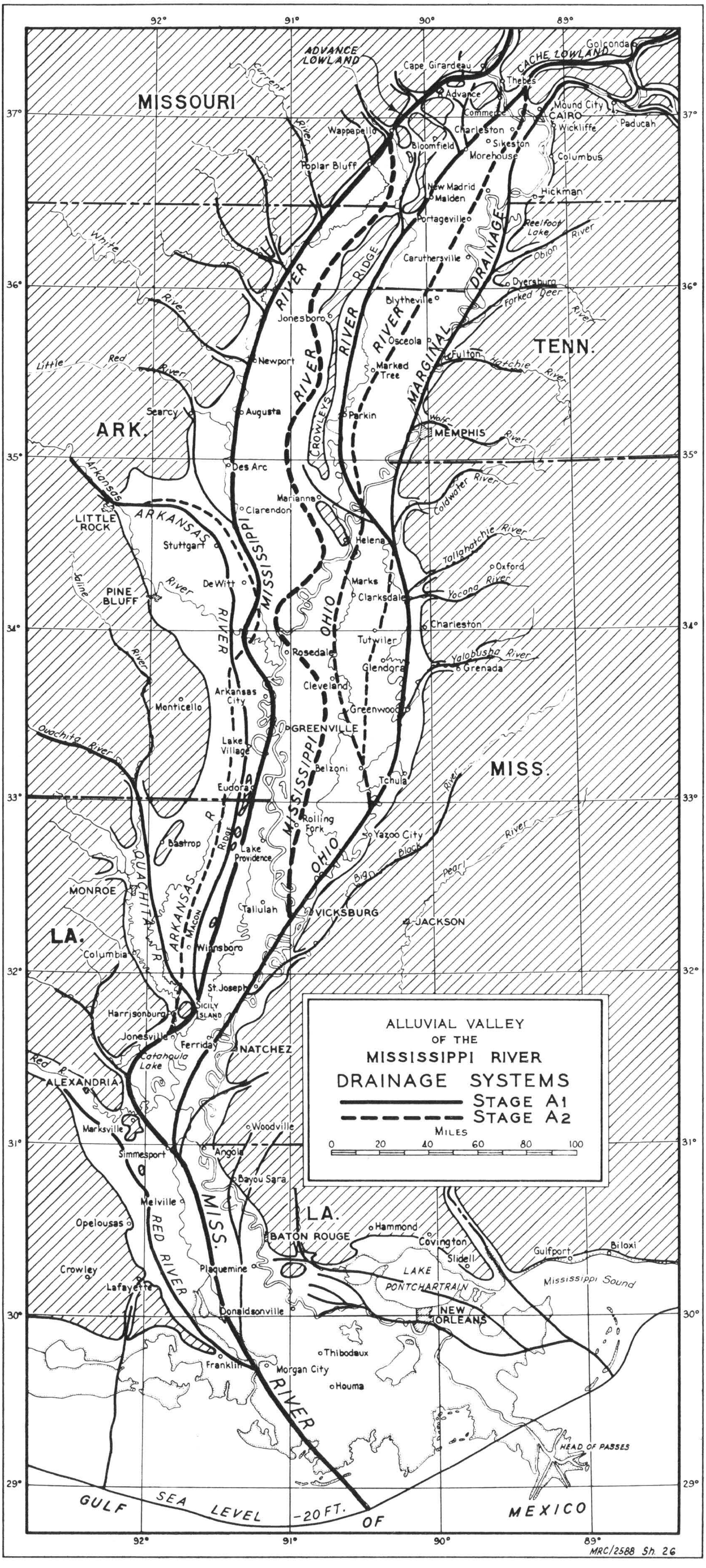

ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEMS
STAGE A1
STAGE A2
MILES
0 20 40 60 80 100
MISSOURI
ARK.
TENN.
MISS.
LA.
ADVANCE LOWLAND
CACHE LOWLAND
CROWLEYS RIDGE
MARGINAL DRAINAGE
MACON RIDGE
GULF OF MEXICO
SEA LEVEL -20 FT.
LAKE PONTCHARTRAIN
Mississippi Sound
HEAD OF PASSES
MEMPHIS
VICKSBURG
NATCHEZ
BATON ROUGE
NEW ORLEANS
LITTLE ROCK
PINE BLUFF
MONROE
ALEXANDRIA
GREENVILLE
JACKSON
CAIRO
MRC/2588 Sh. 26

FIGURE 42

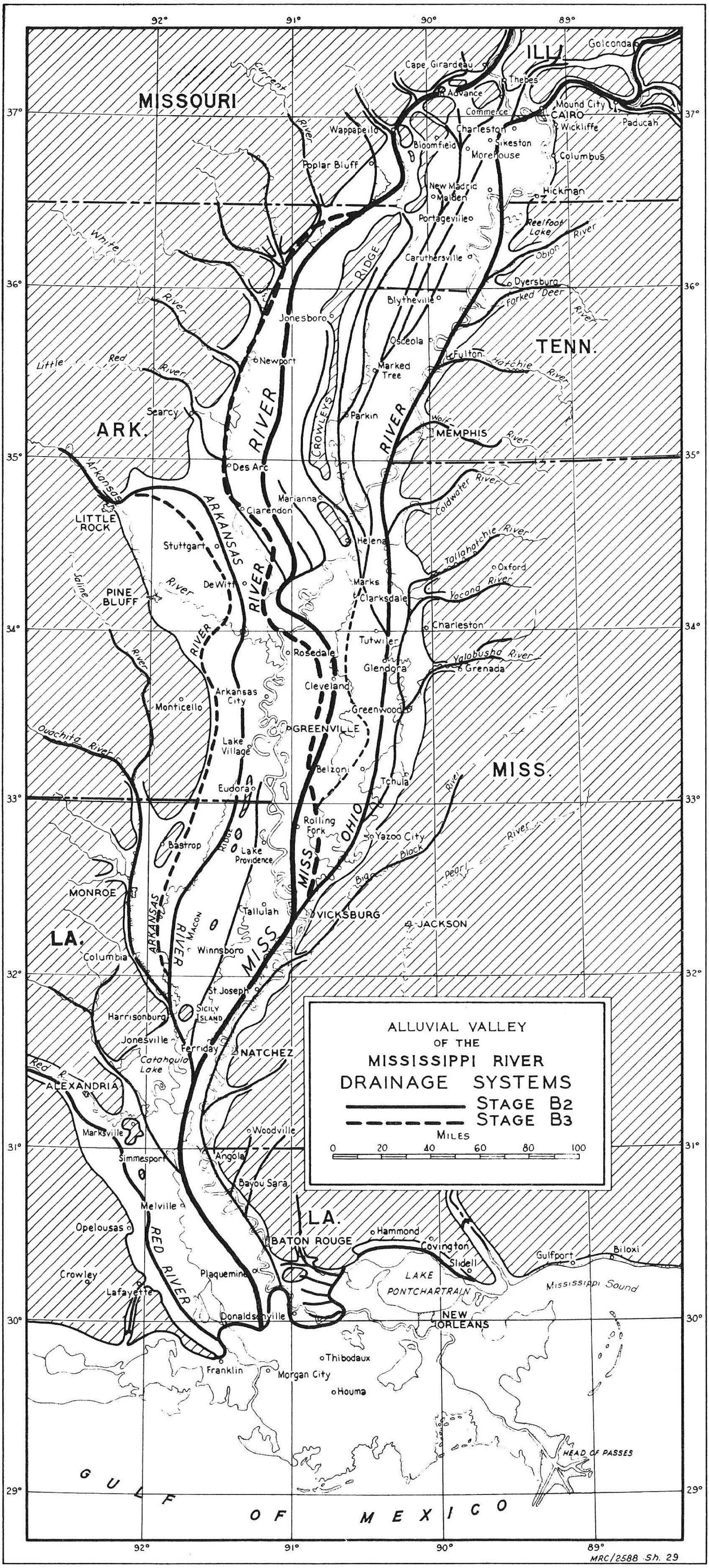

ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEMS
STAGE B2
STAGE B3
MILES
0 20 40 60 80 100
MISSOURI
ILL.
ARK.
TENN.
MISS.
LA.
LA.
GULF OF MEXICO
92°
91°
90°
89°
37°
36°
35°
34°
33°
32°
31°
30°
29°
Cape Girardeau
Thebes
Golconda
Advance
Commerce
Mound City
CAIRO
Wickliffe
Paducah
Wappapello
Charleston
Sikeston
Bloomfield
Morehouse
Columbus
Poplar Bluff
New Madrid
Malden
Hickman
Portageville
Reelfoot Lake
Obion River
Caruthersville
Dyersburg
Forked Deer River
Blytheville
Jonesboro
Osceola
Fulton
Hatchie River
Newport
Marked Tree
Parkin
Searcy
MEMPHIS
Wolf River
Des Arc
Marianna
Clarendon
Coldwater River
LITTLE ROCK
Helena
Stuttgart
Tallahatchie River
Oxford
DeWitt
Marks
Clarksdale
Yocona River
PINE BLUFF
Charleston
Tutwiler
Rosedale
Yalobusha River
Glendora
Grenada
Cleveland
Arkansas City
Greenwood
Monticello
GREENVILLE
Lake Village
Belzoni
Tchula
Eudora
Rolling Fork
Yazoo City
Bastrop
Lake Providence
Big Black River
Pearl River
MONROE
Tallulah
VICKSBURG
JACKSON
Macon Ridge
Winnsboro
Columbia
St. Joseph
Sicily Island
Harrisonburg
Jonesville
Ferriday
NATCHEZ
Catahoula Lake
Red R.
ALEXANDRIA
Marksville
Woodville
Simmesport
Angola
Bayou Sara
Melville
Opelousas
BATON ROUGE
Hammond
Covington
Slidell
Gulfport
Biloxi
Mississippi Sound
Crowley
Plaquemine
LAKE PONTCHARTRAIN
Lafayette
Donaldsonville
NEW ORLEANS
Thibodaux
Franklin
Morgan City
Houma
HEAD OF PASSES
Current River
Black River
White River
Little Red River
Arkansas River
Saline River
Ouachita River
CROWLEYS RIDGE
RIDGE
RIVER
ARKANSAS RIVER
MISS. RIVER
OHIO RIVER
MISS.
ARKANSAS RIVER
RED RIVER
MRC/2588 Sh. 29

FIGURE 44

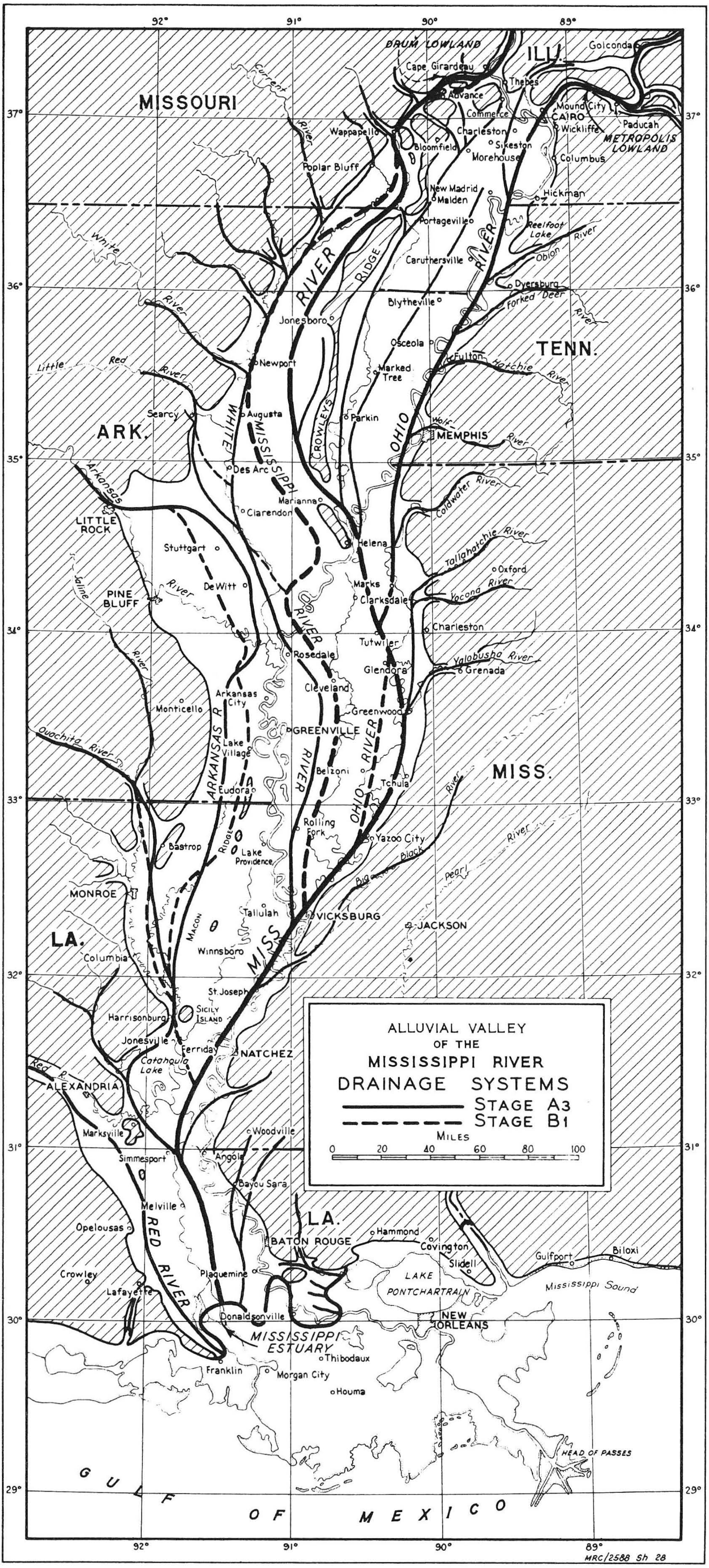

ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEMS
STAGE A3
STAGE B1
MILES
0 20 40 60 80 100
MISSOURI
ARK.
TENN.
MISS.
LA.
ILL.
GULF OF MEXICO
MRC/2588 Sh 28

FIGURE 43

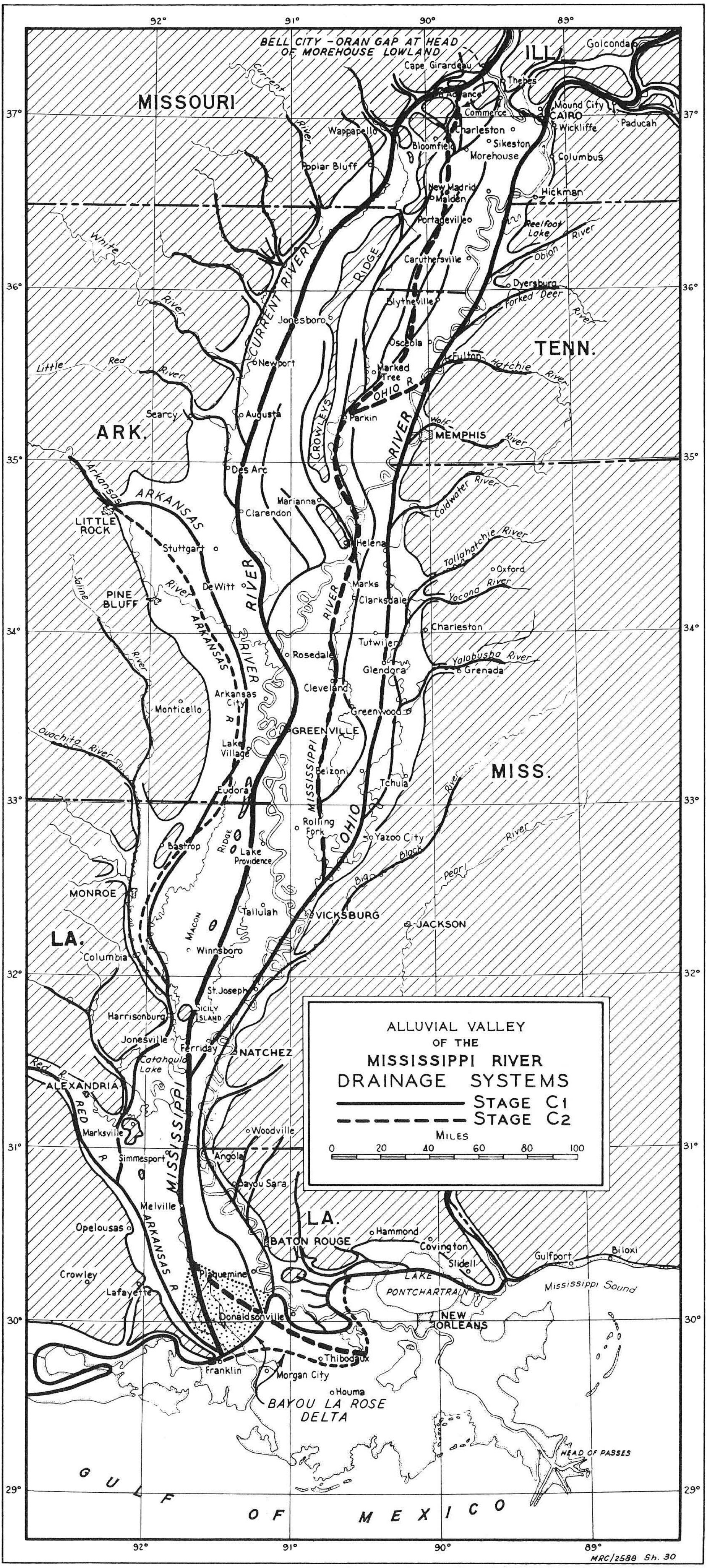

BELL CITY - ORAN GAP AT HEAD OF MOREHOUSE LOWLAND
MISSOURI
ILL.
TENN.
ARK.
MISS.
LA.
ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEMS
STAGE C1
STAGE C2
MILES
0 20 40 60 80 100
CURRENT RIVER
CROWLEYS RIDGE
OHIO RIVER
ARKANSAS RIVER
MISSISSIPPI RIVER
BAYOU LA ROSE DELTA
GULF OF MEXICO
LAKE PONTCHARTRAIN
Mississippi Sound
HEAD OF PASSES
Cape Girardeau
Cairo
Memphis
Helena
Greenville
Vicksburg
Natchez
Baton Rouge
New Orleans
Little Rock
Pine Bluff
Monroe
Alexandria
Jackson
MRC/2588 Sh. 30

FIGURE 45

until the slope was adjusted and the gradient through the Bell City-Oran Gap was no longer appreciably steeper than that upstream. The record of the entrenchment of the Mississippi is preserved in a series of levee ridges east of Advance, Mo., and in the Morehouse Lowland. Each successively younger levee ridge at Advance is found at a lower elevation, indicating that entrenchment was progressive (figure 27 and plate 21). The most westerly and highest levee was probably the result of diversion of bed load at the point where the stream initially bifurcated.

This progressive entrenchment of the Mississippi River in the Morehouse Lowland continued through J stage, as long as the Mississippi continued to flow through the Bell City-Oran Gap.

When the Mississippi River was first diverted into the Eastern Lowland, it followed an independent course west of the Ohio River to Cleveland, Miss., near the north end of the Yazoo Basin. This condition was short lived, however, as the Ohio soon shifted away from its course along the eastern valley wall and established a junction with the Mississippi east of Marked Tree, Ark. Below the Ohio-Mississippi junction, the combined stream, flowing in its earliest Sunflower meander belt, meandered in a channel similar in every respect to that of the present lower Mississippi River. Above the junction the Mississippi was still a braided stream, entrenching in the Morehouse Lowland.

**D Stage—The Sunflower System.** D stage is synonymous with the period of occupancy of the Maringouin Delta following the abandonment of the Bayou La Rose Delta at the end of $C_3$ stage. The D stage Mississippi and Ohio rivers joined east of Marked Tree, Ark. (figure 46), and flowed to the delta by way of the Lower St. Francis and Sunflower meander belt segments (figure 36). The Sunflower system differed most markedly from the present system in that the Mississippi River was still actively adjusting itself above the Ohio junction. This adjustment is evidenced by the entrenchment of the Mississippi in the $C_1$ surface and by the braided character of the channel. It was this process of readjustment by the Mississippi that led to the break up of the Sunflower system and the eventual abandonment of the Sunflower meander belt segment. D stage (plate 19) shows that the gradient through the Morehouse Lowland had flattened significantly since $C_1$ stage and also indicates a comparative flattening of slope downstream in the Yazoo Delta portion of the channel.

**E-J Stages—The Breakdown of the Sunflower System.** The time following the abandonment of the D stage Maringouin Delta system, but prior to the diversion of low-water flow of the Mississippi through Thebes Gap, constitutes stages E to J. During this period there was a gradual increase in the proportion of the Mississippi flow through Thebes Gap and the Cocodrie Delta system was built. The Ohio River was diverted down the "Wolf-Hatchie" River into the Yazoo meander belt, the Mississippi River occupied the short lived Upper Tensas meander belt, and finally the combined Ohio-Mississippi began to occupy the present meander belt from approximately the vicinity of Helena, Ark., to Vicksburg, Miss. The sequence of these events may be summarized as follows:

*Early E Stage*: Start of the diversion of the Ohio River down the "Wolf-Hatchie" River into the Yazoo meander belt and the beginning of the deterioration of the Sunflower meander belt.

*E-H Stages*: Gradual diversion of the Ohio River into the Yazoo meander belt and the establishment of the H Stage Mississippi-Ohio junction near St. Joseph, La.

*F-H Stages*: Gradual diversion of the Mississippi River from its Sunflower course near Helena, Ark., to form the Upper Tensas course in the portion of the modern meander belt as far south as Alsatia, La.

*H-I Stages*: Gradual westward diversion of Ohio River. By I Stage the Yazoo River carried only a small percentage of the Ohio flow.

The Ohio and Mississippi flowed in nearly parallel courses on the same floodplain for nearly 400 miles during H Stage (figure 47 and plate 15). The H stage drainage system, which is termed the Cocodrie system, after Bayou Cocodrie in central Louisiana, the best preserved segment of the master stream, was very unstable and soon gave way to a simpler system in which the main flow of the Mississippi and Ohio rivers was concentrated in a single channel throughout the valley. The Cocodrie system is perhaps better represented as the end product of the breakdown of the Sunflower system.

*I-J Stages*: Gradual abandonment of Upper Tensas course by Mississippi River in favor of the Walnut Bayou course.

**The Thebes Diversion.** The same factors which permitted the diversion of waters from the Advance Lowland through the Bell City-Oran Gap into the Morehouse Lowland caused the diversion of the Mississippi River through Thebes Gap. The shorter course through Thebes Gap to the Ohio River provided a gradient advantage over that by way of the Morehouse Lowland.

Diversion followed the trunk channel of a north-flowing stream within the Commerce Hills (plate 21). The topography of the area indicates that the headwaters of the north-flowing tributary system had been truncated near the mouth of Thebes Gap. This truncation may have been accomplished by faulting which is known to exist at the mouth of the gap,[1] or by the bluff cutting action of the Ohio River when it was occupying its Cache Lowland course, or by a combination of the two processes. It left a sag in the escarpment of the Eastern Lowland, which made possible the diversion.

The north-flowing tributary stream system had been subjected to alternate cutting and filling which affected the major streams during the Quaternary period. During the late Wisconsin glacial stage, the stream was entrenched to meet the lowering Mississippi River and cut a deep, narrow gorge which later filled as the Mississippi alluviated its valley. As valley filling progressed, the trunk tributary was subjected to backwater flooding by the Mississippi, and eventually floodwaters spilled through the sag into the Eastern Lowland.

Floodwaters probably spilled through Thebes Gap from as early as the A stages, when alluviation of the Western Lowland had reached its maximum. The narrowness of the gap and the extreme resistance to scour of its Paleozoic rock floor made difficult the cutting of a channel capable of carrying low-water flow. Braided channels below Thebes Gap can be traced from the area at the eastern foot of Sikeston Ridge directly into

[1] Geological Map of Missouri, Missouri Geol. Survey and Water Resources, 1939.

the gap. They were established by Mississippi flood waters flowing through the gap and indicate that as much as one-half the flood discharge passed through the gap during H-J time.

The diversion of low-water through Thebes Gap following J stage was facilitated by the migration of a bend of the Mississippi River directly against the head of the gap (plate 21). The bend was so shaped that the Mississippi flood was directed into the gap, and eventually the entire low-water flow was diverted.

The waters flowing through Thebes Gap late in J time abandoned the Eastern Lowland course near Sikeston Ridge and shifted their position at the mouth of the gap. They established a short, southeasterly course to the Ohio River near Cairo, Ill., and probably followed the lower course of the Cache-Ohio River. This shift increased the gradient advantage and helped to bring about complete diversion of the Mississippi River.

*Stages 1-20—The Evolution of the Present Meander Belt*

**Introduction.** The early aggradational history of the alluvial valley was characterized by many shifts in positions of the streams. The junction position of the Mississippi and Ohio rivers varied widely in early stages but has remained near Cairo, Ill., since the time of the Thebes Gap diversion. Following the Thebes Gap diversion the only major changes in the master stream have been four downstream diversions which initiated new meander belt segments. The most northerly of the diversions resulted in the abandonment of the St. Francis segment in favor of the presently occupied meander belt between Richardsons, Tenn., and Helena, Ark. The next diversion downstream took place near Vicksburg, Miss., where the Walnut Bayou segment was abandoned in favor of the meander belt between Vicksburg and Angola, La. The third diversion occurred when the Walnut Bayou meander belt bifurcated from the Teche meander belt near the mouth of the present Black River and flowed southward past Donaldsonville, La., in the Lafourche segment. The diversion from the Lafourche segment to the present course past New Orleans took place at Donaldsonville. Minor changes have resulted from meander migration and from the development of distributary systems in the deltas. The position of the meander belts, delta systems, and distributary streams are shown on plate 15.

Details of the history of the Mississippi River following its diversion through Thebes Gap are shown on maps of plate 22. This late epoch of the river's history has been divided into 20 stages, separated by intervals of 100 years, each of which is represented by a reconstructed ancient course. (Stages 17 through 20 are marked by historical courses dating from 1765.) The maps of plate 22 are confined to a strip along the present river and do not show the Teche segment, large parts of the Walnut Bayou segment, or the St. Francis and Lafourche segments of the meander belts in their entirety.

The position of each reconstructed course in the meander belt was established from study of local accretion topography shown on aerial photographs. Reconstructions of stream courses were made by projecting the curvature of an isolated channel segment to its junction with another channel segment whose comparable age had been previously determined by similar studies of local accretion features. The curvature of channel segments is shown in the shape of bar ridges and swales, in the shape of arcuate streams and ox-bow lakes occupying abandoned channels, and in the distribution of natural levee deposits. The relative age of channel segments within local areas of the meander belt was determined by the cross-cutting relationships of the various channel scars but the dating in years given was determined by the rate of local channel migration based on analogy to known migration since 1765.

Only the major events in the evolution of the present meander belt are discussed herein. Those details considered are illustrated on the map (plate 22) or on the profiles of the reconstructed stream courses shown on plate 23. Significant events of the history are summarized and tabulated at the end of this section of the report.

**Stage 1 Drainage.** The drainage system of stage 1 is shown on figure 48. The Mississippi River occupied its present meander belt as far as Richardsons, Tenn., thence swung westward in the St. Francis segment to Helena, Ark., followed the present meander belt to Tallulah, La., and entered the Gulf south of Houma, La., by way of the Walnut Bayou and Teche segments (plate 15). This course differed from the preceding H and J courses mainly in the position through which the Mississippi River entered the valley, the location of the Mississippi-Ohio junction, and in delta position. The Vermilion River at Lafayette, La., probably served as a distributary of the Mississippi for the first time during this stage.

The Teche segment and delta were first occupied following J time, when the Mississippi River broke from its Cocodrie channel near St. Joseph, La., and took a new course to the Gulf. The channel of the combined Red and Arkansas rivers, which were flowing to the Gulf in an independent course along the western valley wall, probably served as the pilot channel followed by the newly diverted Mississippi.

**Stage 2 Drainage.** This stage marks the final occupancy of the St. Francis segment, which was abandoned at the end of the stage for a shorter course past Memphis, Tenn. Scars on the floodplain south of Memphis indicate that the combined eastern marginal drainage, the "Wolf-Hatchie" River, must have served as a by-pass channel for the Mississippi floodwaters as early as stage 1. This by-pass channel carried an increasing flow during stage 2 until the entire low-water flow of the Mississippi was diverted into it.

**Stage 3 Drainage.** Starting with stage 3, the Mississippi River flowed in a meandering channel within its present meander belt from Commerce, Mo., to the latitude of Vicksburg, Miss.; south of this latitude, it followed the Walnut Bayou and Teche segments to the Gulf. The drainage of stage 3, just before the Mississippi shifted out of its Teche channel, is shown on figure 49. Details on the final position of the Teche-Mississippi channel and courses in its delta are shown on the map (plate 15).

**Stage 4 Drainage.** The Mississippi River left its Teche channel north of Marksville, La., and took a new course down the western side of the valley to the Gulf in stage 4. Details of this diversion are not known, but is seems probable that the shift was to a deep-water pilot channel which was carrying the marginal drainage from Memphis, Tenn., southward. (See Yazoo River, figure 50.) Diversion probably took place as a

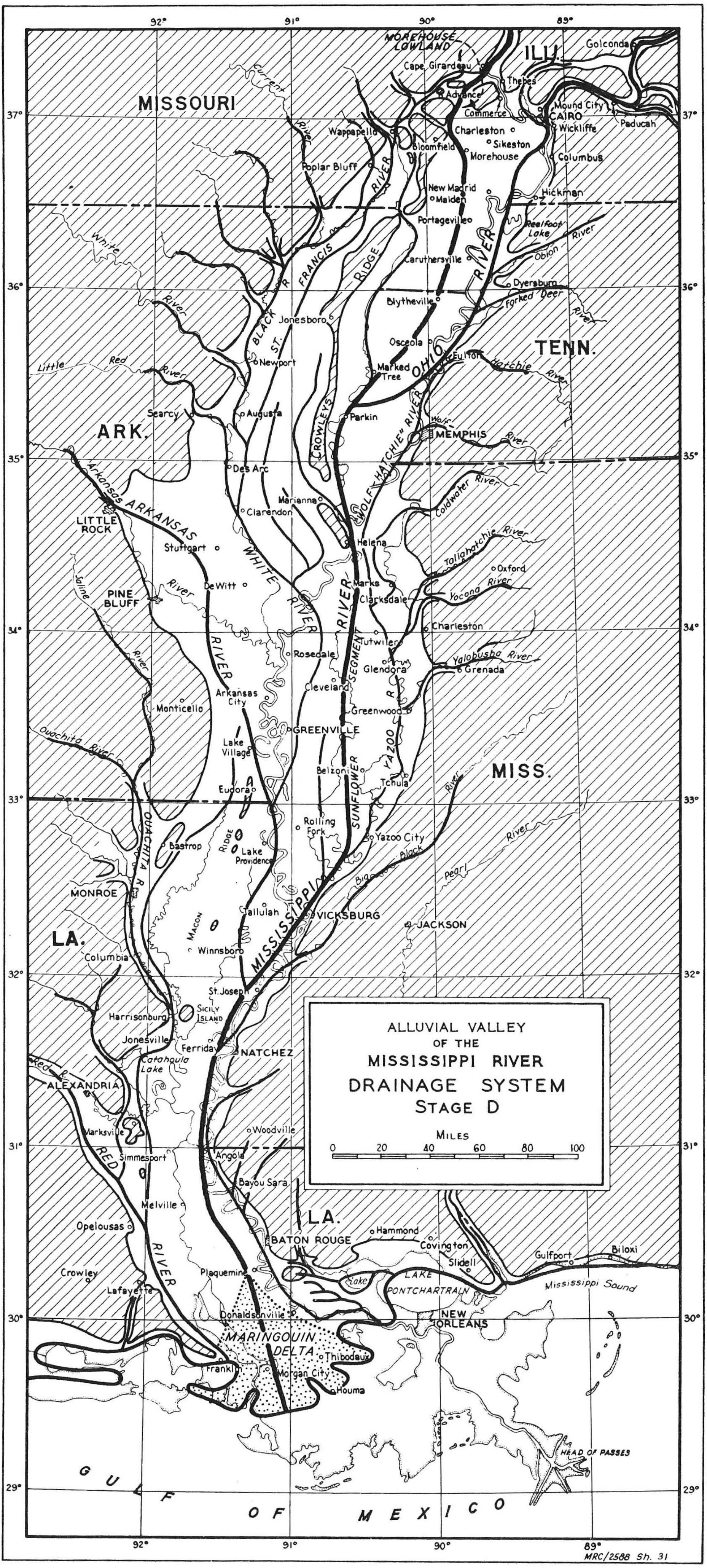

ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEM
STAGE D
MILES
0 20 40 60 80 100
MISSOURI
ILL.
TENN.
ARK.
MISS.
LA.
MISSISSIPPI RIVER
OHIO RIVER
ARKANSAS RIVER
WHITE RIVER
ST. FRANCIS R
BLACK R
CROWLEYS RIDGE
SUNFLOWER RIVER SEGMENT
YAZOO R
RED RIVER
OUACHITA R
MARINGOUIN DELTA
LAKE PONTCHARTRAIN
Mississippi Sound
GULF OF MEXICO
HEAD OF PASSES
MOREHOUSE LOWLAND
MEMPHIS
VICKSBURG
NATCHEZ
BATON ROUGE
NEW ORLEANS
ALEXANDRIA
MONROE
LITTLE ROCK
PINE BLUFF
GREENVILLE
JACKSON
MRC/2588 Sh. 31

FIGURE 46

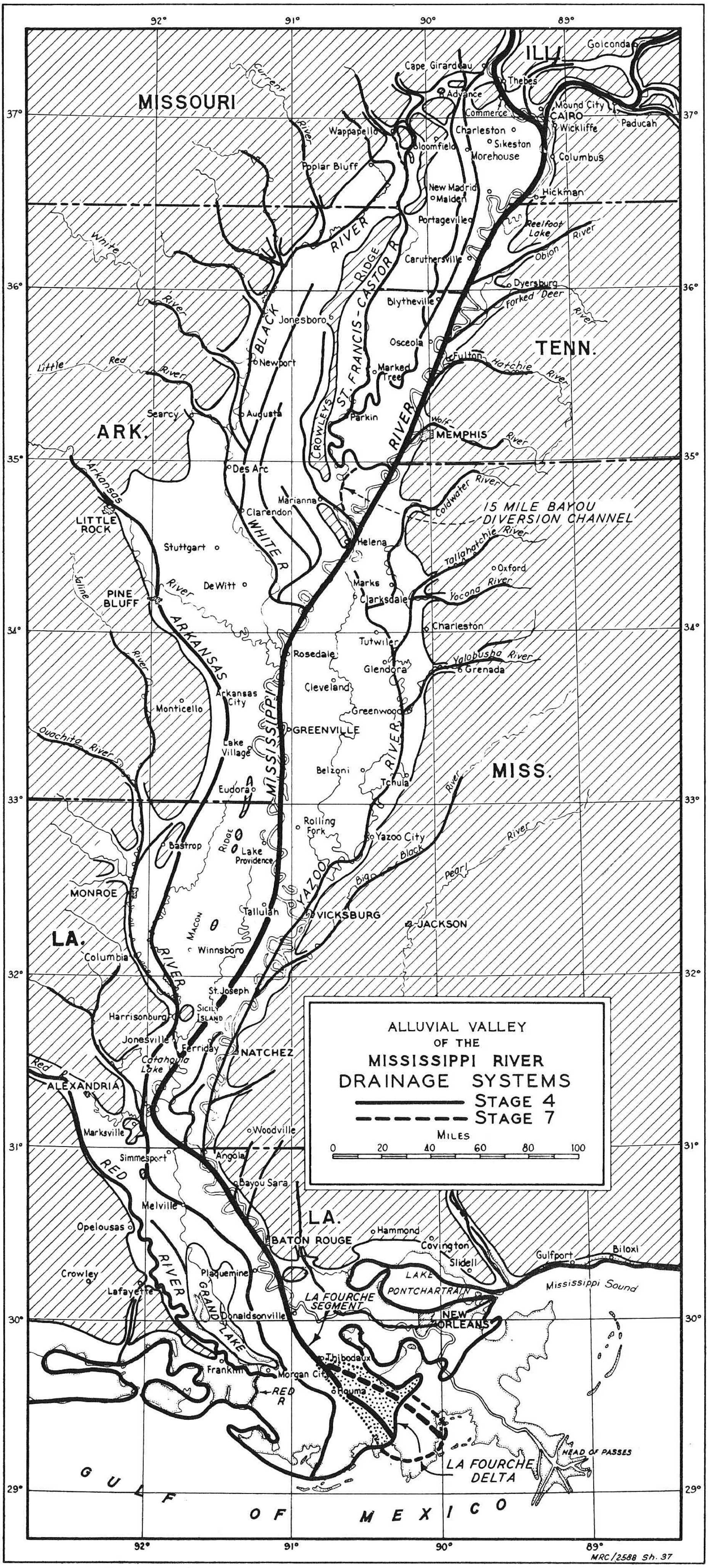

ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEMS
STAGE 4
STAGE 7
MILES
0 20 40 60 80 100
MRC/2588 Sh. 37

FIGURE 50

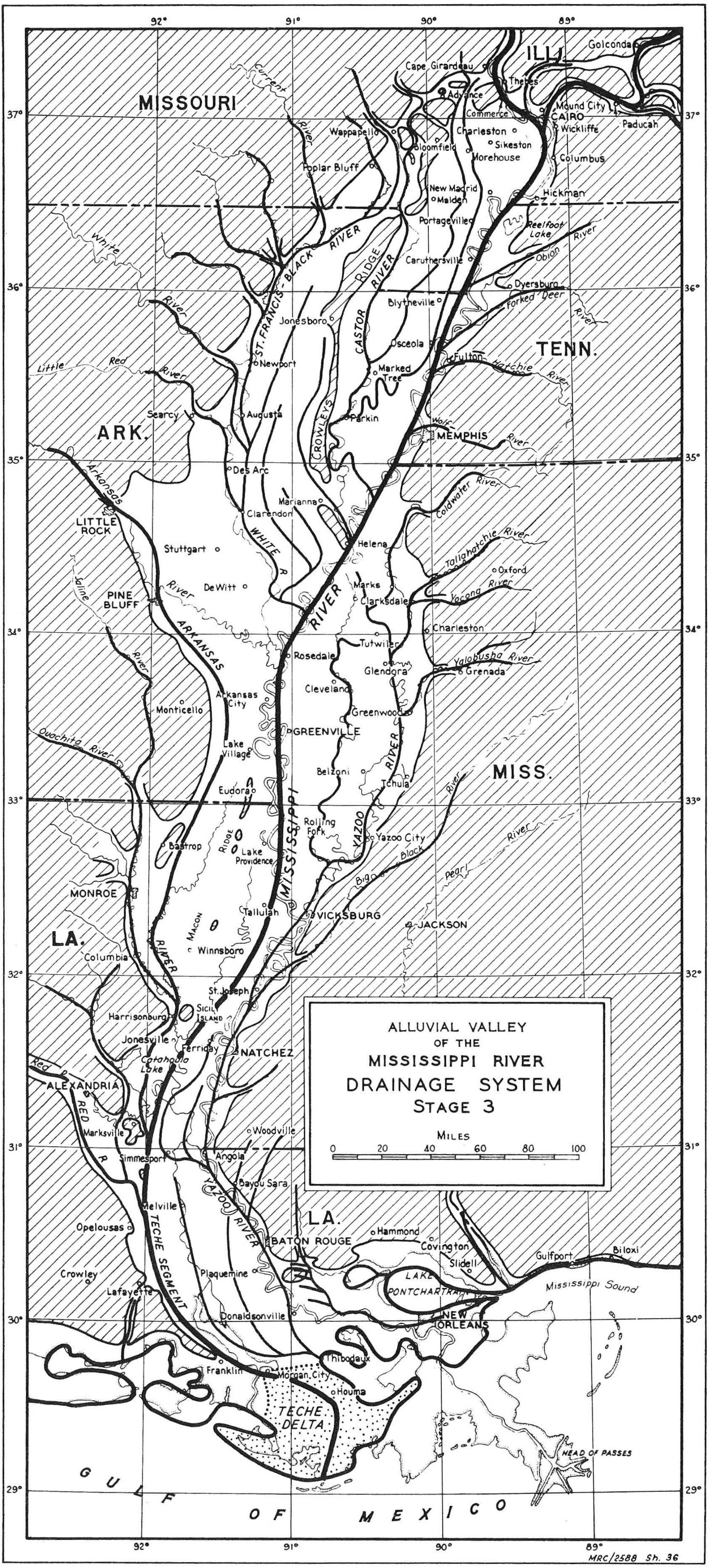
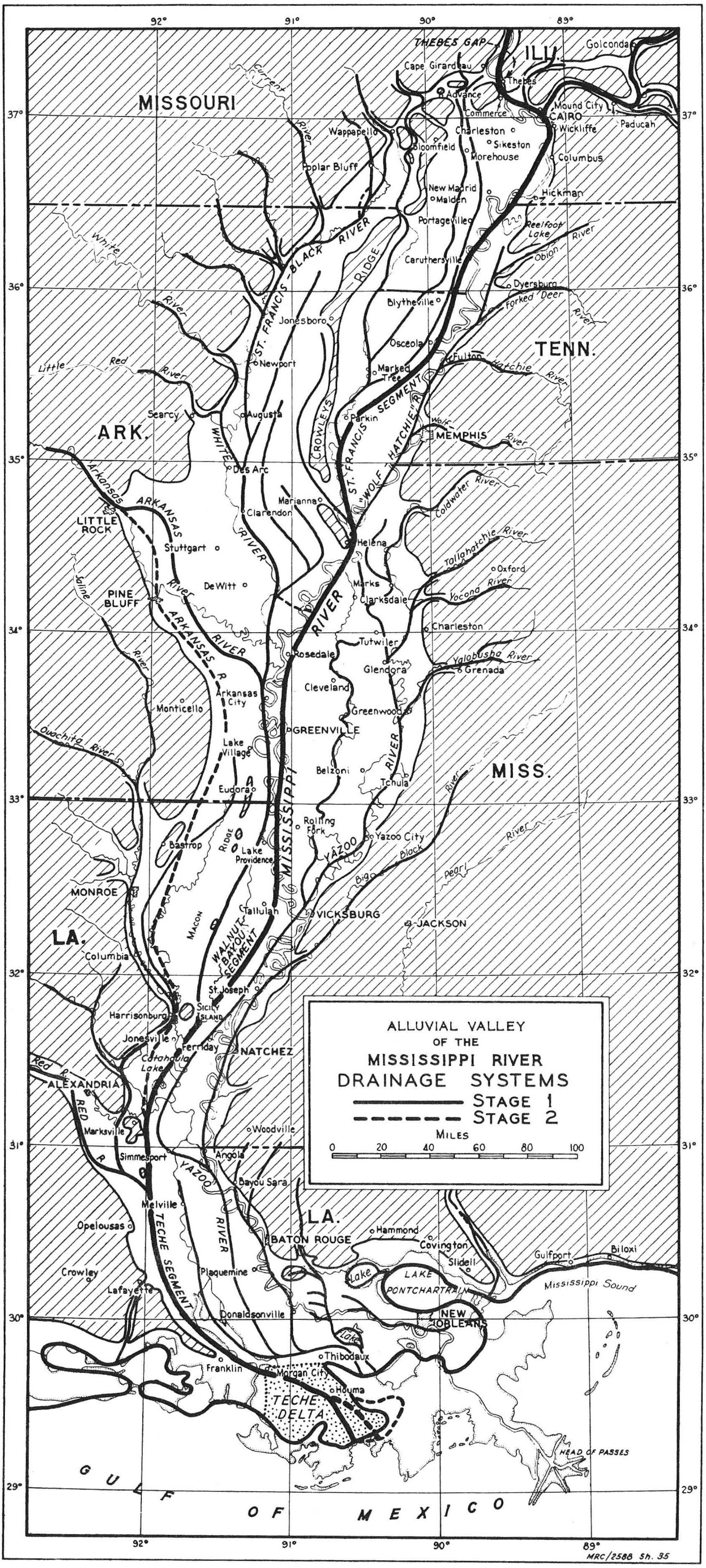

ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEM
Stage 3
Miles
0 20 40 60 80 100
MISSOURI
ILL.
TENN.
ARK.
MISS.
LA.
LA.
GULF OF MEXICO
MISSISSIPPI RIVER
ST. FRANCIS - BLACK RIVER
CASTOR RIVER
RIDGE
CROWLEYS RIDGE
WHITE R
ARKANSAS River
YAZOO RIVER
MACON RIDGE
TECHE SEGMENT
TECHE DELTA
LAKE PONTCHARTRAIN
Mississippi Sound
HEAD OF PASSES
Cape Girardeau
Golconda
Thebes
Advance
Commerce
Mound City
CAIRO
Wickliffe
Paducah
Charleston
Wappapello
Bloomfield
Sikeston
Morehouse
Columbus
Poplar Bluff
New Madrid
Malden
Hickman
Portageville
Reelfoot Lake
Obion River
Caruthersville
Dyersburg
Forked Deer River
Blytheville
Jonesboro
Osceola
Fulton
Hatchie River
Newport
Marked Tree
Searcy
Augusta
Parkin
MEMPHIS
Wolf River
Des Arc
Marianna
Coldwater River
LITTLE ROCK
Clarendon
Helena
Tallahatchie River
Stuttgart
Oxford
DeWitt
Marks
Clarksdale
Yocona River
PINE BLUFF
Charleston
Tutwiler
Rosedale
Glendora
Yalobusha River
Grenada
Cleveland
Arkansas City
Monticello
Greenwood
GREENVILLE
Lake Village
Ouachita River
Belzoni
Tchula
Eudora
Rolling Fork
Yazoo City
Bastrop
Lake Providence
Big Black River
Pearl River
MONROE
Tallulah
VICKSBURG
JACKSON
Winnsboro
Columbia
St. Joseph
Harrisonburg
Sicily Island
Jonesville
Ferriday
NATCHEZ
Catahoula Lake
ALEXANDRIA
Red River
RED R
Marksville
Woodville
Simmesport
Angola
Bayou Sara
Melville
Opelousas
BATON ROUGE
Hammond
Covington
Slidell
Gulfport
Biloxi
Crowley
Lafayette
Plaquemine
Donaldsonville
NEW ORLEANS
Thibodaux
Franklin
Morgan City
Houma
Current River
White River
Little Red River
Saline River
92° 91° 90° 89°
37° 36° 35° 34° 33° 32° 31° 30° 29°
MRC/2588 Sh. 36

FIGURE 49



ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEMS
STAGE 1
STAGE 2
MILES
0 20 40 60 80 100
MISSOURI
ILL.
ARK.
TENN.
MISS.
LA.
GULF OF MEXICO
MRC/2588 Sh. 35


FIGURE 48

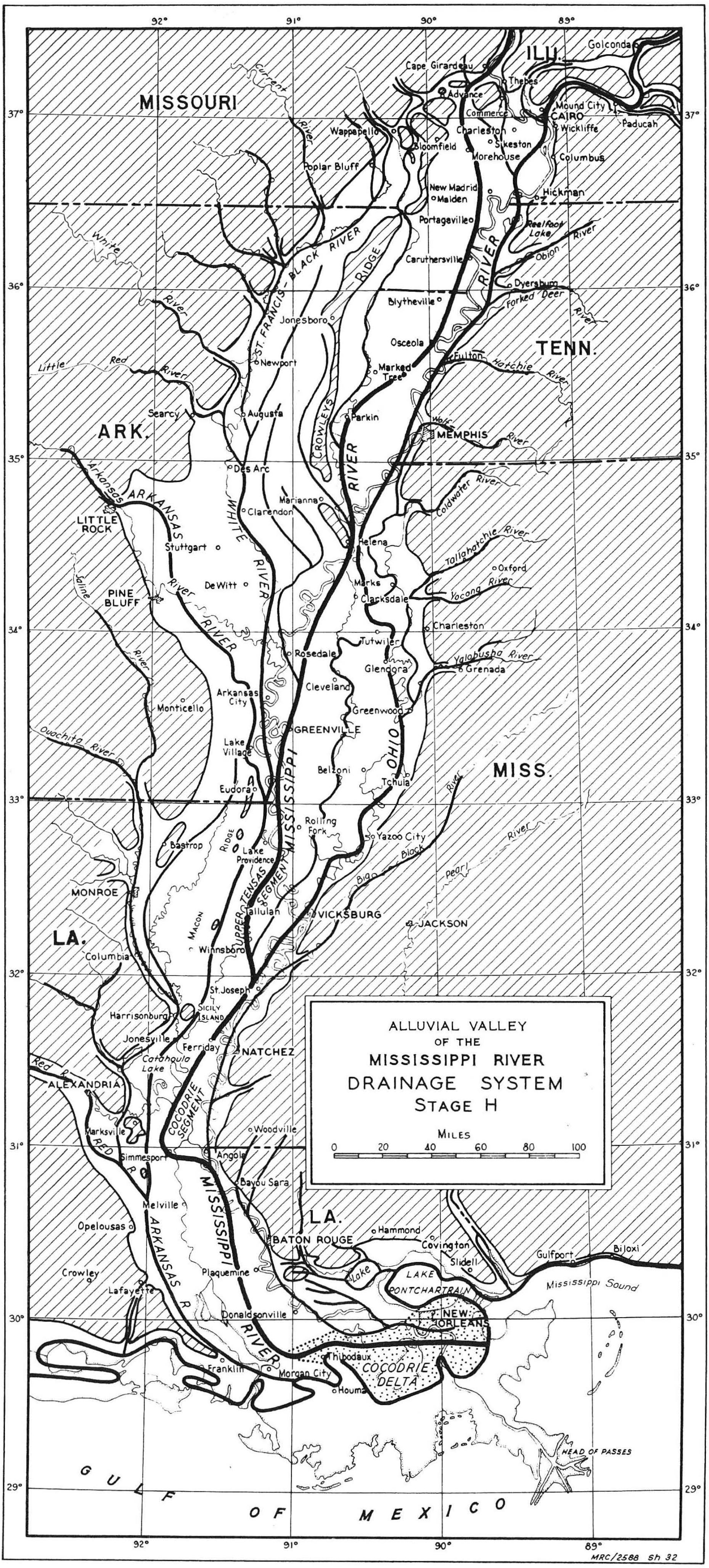

ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEM
STAGE H
MILES
0 20 40 60 80 100
MISSOURI
ILL.
TENN.
ARK.
MISS.
LA.
GULF OF MEXICO
MRC/2588 sh 32

FIGURE 47

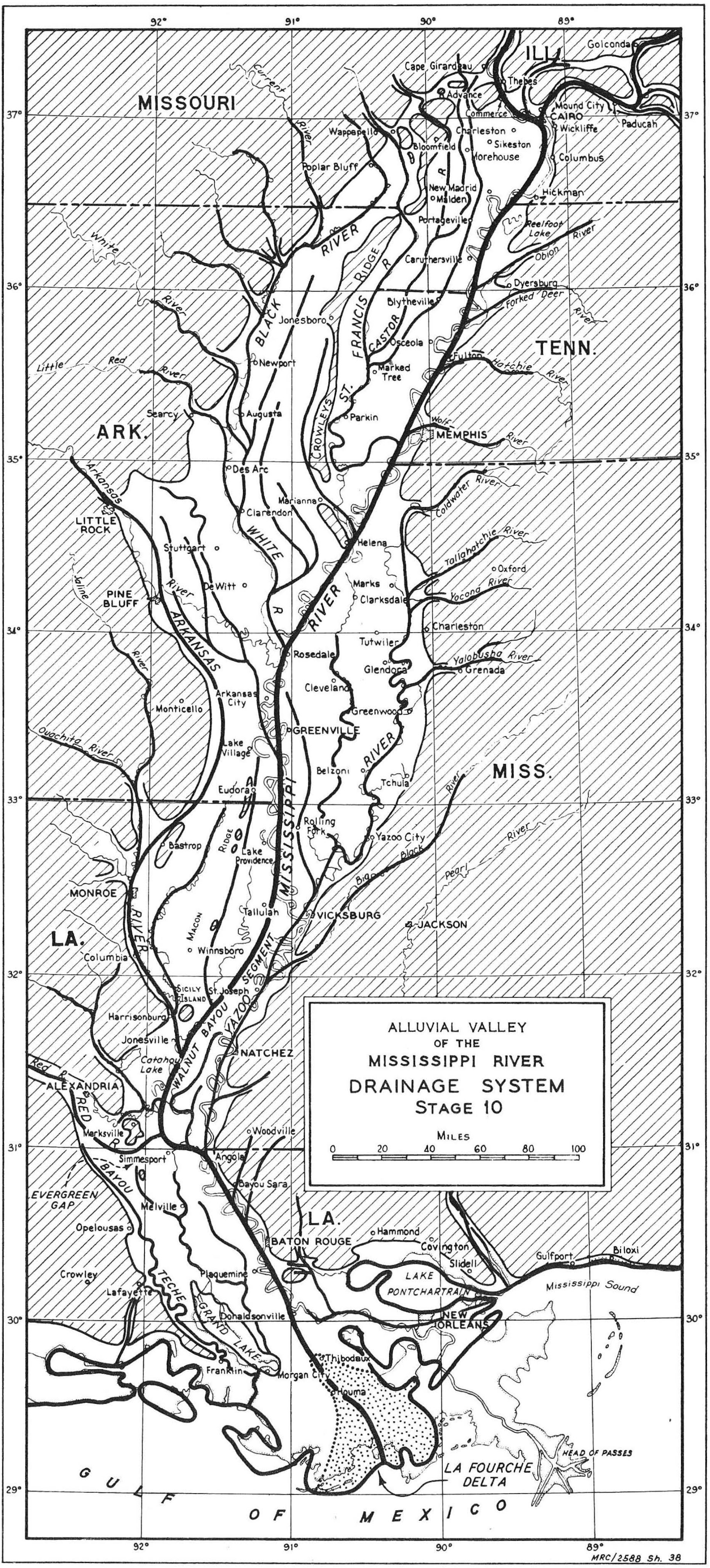

ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEM
STAGE 10
MILES
0 20 40 60 80 100
MISSOURI
ILL.
TENN.
ARK.
MISS.
LA.
GULF OF MEXICO
LA FOURCHE DELTA
HEAD OF PASSES
MRC/2588 Sh. 38

FIGURE 51

result of faulting along the Red River fault zone. Traces of fracturing on the floodplain between the Marksville Hills and Lake Maurepas are observable on aerial photographs. These traces correspond with the direction of stream diversion.

The drainage of stage 4, the stage immediately following the abandonment of the Teche, is shown on figure 50. This map shows the Mississippi River in its first occupancy of the great Lafourche Delta system which built out from near Thibodaux, La. During this stage, the combined Red and Arkansas rivers flowed directly to the Gulf because the Mississippi left its Teche channel above the Red and Arkansas junction and thus abandoned them in its old channel. The Arkansas River soon left the Teche channel for a course down the Atchafalaya Basin and did not rejoin the Mississippi before stage 5. Traces of Red River occupancy of the Teche channel are well preserved in the narrow inner levees of the present Teche Bayou.

**Fifteen Mile Bayou By-pass Channel.** The Mississippi River had part of its flow diverted into a secondary channel west of Memphis. This secondary course, termed the Fifteen Mile Bayou by-pass channel, came into existence in stage 6, when part of the Mississippi flow was diverted by a crevasse channel down the abandoned St. Francis segment. (See plate 15 and figure 34.) It continued to be an important channel carrying perhaps a third of the Mississippi flow until stage 9, when it was abandoned because of a cut-off of the Mississippi bend from which it derives its name. In stage 10 and the following stages the diversion channel was considerably modified by the St. Francis River which occupied the old channel.

**Stage 7 Drainage.** The drainage of stage 7 is shown on figure 50. It differs from that of stage 4 mainly in the existence of the Fifteen Mile Bayou diversion channel, in the direct junction of the Arkansas River with the Mississippi River south of Jonesville, La., and in the delta region where the trunk stream was to the east of its stage 4 position. By stage 7 the Red River had abandoned the lower portion of the Teche channel and flowed to the Gulf south of Morgan City, La., through what is now known as the lower Atchafalaya Basin.

**Stage 10 Drainage—Final Occupation of Walnut Bayou Segment.** The drainage of stage 10 is shown on figure 51. By this stage the drainage north of Rosedale, Miss., had assumed essentially the form it has today. South of Rosedale it differed mainly from the present drainage in the more westerly course followed by the Arkansas and Mississippi rivers, the Red River course through the Evergreen Gap to a junction with the Mississippi River near Bordelonville, La. (figure 39), and the more westerly position of the delta. Portions of the abandoned stage 10 Mississippi channel are shown on figures 22 and 38. A part of the extensive Lafourche Delta of stages 4 to 11 is shown on figure 23.

For reconstruction of the stage 10 channel from Lake Providence, La., south, see plate 15. Detailed reconstructions of parts of stage 10 along the present meander belt are shown on history sheets (plate 22).

**State 11 Drainage—The Vicksburg Diversion.** The Walnut Bayou course was abandoned following stage 10. The diversion which took place near Vicksburg is shown on figure 2. It can be seen that the meander of stage 10 expanded until it encroached on the nearby channel of the Yazoo River at the "diversion point." Mississippi River waters followed this channel south to Angola, La., and soon enlarged it to form the main channel, gradually abandoning the older channel to the west (figure 52).

**Stage 12 Drainage—The Donaldsonville Diversion.** The Mississippi River abandoned the Lafourche Delta following stage 11 (figure 52). The Donaldsonville, La., area where the diversion took place is shown on figure 53. The Mississippi broke out on the outside of a sharp bend in course 11 and thence followed a new course to the sea. The stage 11 channel of the Amite River probably functioned as a pilot channel for this new course (figures 52 and 54). A factor which may have contributed to the diversion was movement along the Red River fault zone. Evidence of recent movement along this zone has been traced southward into the Barataria Depression region.

Diversion of the waters was probably gradual and started with the enlargement of a distributary which together with the Amite River had established a course to the Metairie subdelta east of New Orleans. As the discharge through this channel increased the course became incised in late Pleistocene sediments which underlie Recent deposits at very shallow depth.

**The Plaquemines-St. Bernard Delta.** Since the Donaldsonville diversion the Mississippi River has occupied its present meander belt from Cape Girardeau, Mo., to the apex of its Plaquemines-St. Bernard Delta. The only major shifts of the Mississippi subsequent to course 12 have been shifts from subdelta to subdelta.

**Stage 12—The Metairie Subdelta.** The earliest, or stage 12, subdelta of the Plaquemines-St. Bernard system was the Metairie subdelta. The portion of this channel indicated by Metairie Ridge continued to be occupied as late as stage 15 (figure 54 and plate 15). The subdelta was abandoned when the Mississippi River broke out of its channel within the present city limits of New Orleans, La., and established a new channel to the southeast.

**Stage 13—The St. Bernard Subdelta.** Stage 13 was the period of the building of the St. Bernard subdelta. The Mississippi River occupied a channel at St. Bernard time which followed Metairie Ridge to New Orleans, turned south through the center of the city to McDonoghville, La., and then flowed east in a course indicated by Bayou Terre aux Boeufs-Bayou La Loutre Ridge.

**Stage 14—The River aux Chenes Subdelta.** Stage 14 started with the abandonment of the St. Bernard subdelta. The important Bayou Terre aux Boeufs (plate 15) distributary channel remained open until a later period, but the main area of deltaic deposition shifted to the south. The shift occurred when major distributary channels were established in two positions, north of Gretna and just west of English Turn. This Mississippi River built out from these distributaries the River aux Chenes subdelta (plate 15).

**Stage 15—The Barataria Subdelta.** At the end of stage 14 a major distributary was established near Kenner, La., and by stage 15 (plate 15) this distributary carried Mississippi waters to the Barataria subdelta south and west of New Orleans. The Barataria subdelta, however, did not attain a development comparable to that of the earlier subdeltas, because much of the flow of the river continued to flow eastward into the older subdeltas.

**Stage 16—The Bayou Cheniere Subdelta.** A major change took place when at the end of stage 15 the Mississippi River broke out of its Barataria subdelta between Walkertown and Marrero, La., and took a new course to the east along the Lake Borgne fault zone. The alinement of the stage 16 course appears to have been controlled by the earlier channels of the River aux Chenes subdelta channels, but the direction of flow was reversed between Harvey and Algiers, La.

The system of distributaries which built southward from the vicinity of New Orleans in stage 16, the Bayou Cheniere subdelta, might well be considered as part of the present or Balize subdelta, inasmuch as it was in this stage that the Mississippi River was first established in its present course in the vicinity of New Orleans and in its great swing at English Turn.

**Stages 17-20—The Balize Subdelta.** The Balize subdelta evolved from the Bayou Cheniere subdelta by concentration of the entire flow of the river into one distributary channel. As the Balize subdelta built outward from the trunk stream, many new distributary channels developed. The period of occupancy of the Balize subdelta extends throughout the period of European occupancy of Louisiana, i.e. 1699 to the present, but probably not much longer.

Dohm[1] lists over 250 maps which include the area of the Mississippi delta. Unfortunately, delta topography is extremely difficult to survey; consequently, old maps lack the accuracy and completeness necessary for critical comparison with present-day maps. Comparison of recent maps with Captain Talcot's map of 1838, however, shows that the chief change in the delta has been a general widening of the strip of land south of the great bend at Forts (plate 15). The exact area added to the delta since the days of LaSalle is not known, but presumably it includes a very large part of the present Balize subdelta.

### *Profile Characteristics of the Stream Courses, Stages 1-20*

Several characteristics of the stream profiles as reconstructed from meander belt studies have an important bearing on the interpretation of the evolution of the present Mississippi River. Differences between profiles reflect local aggradation and entrenchment, local disturbances by faulting, prograding at the deltas, and lengthening and shortening by meandering cut-offs.

**Local Entrenchment of the Mississippi River below Thebes Gap.** Stream profiles of stages 1-3, plate 23, indicate that the Mississippi River while flowing through Thebes Gap during these stages, entrenched the Ohio alluvial fan between Commerce and New Madrid, Mo., by a depth of 15 ft. This entrenchment resulted as the Mississippi adjusted its slope to its shorter course to the Ohio River. It reflects the gradual enlargement and deepening of the Thebes Gap channel. Enlargement of the channel through the gap is still going on, but there is no evidence of continued entrenchment south of the gap subsequent to stage 3.

**Local Flattening of the Profiles.** Local flattening of a stream gradient is associated with excessive meandering. A notable example of flattening of the gradient by excessive meandering of the Mississippi River is the Greenville area where several large bends developed and were cut-off artificially (figure 55). Studies of older meander belt courses show that excessive meandering was associated with the abnormally low gradient of the Walnut Bayou stage 3 segment between Marksville and Tallulah, La., and with the low-gradient stage 10 Walnut Bayou segment between Arkansas City, Ark., and Angola, La. Diversions of the Mississippi which took place in these segments indicate that slope flattening tends to produce conditions under which bifurcation is likely to occur. The position of diversion, however, is controlled by faulting or by the point of intersection of a deep channel and a migrating river bend.

**Local Faulting.** Abrupt breaks in the stream profiles which cross the Tiptonville-Reelfoot Lake area are the result of continued movement along the Reelfoot Lake fault. (See figure 33 and plate 23.)

Breaks in the valley slope shown on the profiles of plate 19 indicate that movement along the Big Creek fault zone continued from the $A_1$ to the $C_1$ stage.

**Adjustment of Stream Gradient to Prograding of Deltas.** Prograding of the delta by lengthening of the streams tends to flatten the lower part of the stream gradient, but the river builts up its banks upstream and thereby tends to maintain its slope. Examples of adjustment to local out-building of the delta are shown on profiles, plates 19 and 23, where in the vicinity of Baton Rouge there has been an aggradation of 15 ft. between stages 4 and 10 and a further 10 ft. of upbuilding between stages 10 and 18.

**Length of Streams.** The profiles (plate 23) show the length of the Mississippi River at various stages. The length of the river has not varied over 10 percent of its mean length during its period of occupancy of Thebes Gap. Local sections, however, have varied greatly because of lengthening by meandering and shortening by natural cut-offs. Natural cut-offs cause local steepening of the gradient, and excessive meandering causes local gradient flattening. The effect of local variation in length is shown by the difference in distance between the location of towns shown on the profiles.

### *Correlation Chart*

The main features of the Recent geological history of the Lower Mississippi Alluvial Valley, which have been described in the preceding paragraphs, are summarized on the correlation chart, table 3. This chart indicates the character of the Ohio, Mississippi, Red, and Arkansas rivers during the various stages of the Recent alluvial valley history. It also shows where the Mississippi and Ohio rivers entered the alluvial valley and their junction positions. The last three columns of the chart show the channel segments and

[1] Dohm, C. F., "List of Maps Dealing with Plaquemines and St. Bernard Parishes," Louisiana Dept. Cons., Geol. Bull. No. 8, pp. 321-338, 1936.

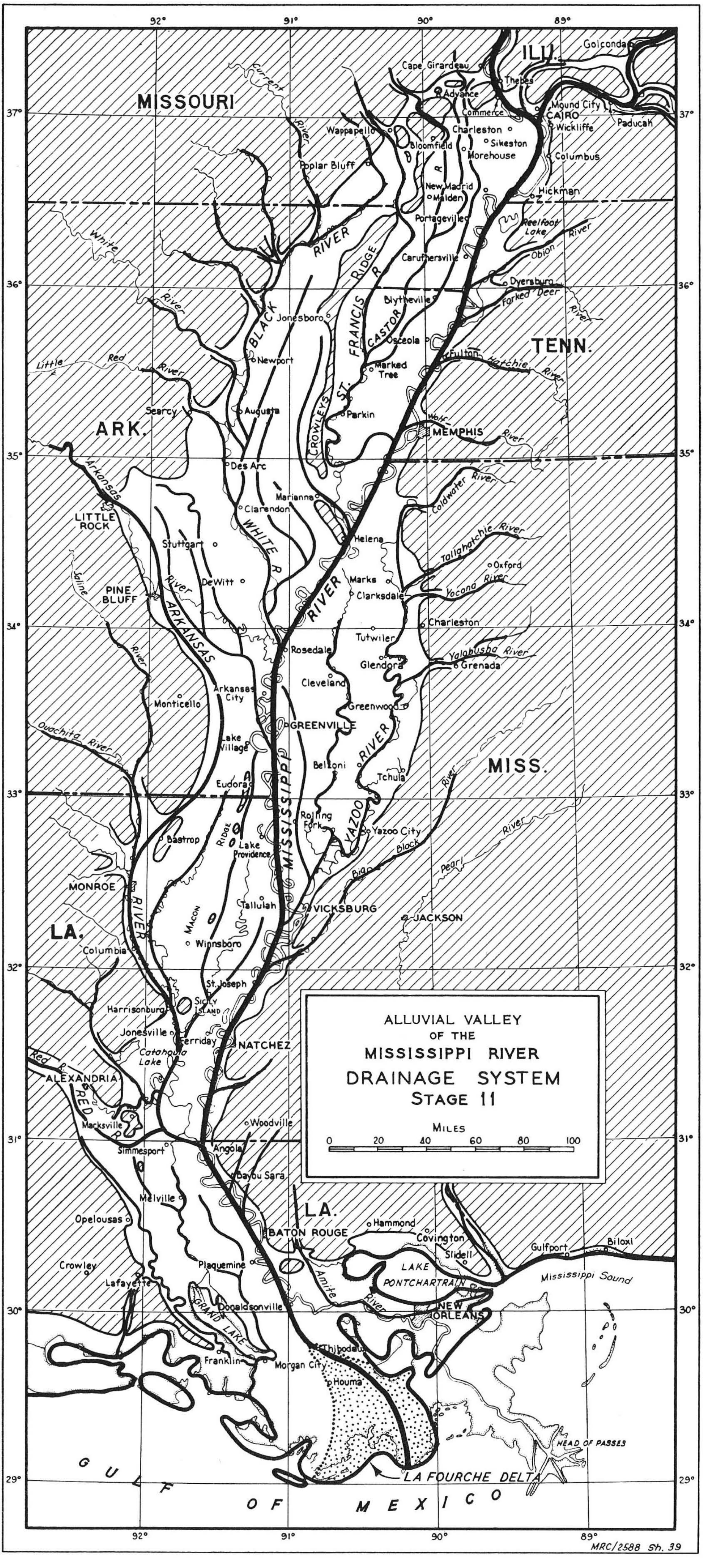

ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEM
STAGE 11
MILES
0 20 40 60 80 100
MISSOURI
ILL.
TENN.
ARK.
MISS.
LA.
LA.
GULF OF MEXICO
92° 91° 90° 89°
37° 36° 35° 34° 33° 32° 31° 30° 29°
Cape Girardeau
Thebes
Golconda
Advance
Commerce
Mound City
CAIRO
Wickliffe
Paducah
Wappapello
Charleston
Bloomfield
Sikeston
Morehouse
Columbus
Poplar Bluff
New Madrid
Malden
Hickman
Portageville
Reelfoot Lake
Obion River
Caruthersville
Dyersburg
Forked Deer River
Blytheville
Jonesboro
Osceola
Fulton
Hatchie River
Newport
Marked Tree
Little Red River
Searcy
Augusta
Parkin
Wolf River
MEMPHIS
Des Arc
Marianna
Clarendon
Coldwater River
LITTLE ROCK
Helena
Tallahatchie River
Stuttgart
Oxford
DeWitt
Marks
Clarksdale
Yocona River
PINE BLUFF
Charleston
Tutwiler
Rosedale
Glendora
Yalobusha River
Grenada
Arkansas City
Cleveland
Monticello
Greenwood
GREENVILLE
Lake Village
Ouachita River
Belzoni
Tchula
Eudora
Rolling Fork
Yazoo City
Bastrop
Lake Providence
Big Black River
Pearl River
MONROE
Tallulah
VICKSBURG
JACKSON
Winnsboro
Columbia
St. Joseph
Harrisonburg
Sicily Island
Jonesville
Ferriday
NATCHEZ
Catahoula Lake
ALEXANDRIA
Marksville
Woodville
Simmesport
Angola
Bayou Sara
Melville
Opelousas
BATON ROUGE
Hammond
Covington
Slidell
Gulfport
Biloxi
Crowley
Plaquemine
Lafayette
LAKE PONTCHARTRAIN
Mississippi Sound
Amite River
Donaldsonville
NEW ORLEANS
GRAND LAKE
Thibodaux
Franklin
Morgan City
Houma
HEAD OF PASSES
LA FOURCHE DELTA
MISSISSIPPI RIVER
YAZOO RIVER
ARKANSAS RIVER
WHITE R.
BLACK RIVER
ST. FRANCIS R.
CROWLEYS RIDGE
CASTOR R.
MACON RIDGE
RED R.
White River
Current River
Saline River
MRC/2588 Sh. 39

FIGURE 52

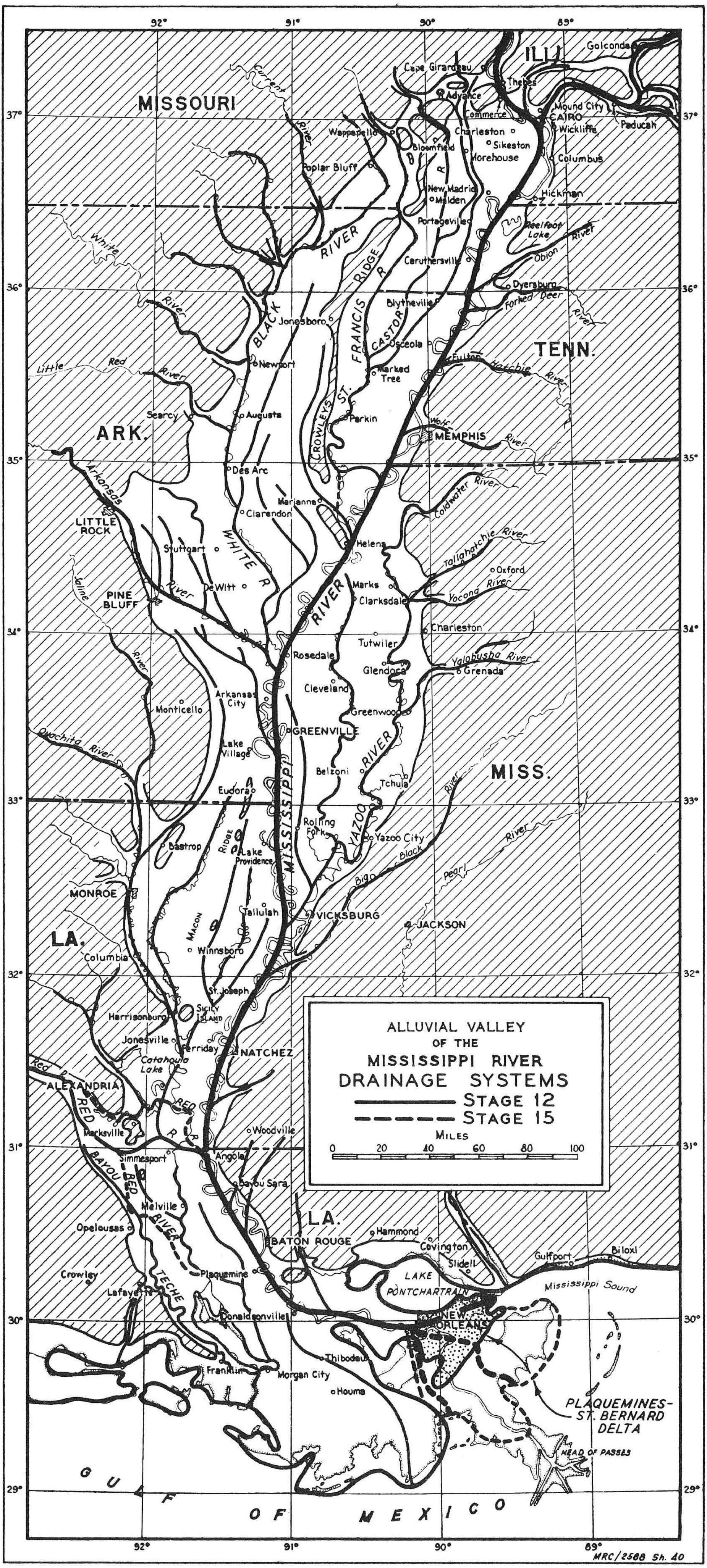
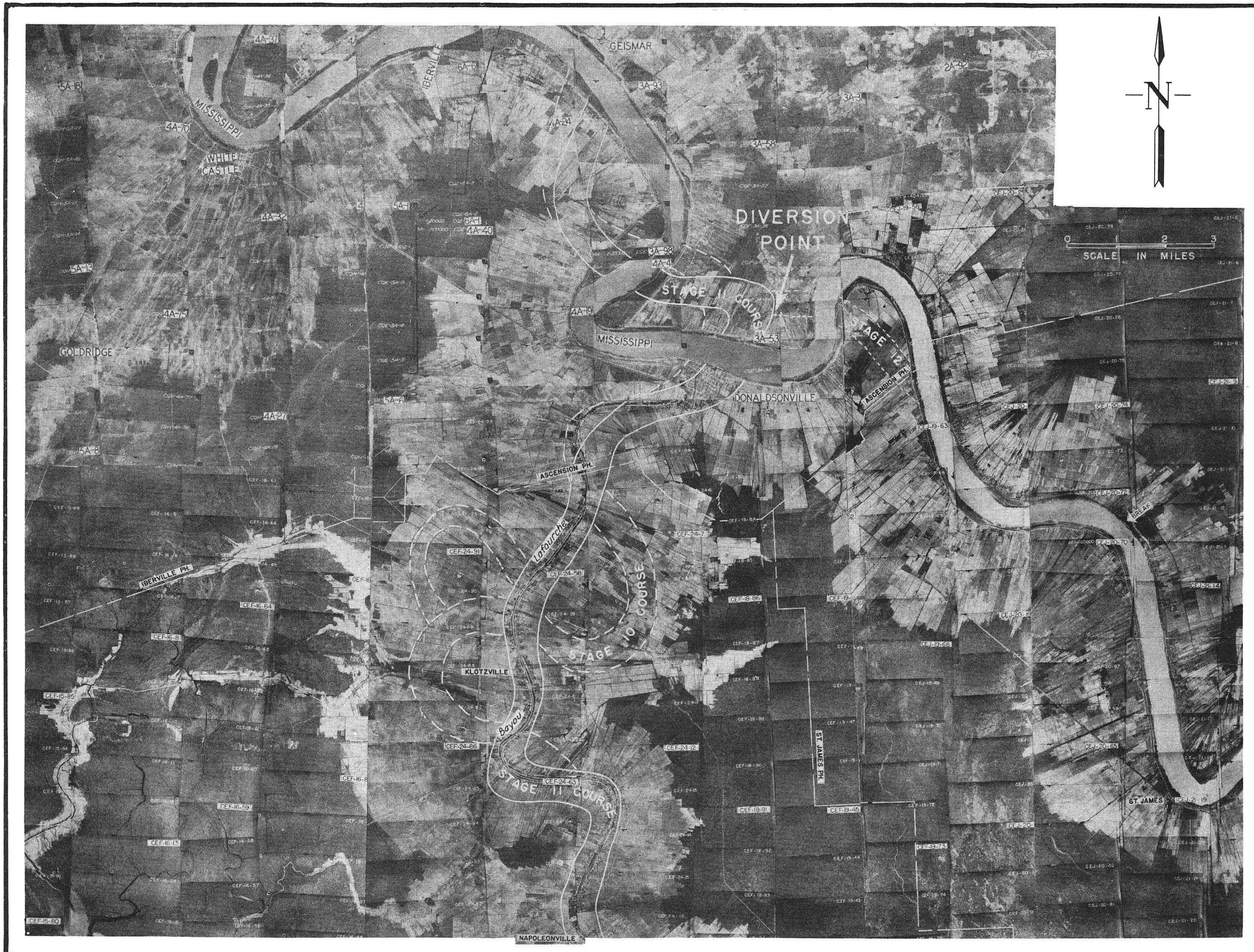

ALLUVIAL VALLEY
OF THE
MISSISSIPPI RIVER
DRAINAGE SYSTEMS
STAGE 12
STAGE 15
MILES
0 20 40 60 80 100
MISSOURI
ILL.
TENN.
ARK.
MISS.
LA.
LA.
92° 91° 90° 89°
37° 36° 35° 34° 33° 32° 31° 30° 29°
Golconda
Cape Girardeau
Thebes
Advance
Commerce
Mound City
CAIRO
Wickliffe
Paducah
Wappapello
Charleston
Sikeston
Bloomfield
Morehouse
Columbus
Poplar Bluff
New Madrid
Malden
Hickman
Portageville
Reelfoot Lake
Obion River
Caruthersville
Dyersburg
Forked Deer River
Blytheville
Jonesboro
Osceola
Fulton
Hatchie River
Newport
Marked Tree
Searcy
Augusta
Parkin
MEMPHIS
Wolf River
Des Arc
Marianna
Coldwater River
LITTLE ROCK
Clarendon
Helena
Stuttgart
Tallahatchie River
Oxford
DeWitt
Marks
PINE BLUFF
Clarksdale
Yocona River
Charleston
Tutwiler
Rosedale
Glendora
Yalobusha River
Grenada
Arkansas City
Cleveland
Monticello
Greenwood
GREENVILLE
Lake Village
Belzoni
Tchula
Eudora
Rolling Fork
Yazoo City
Bastrop
Lake Providence
MONROE
Tallulah
VICKSBURG
JACKSON
Winnsboro
Columbia
St. Joseph
Sicily Island
Harrisonburg
Jonesville
Ferriday
NATCHEZ
Catahoula Lake
ALEXANDRIA
Marksville
Woodville
Simmesport
Angola
Bayou Sara
Melville
Opelousas
BATON ROUGE
Hammond
Covington
Slidell
Gulfport
Biloxi
Crowley
Plaquemine
LAKE PONTCHARTRAIN
Mississippi Sound
Lafayette
Donaldsonville
NEW ORLEANS
Thibodaux
Franklin
Morgan City
Houma
PLAQUEMINES-ST. BERNARD DELTA
HEAD OF PASSES
GULF OF MEXICO
Current River
White River
Black River
St. Francis R
Castor R
Crowleys Ridge
Little Red River
Arkansas River
White R
Saline River
Ouachita River
Mississippi River
Yazoo River
Big Black River
Pearl River
Macon Ridge
Red R
Red River
Bayou Teche
MRC/2588 Sh. 40

FIGURE 54

FIGURE 53




POINT OF DIVERSION OF MISSISSIPPI RIVER FROM ITS BAYOU LAFOURCHE COURSE – STAGES 10 & 11

N
MOUND CREVASSE
1927
MISSISSIPPI
ASHBROOK
CUT-OFF
1935
DEER
MILLER BEND
ROWDY
BEND
CREEK
BACHELOR
TARPLEY
CUT-OFF
1935
GREENVILLE
RIVER
SPANISH MOSS BEND
LELAND CUT-OFF
1933
LA GRANGE
CREVASSE
WARFIELD
POINT
LAKE LEE
Floodplain Features
vicinity of
Greenville Bends
Scale in Miles
0 1 2 3 4


FIGURE 55

deltas occupied during the various stages. Valley slopes for several stages are expressed in feet per mile and correspond with graphic slopes indicated on the profiles (plate 19). The nature and position of the Mississippi and Ohio rivers at any stage may be ascertained by reading across the chart.

**Basis for Chronology.** Dating of the stages in the evolution of the Mississippi Alluvial Valley is based on the crosscutting relations between channel scars and the stratigraphic position of deposits and shows only relative values. The specific dates shown in years in table 4 were established by correlation with chronologies of Recent time developed from studies in other parts of the world. These chronological studies have established the date of maximum late Wisconsin glaciation as approximately 25,000-30,000 years and they fix the age of the entrenched stage in valley history. The age of the various epochs in rising sea level, inferred from studies of Mississippi Alluvial Valley deposits, were determined from European and North American glacial studies which accurately date retreat of the glaciers. The time when sea level reached its present stand approximately 6,000 years ago, was determined from European glacial studies.

The history of the development of the alluvial valley during stages 1 to 20 was established from study of floodplain accretion and channel migration in the present Mississippi River meander belt. Stages 1 to 17 cover intervals of approximately 100 years. This interval was determined by comparison with known rates of channel migration since 1765 (end of stage 17).

The chronology established from the sequence of Indian cultures[1,2] in the alluvial valley agrees closely with the stages in meander belt development.

The chronology of Recent time and the correlation with the stages in the development of the alluvial valley are presented in table 4.

### *Evolution of Major Tributary Streams*

The history of the tributary streams of the lower Mississippi within the alluvial valley reveals a complexity which rivals that of the Mississippi itself. Changes in character and position of the master stream have repeatedly disturbed the equilibrium of the tributaries and necessitated readjustment of channel and gradient. To a lesser extent, activities of the tributaries have influenced the slope and behavior of the master stream. The histories of some of the more important tributaries are briefly discussed and presented in tabular form (tables 5 to 9). Their stages are correlated with those established for the Mississippi River. Positions of tributary streams at various stages are shown on figures 42 to 52 and plate 15. The streams are discussed in order of their importance to the interpretation of the history of the alluvial valley.

**The Arkansas River.** The Arkansas River has been a tributary of the Mississippi River except during stages $A_2$, C, and E through H, when it followed an independent course to the Gulf of Mexico. Throughout most of its history it has followed courses west of Macon Ridge and joined the Ouachita River above its junction with the Mississippi, but during stages D to 1 and 12 to 20 it flowed east of the ridge. The level to which the Arkansas River attempted to adjust its course was in turn, the Mississippi, the Ouachita, and the Gulf of Mexico, depending into which water body it flowed (table 5).

The Arkansas receives no major tributaries in the alluvial valley today, but in the past the Red, the Ouachita, and the White rivers have been direct tributaries. The introduction of these tributaries modified the activity of the Arkansas by enabling it to flow on a lower slope or by otherwise changing its regimen. On the northern portion of the Arkansas alluvial fan, abandoned meander scars indicate channels similar to that which is occupied by the present river. Active faulting along the Catahoula Lake fault zone, however, caused the river to entrench its alluvial fan on Macon Ridge and to develop shallow braided channels.

Shifts in the Arkansas River course took place most frequently near the head of the alluvial fan at Little Rock, Ark. An important downstream shift during stage $C_2$ diverted the Arkansas to the west of the Marksville Hills in Louisiana. This diversion was southwestward through the Moncla Gap into a south-flowing tributary of the Red River. Another shift, during stage 5, diverted the river to the west of the Bastrop Hills. This course followed a valley excavated by the east-flowing entrenched Ouachita River in late glacial time. The Ouachita had abandoned this gap and shifted to the south early in the alluviation of the valley. In stage 4 just before the diversion of the Arkansas, the gap west of the Bastrop Hills was drained by a minor southwest-flowing tributary of the Ouachita River. The present stream flowing through this gap, Bayou Bartholomew, has excellently preserved Arkansas meanders. It was abandoned by the Arkansas during stage 12.

Channel shifts of the Arkansas River usually followed those of the Mississippi River. An instance of such a relationship is the diversion of the Mississippi from its Teche course, which left the Arkansas in the old Mississippi channel early in stage 4. The Arkansas was not able to maintain this channel and soon shifted out of it in favor of a more direct junction with the Mississippi.

**The Red River.** The Red River differs from other major tributaries of the lower Mississippi River in the great width of its alluvial valley. It enters the Central Gulf Coastal Plain along the Texas-Oklahoma boundary and flows in an open valley from 5 to 15 miles wide, the narrowest portion being where the river crosses the Miocene outcrop near Boyce, La. Even at its narrowest position, the valley is wide enough to show scars of several older channels. There is no "fanning out" of the courses from a narrow position comparable to that below Little Rock on the Arkansas fan.

The correlation chart, table 6, shows the sequence of courses of the Red River below Alexandria, La. The oldest mappable stage of the Red River is $C_1$, earlier ones having been buried or destroyed.

During most of its alluvial history the Red River flowed in an alluvial valley whose axis was that of the entrenched valley, but in stage 8 it spilled through the Evergreen Gap in the Prairie Terrace. Later, in stage 15, it shifted northward to its present course through Moncla Gap where it leaves its own floodplain in favor of that of the Mississippi River.

[1] Ford, J. A. and Willey, G. R., "An Interpretation of the Prehistory of the Eastern United States," American Anthropologist, vol. 43, no. 3, pp. 325-363, 1941.

[2] Kniffen, F. B., personal communication.

Although the Red River has, at various times, flowed into the Arkansas River or directly into the Gulf of Mexico, shifts of the Red mainly represent adjustments to shifts in the position of the Mississippi River. Diversion of the Mississippi from the Teche and Walnut Bayou segments was in both cases above the Red-Mississippi junction. The smaller river was not able to accommodate itself to the wide channel and low slope of the Mississippi and soon abandoned it. Repeated shifting from short-lived channels ultimately brought the Red River into a course which led directly to the Mississippi River.

It first joined the Walnut Bayou segment of the Mississippi River by way of Bayou Huffpower. The height of Bayou Huffpower levees and the development of its meander belt indicate even longer Red River occupancy than does the modern course.

The Huffpower channel was abandoned in favor of the north-flowing short-lived Bayou Boeuf course which originated from the enlargement of a crevasse channel along a fault west of Bunkie, La. The diversion took place following stage 14. It was facilitated by the flattening of the Red River gradient brought by lengthening of the Red-Huffpower channel when the Mississippi abandoned the Walnut Bayou segment. Although the Boeuf served as a flood distributary of the Red and was a navigable channel in the last century, the lack of characteristic Red River meanders reflects its short period of occupancy as the main channel.

**The Present Course of the Red River.** The present course of the Red River is a composite feature involving segments of diverse origin. It was first occupied by the Red in stage 15, when the diversion through Moncla Gap occurred. Between Alexandria and Moncla, the river follows a very young meander belt developed from a marginal "rimswamp" stream which drained into the Mississippi Valley through the Moncla Gap. Downstream from Moncla to the mouth of Saline Bayou, the Red River has formed a meander belt within the abandoned course of the $C_2$ stage Arkansas River. From the mouth of Saline Bayou to Lake Long, the Red River meander belt follows an old course of Little River. Between Lake Long and the mouth of Black River, the Red follows an old channel originally established by the stage 10 Walnut Bayou-Mississippi course, but subsequently occupied by the Bayou Bartholomew-Arkansas River (stage 11) and by the Black River (stage 12). In this segment the Red reversed the flow taken by the Black, the Arkansas, and the Mississippi rivers. Between the mouths of Black and Old River, Red River occupies a stage 13 to 15 Black River course. The Black was established in a stage 10 Mississippi crevasse channel which followed a still older $C_2$ stage Mississippi meander channel.

The Red River is not a direct tributary of the Mississippi; it discharges into Old River. Old River flows into the Atchafalaya or the Mississippi, depending on relative stages of the Mississippi and Red rivers. In most cases, the flow is from the Mississippi into the Atchafalaya; but, when the Mississippi stage is low and the Red is in flood, part of the flood waters flow into the Mississippi. Prior to the Shreves Cut-off in 1831, the Red River flowed directly into the Mississippi. From 1831 to 1872 the Red flowed into upper Old River, but since 1872 it has flowed into lower Old River.

**The White River.** The White River which enters the Western Lowland from a narrow, rock-walled valley in the Paleozoic uplands near Newark, Ark., has been alternately a tributary of the Mississippi River and of the Arkansas River. The correlation of stages of its history are shown in table 7. At various times the Mississippi flowed fairly close to Newark and prevented the formation of a large White River alluvial fan. Doubtless the small size of the alluvial fan, less than 350 square miles, also reflects the small sedimentary load of the White. The contrast between the silt-laden Arkansas River and the clear-water White is particularly striking inasmuch as the two streams have somewhat similar discharges.

The present alluvial fan of the White River was deposited in a trench cut during $C_1$ stage when the Mississippi had its final course in the Western Lowland. The White River meandered freely within its narrow trench, and its principal change in course consisted of a shift from the east side to the west side of Surrounded Hills.

Following $C_2$ stage, the White has successively lost the drainage of the Whitewater, the Castor, and the St. Francis rivers, as each in turn shifted to the Eastern Lowland. The last important shift of the White took place following stage 11 when the river shifted to its present meander belt from its course down Scrubgrass Bayou. Since stage 12 the White River has remained in the same meander belt, except for minor changes near its mouth.

**The Black River of Missouri and Arkansas.** The alluvial fan of the Black River, like that of the White, has been mainly constructed since the Mississippi River was diverted into the Eastern Lowland in $C_2$ time. It occupies a trench cut by the $C_1$ stage Mississippi and covers an area of 250 square miles. The history of Black River is shown in table 8. When the Mississippi first abandoned the Western Lowland, its direct tributaries, the Whitewater, Castor, St. Francis, and Black rivers, were left flowing in the old channel. The flow of the combined streams was augmented by residual Mississippi overflow still coming across the levee at Advance, Mo. The stream resulting from this combined flow may be termed the Cache-Black River, after the Cache River of Arkansas which marks the approximate position of the old channel. Portions of the $C_2$ stage of Cache-Black River are shown on plate 2. The contrast between the wide gentle arcs of the braided Mississippi and the smaller meander loops of $C_2$ stage Black is readily distinguishable. The large Cache-Black meander pattern could not be maintained in subsequent stages when the Black River shifted to the western margin of the valley. The successive loss in tributary discharge of the Whitewater, the Castor, and St. Francis rivers is reflected in the decreasing size of the Black River meanders. The present western tributaries of the Black, the Current, Spring, Eleven Point, and Strawberry rivers, flowed along the western valley wall during stage $C_2$ and served as a pilot channel down which the Black River was diverted. Black River is a conspicuous example of a stream which has been controlled by faulting, and the "grain" of the Black alluvial fan drainage coincides with the trend of the regional fault system.

**The St. Francis River.** The history and correlation of the channels of the St. Francis River are presented in table 9. Like the Black, Castor, and Whitewater rivers, the St. Francis was a direct tributary of the Mississippi River in the Western Lowland. These streams were not able to maintain channels in the abandoned Mississippi course, and they built alluvial fans where they debouched into the alluvial valley. The

| Epoch | Sea Level | Equivalency of Units | Time Units or Stages | Entrance to Alluvial Valley: Mississippi | * | Entrance to Alluvial Valley: Ohio | * | Ohio-Mississippi Junction |
|---|---|---|---|---|---|---|---|---|
| RECENT | Stand in Sea Level (Interglacial interval) | Historic Courses | 20 (1943) | Thebes Gap | | Metropolis Lowland | | Near Cairo, Illinois |
| | | | 19 (1890) | | 0.80 | | 0.36 | |
| | | | 18 (1820) | | | | | |
| | | | 17 (1765) | | | | | |
| | | Equivalent Short Time Units — 2,000 yrs. | 16 | | | | | |
| | | | 15 | | | | | |
| | | | 14 | | | | | |
| | | | 13 | | | | | |
| | | | 12 | | | | | |
| | | | 11 | | | | | |
| | | | 10 | | | | | |
| | | | 9 | | | | | |
| | | | 8 | | | | | |
| | | | 7 | | | | | |
| | | | 6 | | | | | |
| | | | 5 | | | | | |
| | | | 4 | | | | | |
| | | | 3 | | | | | |
| | | | 2 | | | | | |
| | | | 1 | | | | | |
| | | Short Time Units Length Unequal — 1,000 yrs. | J | Morehouse Lowland | 1.08 | | | Near Tiptonville, Tenn. |
| | | | I | | | | | Near St. Joseph, La. |
| | | | H | | 1.08 | | 0.62 | |
| | | | G | | | | | |
| | | | F | | | | | Near Parkin, Ark. |
| | | | E | | | | | |
| | | Long Time Units Length Unequal — 3,000 yrs. | D | | 1.21 | | 0.78 | |
| | | | $C_2$ | | 1.75 | | | |
| | | | $C_1$ | Advance Lowland | 0.78 | | | Various junctions in middle of valley north of Vicksburg, Miss. |
| | | | $B_3$ | | | | | |
| | | | $B_2$ | | | | | |
| | | | $B_1$ | | | | | |
| | | | $A_3$ | Drum and Advance Lowlands | | Cache Lowland | | |
| | Rising Sea Level (Waning Glaciation) | | $A_2$ | | | | | |
| | | | $A_1$ (-20 ft. stage) | | 0.74 | | 0.92 | Near Sicily Island, La. |
| PLEISTOCENE (LATE WISCONSIN GLACIAL STAGE) | | Long Period — 20,000 yrs. | -55 ft. stage | | | | | |
| | | | -80 ft. stage | | | | | Near Greenville, Miss. |
| | | | -200 ft. stage | | | | | |
| | | | -300 ft. stage | | | | | East of Rosedale, Miss. |
| | Lowering Sea Level, Glaciation | Long Period — 25,000 yrs. | Entrenched Stage | | | | | |

CHARACTER OF STREAM

| Time Units or Stages | Mississippi above Ohio Junction | * | Ohio | * | Mississippi-Ohio | * | Lower Arkansas | Lower Arkansas | *x | Lower Red | Lower Red | *x |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 (1943) | Meandering Poised | | Open meandering, poised or very slow | | Meandering Poised | | Meandering | Entrenching | | Meandering | Entrenching | |
| 19 (1890) | | 0.52 | | 0.31 | | 0.65 | | | 1.02 | | | 0.76 |
| 18 (1820) | | | | | | | | | | | | |
| 17 (1765) | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | 0.95 |
| 15 | | | | | | | | | | | | 0.75 |
| 14 | | | | | | | | | | | Aggrading | |
| 13 | | | | | | | | | | | | |
| 12 | | | | | | | | Aggrading | 1.13 | | | |
| 11 | | | | | | | | | | | | 0.36 |
| 10 | | | | | | | | | 1.03 | | | 1.35 |
| 9 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | 0.64 |
| 7 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | 0.39 |
| 5 | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | 0.35 |
| 3 | | | | | | | | | | | Entr. | 1.30 |
| 2 | | | | | | | | | 1.00 | | | |
| 1 | | 1.65 | | | | | | | 0.92 | | | 1.20 |
| J | Braided and entrenching | 1.08 | Meandering and entrenching | | | | | | | | Poised | |
| I | | | | | | | | | | | | |
| H | | 1.08 | | | | | | | 0.89 | | | |
| G | | | | | | | | | | | | |
| F | | | | | | | | | | ? | | |
| E | | | | | | | | | | | | |
| D | | 0.96 | | 0.65 | | 0.66 | | | 1.30 | | | |
| $C_2$ | | 1.01 | | | | | | | | | | |
| $C_1$ | Braided, Aggrading upper end of alluvial fan, entrenching lower end of fan | 0.70 | | | | | Braided and Aggrading | | | — ? — | | |
| $B_3$ | | | | | | | | | | Braided and Aggrading | | |
| $B_2$ | | 0.71 | | | | | | | | | | |
| $B_1$ | | | | | | | | | | | | |
| $A_3$ | | 0.70 | | 0.63 | | 0.54 | Braided and Aggrading | | 0.86 | | | |
| $A_2$ | | | Braided, Aggrading | | Braided, Aggrading | | | | 0.75 | | | |
| $A_1$ (-20 ft. stage) | Braided Aggrading | 0.77 | | 0.57 | | | | | | | | |
| -55 ft. stage | | | Braided, Aggrading, Gravel Carrying | 1.00 | | | Braided, Aggrading, Gravel Carrying | | | | | |
| -80 ft. stage | Braided, Aggrading, Gravel Carrying | 0.90 | | 1.25 | | | | | 0.85 | Gravel Carrying, Braided, Aggrading | | 0.95 |
| -200 ft. stage | | | | 0.92 0.50 | Braided, Aggrading, Gravel Carrying | 0.70 | | | 1.40 | | | 2.50 |
| -300 ft. stage | | | | | | 0.63 | | | | | | 0.92 |
| Entrenched Stage | Entrenching | 0.82 | Entrenching | 0.63 | Entrenching | 0.83 | Entrenching | | 1.02 | Entrenching | | 3.00 |

COURSES

| Time Units or Stages | ** | Upper Valley ***: Mississippi | ** | Upper Valley ***: Ohio | Upper Valley ***: Ohio | ** | Lower Valley [1]: Mississippi | Lower Valley [1]: Mississippi | * | Delta |
|---|---|---|---|---|---|---|---|---|---|---|
| 20 (1943) | | Present Meander Belt | | Present Meander Belt | | | Present Meander Belt | | | Present sub-delta |
| 19 (1890) | 0.63 | | | | | 0.45 | | | 0.22 | |
| 18 (1820) | | | | | | | | | | |
| 17 (1765) | | | | | | | | | | |
| 16 | | | | | | | | | | Plaquemines St. Bernard |
| 15 | | | | | | | | | | |
| 14 | | | | | | | | | | |
| 13 | | | | | | | | | | |
| 12 | | | | | | | | | | |
| 11 | | | | | | | | Bayou Lafourche | | Lafourche |
| 10 | 0.65 | | | | | 0.45 | Walnut Bayou below Vicksburg, Miss. | | 0.17 | |
| 9 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 3 | | St. Francis Lowland | | St. Francis Lowland | | | | Bayou Teche | | Teche |
| 2 | | | | | | | | | | |
| 1 | 0.63 | | | | | 0.45 | | | 0.18 | |
| J | | Little River Lowland | | Present Meander Belt to Fulton, Tenn. | St. Fran. | | Walnut Bayou | | | Cocodrie |
| I | | | 0.65 | | | | | | | |
| H | 0.59 | | | | Yazoo | 0.65 | Upper Tensas | | 0.13 | |
| G | | | | | St. Francis | | | | | |
| F | | | | | | | Sunflower | | | |
| E | | | | | | | | | | |
| D | | | | | | 0.40 | | | | Maringouin |
| $C_2$ | 1.01 | | | | | | Sunflow. | (Ohio Course) Yazoo | | Bayou La Rose |
| $C_1$ | | White River Lowland | | | Present Meander Belt to Memphis (Coldwater - Yazoo) | | East of Macon Ridge | | 0.31 | |
| $B_3$ | | | | | | | | | | |
| $B_2$ | | Bayou DeView | | | | | West of Sunflower | | | Buried ? |
| $B_1$ | | Big Creek | | | | | Yazoo | | | |
| $A_3$ | | Marianna Gap | | | | 0.54 | | | | |
| $A_2$ | | East side of valley | | East side of valley | | | | | | |
| $A_1$ (-20 ft. stage) | | West side of valley | | West side of valley | | 0.65 | Near Macon Ridge | | | |
| -55 ft. stage | | | | | | | | | | Continental Shelf Y |
| -80 ft. stage | | | | | | | | | | |
| -200 ft. stage | | | | | | | | | | |
| -300 ft. stage | | | | | | | | | | |
| Entrenched Stage | | | | | | | | | | |

* Valley slope in feet per mile for segment of valley shown in column to left of figure

** Valley slope in feet per mile for segment of valley shown in column to right of figure

*** Valley above Helena, Ark.

1 Valley below Helena, Ark.

x Slopes measured to Mississippi Valley not to Mississippi River Junction.

Y West and South of present delta near 90° meridian

TABLE 3 — Characteristics of the Lower Mississippi River and Major Tributaries During Stages in Recent History of the Alluvial Valley

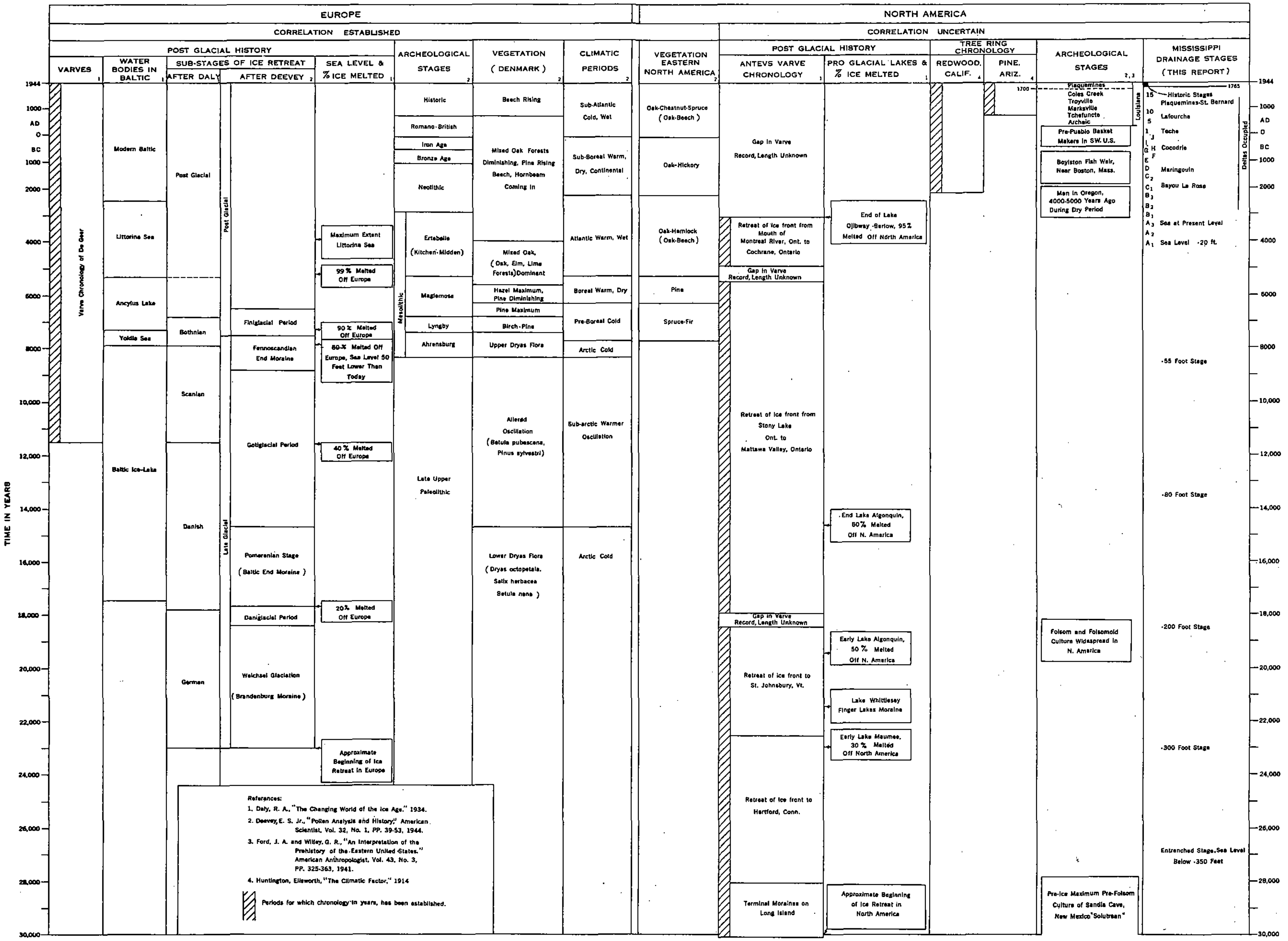



**TABLE 4 — Correlation of Stages of Development of the Mississippi Valley with Established Chronology**

| STAGES | CONFLUENCE WITH MISSISSIPPI RIVER | MAJOR TRIBUTARIES | LOCATION OF COURSES* — COURSE SEGMENTS: LITTLE ROCK, ARK. TO LATITUDE OF PINE BLUFF, ARK. | BETWEEN LATITUDES OF PINE BLUFF AND EUDORA, ARKANSAS | LATITUDE OF EUDORA, ARK. TO SICILY ISLAND, LA. | SICILY ISLAND, LA. TO MOUTH |
|---|---|---|---|---|---|---|
| 20 (1939-43) | Below Napoleon Cut-off | | Present Meander Belt | | | |
| 19 (1890) | | | | | | |
| 18 (1820) | Below Beulah Bend | | | | | |
| 17 (1765) | Near Caulk Neck | | | | | |
| 16 | | | | | | |
| 15 | West of Rosedale, Miss. | White River, 5 Miles East of Yancopin, Ark. | | | | |
| 14 | | | | | | |
| 13 | | | | | | |
| 12 | | | | | | |
| 11 | Near Angola, La. | Ouachita River Near Monroe, La.; Red R. Near Bordelonville, La. | Plum Bayou | Bayou Bartholomew | Bayou De Siard to Ouachita River | Ouachita R., Black R. and Bayou Des Glaises |
| 10 | Near Jonesville, La. | Ouachita River Near Monroe, La. | | | | Ouachita River |
| 9 | | | | | | |
| 8 | | | | | | |
| 7 | South of Jonesville, La. | | | | | |
| 6 | | | | | | |
| 5 | | | | | | |
| 4 | Gulf of Mexico | Red R. Gibson, La. / Opelousas, La. | | | Fleschmans Bayou, Bayou Bonne Idee to Boeuf River | Big Bayou to Old Saline Bayou; Atchafalaya Swamp Network; Bayou Teche |
| 3 | Near Lake St. Agnes, La. | Ouachita River North of Sicily Island, La. | | | | |
| 2 | | | | | | |
| 1 | 10 Miles Southeast of Sicily Island, La. | White River North of Arkansas City, Ark. | Bakers Bayou, to Indian Bayou, to Flat Bayou | Choctaw Bayou | Amos Bayou to Present Mississippi River Meander Belt to Joes Bayou to Bayou Macon | |
| J | | | | | | |
| I | | | | | | |
| H | Gulf of Mexico | White River Near Grand Lake, Ark. | | | Bayou Macon, Present Mississippi River Meander Belt, Baxter Bayou, Bayou Macon and Big Bayou | Bayou Louis, Hanna Bayou and Long Branch; Bayou Portage |
| G | | | | | | |
| F | | | | | | |
| E | | Red River Near Palmetto, La. | | | | |
| D | Near St. Joseph, La. | White River Near Longwood, Miss. | Crooked Creek to Bayou Meto to Cross Bayou | Little Bayou; Present Miss. Meander Belt | Upper Tensas-Mississippi Meander Belt | |
| $C_2$ | Gulf of Mexico | Ouachita River North of Sicily Island, La. | Wabbaseka Bayou to Little Bayou Meto | Cypress Cr., Coon B., Crooked B. and Boeuf R. | Bayou Lafourche, Gourd Bayou and B. Lafourche | French Fork of Little River, Muddy Bayou, Bayou Friejon and Bayou Du Lac |
| $C_1$ | | | Bayou Meto, King Bayou, Big Bayou Meto | Oak Log Bayou and Boeuf River | Dry B., B. Gallon, B. Lafourche to B. Marengo | |
| $B_3$ | Near Deer Park, La. | | King Bayou and Pecan Bayou | Ables Creek, Cut-off Creek and Overflow Cr. | Bayou Lafourche to Daves Bayou | ? |
| $B_2$ | | | Two Prairie Bayou, LaGrue Bayou, Mill Bayou, to Deluce Bayou | Destroyed by Subsequent Erosion | Caney Bayou, Little Creek and Goose Creek | |
| $B_1$ | | | Little Bayou LaGrue | | Hurricane Creek, Big Creek and Turkey Creek | |
| $A_3$ | Near Simmesport, La. | | Big Creek East of DeWitt, Ark. | | Turkey Creek | |
| $A_2$ | | | Tarleton Creek | | Deer Creek | |
| $A_1$ (-20 ft.) | North of Sicily, Island, La. | | Prairie Bayou and Hurricane Bayou | | Alligator Bayou | |
| -55 ft. | ? | ? | ? | ? | ? | |
| -80 ft. | | | | | | |
| -200 ft. | | | | | | |
| -300 ft. | | | | | | |
| Entrenched | Near Waterproof, La. | Ouachita River Near Bonita, La. | Near Western Valley Wall | | | |

(Hatched area) Indicates not present

*ABANDONED ARKANSAS RIVER COURSES LOCATED BY STREAMS NOW OCCUPYING PORTIONS OF OLD MEANDER BELTS

TABLE 5 — Stages in the Development of the Arkansas River

| STAGES | ENTRANCE TO ALLUVIAL VALLEY | MASTER STREAM | LOCATION OF MOUTH | MAJOR TRIBUTARIES | LOCATION OF COURSES* — COURSE SEGMENTS (WEST LONGITUDE): 92°30′ TO 92°15′ | 92°15′ TO 92°00′ | EAST OF 92°00′ |
|---|---|---|---|---|---|---|---|
| 20 (1939-43) | Moncla Gap | Lower Old River | Near Angola, La. | Black-Ouachita River Near Acme, La. | Present Meander Belt | | In Present Course |
| 19 (1890) | | | | | | | |
| 18 (1820) | | Upper Old River (1872–1831) | | | | | |
| 17 (1765) | | Mississippi River in Present Meander Belt | | | | | |
| 16 | | | | | | | |
| 15 | Main Red River Valley | To Gulf via Atchafalaya Swamps | South of Morgan City, La. | ▨ | Bayou Robert to Bayou Boeuf | Bayou Boeuf | Bayou Courtableau |
| 14 | Evergreen Gap | Mississippi River in Present Meander Belt | Near Angola, La. | Black River West of Angola, La. | | Bayou Huffpower, Bayou Rouge and Bayou Des Glaises | Bayou Des Glaises to Simmesport, La., Atchafalaya River, to Bayou Lettsworth |
| 13 | | | | | | | |
| 12 | | | | Black River Near Bordelonville, La. | | | |
| 11 | | Arkansas River in Bayou Bartholomew Course | Bordelonville, La. | ▨ | | | Bayou Des Glaises |
| 10 | | Mississippi River in Walnut Bayou Course | 7 Miles North of Simmesport, La. | ▨ | | | |
| 9 | | | | ▨ | | | |
| 8 | Main Red River Valley between Big Cane and Washington, La. | ▨ | Gulf of Mexico South of Morgan City, La. | ▨ | | Bayou Huffpower to Clear Bayou to Dry Bayou | Bayou Petite Prairie |
| 7 | | ▨ | | ▨ | Pecan Bayou to Bayou Robert to Bayou Boeuf to Bayou Cocodrie | Bayou Boeuf / Bayou Mariecroquant | Bayou Teche to Morgan City, La. / Bayou Boeuf to Bayou Chene to Lower Atchafalaya |
| 6 | | ▨ | | ▨ | | | |
| 5 | | ▨ | | ▨ | | | |
| 4 | | Arkansas River | Gibson, La. / Opelousas, La. | ▨ | | | Bayou Boeuf to Bayou L'Ourse |
| 3 | | Mississippi River in Teche Course | Near Washington, La. | ▨ | | North of B. Wauksha, B. Cocodrie | ▨ |
| 2 | | | 5 Miles East of Palmetto, La. | ▨ | | Dry Bayou, Bayou Petite Prairie | ▨ |
| 1 | | | | Ouachita River / Near Bunkie, La. | | | ▨ |
| J | | ▨ | Gulf of Mexico Near Morgan City, La. | | Bayou Latanier to Chatlin Lake, Southwest to Meeker, La., Bayou Cocodrie to Lonepine, Eastward to Haasville, La. | Clear Bayou, Dry Bayou, Bayou Petite Prairie and Bayou Wauksha | ▨ |
| I | | ▨ | | | | | ▨ |
| H | | Arkansas River | Near Palmetto, La. | | | | ▨ |
| G | | | | | | | ▨ |
| F | | | | | | | ▨ |
| E | | ▨ | Gulf of Mexico Near Franklin, La. | Near Palmetto, La. | ? | Bayou Cocodrie | Bayou Portage |
| D | | ▨ | | Near Washington, La. | | | |
| $C_2$ | | Arkansas River | Near Washington, La. | ▨ | | | ▨ |
| $C_1$ | | | | ▨ | | | ▨ |
| $B_3$ | | ▨ | Gulf of Mexico Near Morgan City, La. | ? | Buried | | ? |
| $B_2$ | | ▨ | | | | | |
| $B_1$ | | ▨ | | | | | |
| $A_3$ | | ▨ | | | | | |
| $A_2$ | | Mississippi River | Near Morgan City, La. | | | | |
| $A_1$ (-20 ft.) | | | | | | | |
| -55 ft. | | | North of Plaquemine, La. | | | | |
| -80 ft. | | ▨ | East of Butte La Rose, La. | | | | |
| -200 ft. | | Mississippi River | Near Plaquemine, La. | | | | |
| -300 ft. | | | Near Courtableau, La. | | | | |
| Entrenched | | | | ▨ | Alexandria, La. to Melville, La. | | |

▨ Indicates not present

*ABANDONED RED RIVER COURSES LOCATED BY STREAMS NOW OCCUPYING PORTIONS OF OLD MEANDER BELTS

TABLE 6 — Stages in the Development of the Red River

| STAGES | LOWLAND OCCUPIED | MASTER STREAM | LOCATION OF MOUTH | MAJOR TRIBUTARIES ALL POINTS IN ARKANSAS | | LOCATION OF COURSES * COURSE SEGMENTS: NEWARK TO GEORGETOWN | GEORGETOWN TO CLARENDON | CLARENDON TO INDIAN BAY | INDIAN BAY TO MOUTH |
|---|---|---|---|---|---|---|---|---|---|
| 20 (1939-43) | White River Lowland; West of Surrounded Hills | Mississippi River | Near Present Mouth | Black River Near Jacksonport, Little Red R. North of Georgetown, Big Creek South of Indian Bay | | Present Meander Belt | | | |
| 19 (1890) | | | | | | | | | |
| 18 (1820) | | | | | | | | | |
| 17 (1765) | | | | | | | | | |
| 16 | | | | | | | | | |
| 15 | | | | | | | | | Present Meander Belt to Arkansas River |
| 14 | | Arkansas River | 5 Miles East of Yancopin, Ark. | | | | | | |
| 13 | | | | | | | | | |
| 12 | | | | | | | | | |
| 11 | East of Surrounded Hills | Mississippi River | About 8 Miles North of Rosedale, Miss. | Black River Near Maberry | Little Red River Near DeValls Bluff and Big Creek Near Head of Scrubgrass Bayou | Departe Creek | Roaring Slough to Cache River | Meander Belt East of Present White River | Essex Bayou to Prairie Bayou to Scrubgrass Bayou |
| 10 | | | | | | | | | |
| 9 | | | | | | | | | |
| 8 | | | | | | | | | |
| 7 | | | | | | | | | |
| 6 | | | | | | | | | |
| 5 | | | | | | | | | |
| 4 | | | | | | | | | |
| 3 | | | | Black-St. Francis River Near Maberry | | | | | |
| 2 | | | | | | | | | |
| 1 | | Arkansas River | About 15 Miles North of Arkansas City, Ark. | Black-St. Francis River Near Maberry, Little Red River South of Bald Knob | | Course Near Western Edge of White River Lowland | | | Essex Bayou, Prairie Bayou, to LaGrue Bayou and Rube Bayou South of Yancopin |
| J | | | | | | | | | |
| I | | | | | | | | | |
| H | | | Near Grand Lake, Ark. | | | | | | |
| G | | | | | | | | | |
| F | | | | Black-St. Francis River South of Newport, Little Red River Near Georgetown | | Meander Belt Near Axis of White R. Lowland | | | |
| E | | | | Black-St. Francis-Castor-Whitewater River South of Newport, Little Red R. Near Georgetown | | Along Eastern Edge of White R. Lowland South of Newport, Ark. | | | |
| D | | | Near Longwood, Miss. | Black R. South of Newport, Little Red R. Near Georgetown, Castor-St. Francis R. Near Cotton Plant | | ? | | | Snake Bayou to Clear Bayou to Black Bayou |
| $C_2$ | | Mississippi River | Near Deer Park, La. | Black-St. Francis-Castor-Whitewater River, N.W. of Cotton Plant, Little Red River Near Clarendon | | | | | |
| C | | | West of Cotton Plant, Ark. | Current-Spring-Eleven Point-Strawberry River Near Newport | | | | | |
| $B_3$ | Direct to Mississippi River | | Near Newport, Arkansas | | | | | | |
| $B_2$ | West Side of Western Lowland | | Near St. Charles, Arkansas | Current-Spring-Eleven Point-Strawberry River Near Newport, Little Red River Near Des Arc | | | ? | ? | |
| $B_1$ | | | | | | | ? | ? | |
| $A_3$ | | | Mississippi | Black River Near Newport, Little Red River Near DeValls Bluff | | ? | ? | ? | ? |
| $A_2$ | | Arkansas River | Southeast of DeWitt, Ark. | | | | ? | ? | ? |
| $A_1$ (-20 ft.) | Direct to Mississippi River | Mississippi River | Near Olyphant, Ark. | | | | | | |
| -65 ft. | West Margin of Valley | | ? | ? | | | | | |
| -80 ft. | | | | | | | | | |
| -200 ft. | | | | | | | | | |
| -300 ft. | | | | | | | | | |
| Entrenched | | | Near Greenville, Miss. | Little Red River Near Stuttgart | | ENTRENCHED VALLEY UNDERLIES PRESENT WHITE RIVER LOWLAND | | | |

Indicates not present

* ABANDONED WHITE RIVER COURSES LOCATED BY STREAMS NOW OCCUPYING PORTIONS OF OLD MEANDER BELTS

**TABLE 7 — Stages in the Development of the White River**

| STAGES | LOWLAND OCCUPIED | | MASTER STREAM | LOCATION OF MOUTH | MAJOR TRIBUTARIES ALL POINTS IN ARKANSAS | | LOCATION OF COURSES * COURSE SEGMENTS | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | NEWARK TO GEORGETOWN | GEORGETOWN TO CLARENDON | CLARENDON TO INDIAN BAY | INDIAN BAY TO MOUTH |
| 20 (1930-43) | White River Lowland | West of Surrounded Hills | Mississippi River | Near Present Mouth | Black River Near Jacksonport, Little Red R. North of Georgetown, Big Creek South of Indian Bay | | Present Meander Belt | | | |
| 19 (1890) | | | | | | | | | | |
| 18 (1820) | | | | | | | | | | |
| 17 (1765) | | | | | | | | | | |
| 16 | | | | | | | | | | |
| 15 | | | | | | | | | | |
| 14 | | | Arkansas River | 5 Miles East of Yancopin, Ark. | | | | | | Present Meander Belt to Arkansas River |
| 13 | | | | | | | | | | |
| 12 | | | | | | | | | | |
| 11 | | East of Surrounded Hills | Mississippi River | About 8 Miles North of Rosedale, Miss. | Black River Near Maberry | Little Red River Near DeValls Bluff and Big Creek Near Head of Scrubgrass Bayou | Departe Creek | Roaring Slough to Cache River | Meander Belt East of Present White River | Essex Bayou to Prairie Bayou to Scrubgrass Bayou |
| 10 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 3 | | | | | Black-St. Francis River Near Maberry | | | | | |
| 2 | | | | | | | | | | |
| 1 | | | Arkansas River | About 15 Miles North of Arkansas City, Ark. | Black-St. Francis River Near Maberry, Little Red River South of Bald Knob | | Course Near Western Edge of White River Lowland | | | Essex Bayou, Prairie Bayou, to LaGrue Bayou and Rube Bayou South of Yancopin |
| J | | | | | | | | | | |
| I | | | | | | | | | | |
| H | | | | Near Grand Lake, Ark. | | | | | | |
| G | | | | | | | | | | |
| F | | | | | Black-St. Francis River South of Newport, Little Red River Near Georgetown | | Meander Belt Near Axis of White R. Lowland | | | |
| E | | | | | Black-St. Francis-Castor-Whitewater River South of Newport, Little Red R. Near Georgetown | | Along Eastern Edge of White R. Lowland South of Newport, Ark. | | | |
| D | | | | Near Longwood, Miss. | Black R. South of Newport, Little Red R. Near Georgetown, Castor-St. Francis R. Near Cotton Plant | | ? | | | Snake Bayou to Clear Bayou to Black Bayou |
| $C_2$ | | | Mississippi River | Near Deer Park, La. | Black-St. Francis-Castor-Whitewater River, N.W. of Cotton Plant, Little Red River Near Clarendon | | | | | |
| C | | | | West of Cotton Plant, Ark. | Current-Spring-Eleven Point-Strawberry River Near Newport | | | | | |
| $B_3$ | Direct to Mississippi River | | | Near Newport, Arkansas | | | | | | |
| $B_2$ | West Side of Western Lowland | | | Near St. Charles, Arkansas | Current-Spring-Eleven Point-Strawberry River Near Newport, Little Red River Near Des Arc | | | ? | ? | |
| $B_1$ | | | | | | | | ? | ? | |
| $A_3$ | | | | Mississippi | Black River Near Newport, Little Red River Near DeValls Bluff | | ? | ? | ? | ? |
| $A_2$ | | | Arkansas River | Southeast of DeWitt, Ark. | | | | ? | ? | ? |
| $A_1$ (-20 ft.) | Direct to Mississippi River | | Mississippi River | Near Olyphant, Ark. | | | | | | |
| -65 ft. | West Margin of Valley | | | ? | ? | | | | | |
| -80 ft. | | | | | | | | | | |
| -200 ft. | | | | | | | | | | |
| -300 ft. | | | | | | | | | | |
| Entrenched | | | | Near Greenville, Miss. | Little Red River Near Stuttgart | | ENTRENCHED VALLEY UNDERLIES PRESENT WHITE RIVER LOWLAND | | | |

(Hatched) Indicates not present

* ABANDONED WHITE RIVER COURSES LOCATED BY STREAMS NOW OCCUPYING PORTIONS OF OLD MEANDER BELTS

TABLE 7 — Stages in the Development of the White River

| STAGES | LOWLAND OCCUPIED | MASTER STREAM | LOCATION OF MOUTH | MAJOR TRIBUTARIES | LOCATION OF COURSES * COURSE SEGMENTS | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | POPLAR BLUFF, MO. TO CORNING, ARK. | CORNING, TO POCAHONTAS, ARK. | POCAHONTAS, TO BLACK ROCK, ARK. | BLACK ROCK, TO MOUTH |
| 20 (1939-43) | Present Black River Lowland | White River | Near Jacksonport, Ark. | Current River Near Pocahontas, Ark.; Spring and Eleven Point Rivers Near Portia, Ark.; Strawberry River Near Saffell, Ark | Present Meander Belt | | | |
| 19 (1890) | | | | | | | | |
| 18 (1820) | | | | | | | | |
| 17 (1765) | | | | | | | | |
| 16 | | | | | Catherine Slough, 3 Miles South, 3 1/2 Miles East of Poplar Bluff, Mo. | | | |
| 15 | | | | | Unnamed Sloughs East of Poplar Bluff, Mo. | | | |
| 14 | | | | | | | | |
| 13 | | | | | | Little River Near Present Black River | | |
| 12 | | | | | Palmer Slough, 4 1/2 Miles East of Poplar Bluff, Mo., to Dan River | | | |
| 11 | | | Near Cotton Plant, Ark. | | Caney Slough 4 Miles East and 4 Miles South of Poplar Bluff, Mo. | | West of Present Black River | Along Western Valley Wall as Far South as Mouth of Strawberry River |
| 10 | | | | | | | | |
| 9 | | | | | | | | |
| 8 | | | | | | | | |
| 7 | | | | | | | | |
| 6 | | | | | | | | |
| 5 | | | | | | | | |
| 4 | | | | | Course East of Poplar Bluff, Mo. | Rankine Slough, 3 Miles West, 1 Mile South of Knobel, Ark. | | |
| 3 | | | | St. Francis River: Near Corning, Ark. | Dan River | | | |
| 2 | | | | Mile 190, Black River | West of Dan River | | | |
| 1 | | | Near Maberry, Ark. | Near 90°27'W, 36°31'N | Pike and Big Hunting Slough | | | |
| J | | | | | West of Pike Slough | | | |
| I | | | | Near Moark, Ark. | | | | |
| H | | | | 15 Mi. S. Poplar Bluff, Mo. | East of Pike Slough to Little Hunting Slough | | | |
| G | | | | Near Moark, Ark. | West of Pike Slough | | | |
| F | | | South of Newport, Ark. | | Big Cane Creek | | | |
| E | | | | Southeast of Poplar Bluff, and Castor-Whitewater River, Southeast of Corning, Ark. | West of Big Hunting Slough | Large Meanders Along Bluffs Between Corning and Pocahontas, Ark. | Large Meanders East of Black River | East of Black River and Curia Creek, West of Black River From Mile 10-30 |
| D | | | | | Big Cane Creek | | | |
| $C_2$ | Cache River Lowland | | Near Cotton Plant, Ark. | Whitewater-Castor-St. Francis River Near 90°22'W, 36°37'N | Course South from Poplar Bluff, Mo. | Valley of Cache River, South from Knobel, Ark. | | |
| $C_1$ | Direct Junction with Mississippi River Near Bluffs | Mississippi River | Near Maberry, Ark. | | | | | |
| $B_3$ | | | Near Neelyville, Mo. | | | | | |
| $B_2$ | | | | | | | | |
| $B_1$ | | | Pocahontas, Ark. | Current River | ? | | | |
| $A_3$ | | White River | Newport, Ark. | Current-Spring-Eleven Point-Strawberry Rivers | | | | |
| $A_2$ | | | | | | | | |
| $A_1$ (-20 ft.) | | Mississippi River | Near Poplar Bluff, Mo. | | | | | |
| -55 ft. | | | ? | | ? | | | |
| -80 ft. | | | | | | | | |
| -200 ft. | | | | | | | | |
| -300 ft. | | | | | | | | |
| Entrenched | | | Near McDougal, Ark. | | South of Poplar Bluff, Mo. | | | |

(Hatching) indicates not present

*ABANDONED BLACK RIVER COURSES LOCATED BY STREAMS NOW OCCUPYING PORTIONS OF OLD MEANDER BELTS.

**TABLE 8 — Stages in the Development of the Black River**

| STAGES | LOWLAND OR GAP OCCUPIED | MASTER STREAM | LOCATION OF MOUTH | MAJOR TRIBUTARIES | LOCATION OF COURSES* | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | COURSE SEGMENTS | | | |
| | | | | | WEST OF CROWLEYS RIDGE | | EAST OF CROWLEYS RIDGE | |
| | | | | | NORTH OF POPLAR BLUFF, MO. | SOUTH OF POPLAR BLUFF, MO. | NORTH OF PARKIN, ARK. | SOUTH OF PARKIN, ARK. |
| 20 (1939-43) | | | | | | | | |
| 19 (1890) | | | | | | | | |
| 18 (1820) | | | St. Francis Bend 10 Miles North of Helena, Ark. | | | | | |
| 17 (1765) | | | | | | | | |
| 16 | | Mississippi River | | | | | | |
| 15 | | | | | | | | |
| 14 | East of Fisk, Mo. to St. Francis Gap | | Near Horseshoe Lake, 5 Miles East, 2 Miles South of Hughes, Ark. | Castor- Little River Near | Near Present Course | | | To Boggy Bayou to Fish Bayou |
| 13 | to St. Francis Lowland | | 2 Miles East of Mile 250, Miss. R., East of Hughes | Marked Tree, Ark. | | | | To Boggy Bayou |
| 12 | to Little River Lowland | | Near Horseshoe Lake Southeast of Hughes, Ark. | | | | | Near Present Course to Black Fish Bayou to Fifteen Mile Bayou |
| 11 | | | Old Walnut Bend 12 Miles East of Marianna, Ark. | | | | | To Alligator Bayou |
| 10 | | | 1 Mile East, 2 Miles South of Edmondson, Ark. | | | | | To Cut-off Bayou |
| 9 | | | | | | | | |
| 8 | | Fifteen Mile Bayou, Diversion Channel of Mississippi River | Near Lakeside, Ark. 12 Miles East of Forrest City, Ark. | | | | | Near Present Course |
| 7 | | | | | | | | |
| 6 | | | | | | | | Near Present Course to Black Fish Bayou |
| 5 | | Mississippi River | Northwest of Hughes, Ark. | | | | | |
| 4 | Mingo Swamp to Duck Creek Lowland to East of Fisk, Mo. to St. Francis Gap | | | Castor River 6 Miles Northeast of Puxico, Mo., Little R. Near Parkin, Arkansas | Mingo Creek, to Duck Creek, to Present St. Francis River 2 Mi. S. of Fisk, Mo. | | 2 Miles E. of Piggott, Ark. | Near Present Course to Spencer Bayou |
| 3 | East of Fisk, Mo. to Black River Lowland | | Near Corning, Ark. | | Menorkenut Slough South of Fisk, Mo. | Menorkenut Slough | | |
| 2 | | | Near Mile 190, Black R. | | Blue Spring Slough, 6 Miles East of Poplar Bluff, Mo. | Buried by Black River Sediment | | |
| 1 | | | Near 90°27' W., 35°31' N. | | | | | |
| J | | | | | | | | |
| I | West of Fisk, Mo. to Black River Lowland | Black River | Near Moark, Ark. | | | Series of Unnamed Sloughs Between Pike Slough and Dan River | | |
| H | | | 15 Miles South of Poplar Bluff, Mo. | | | | | |
| G | | | Near Moark, Ark. | | Series of Unnamed Sloughs Northeast of Poplar Bluff, Mo. | | | |
| F | | | | | | | | |
| E | | | 7 Miles Southeast of Poplar Bluff, Mo. | | | | | |
| D | West of Fisk, Mo. to Lowland of the Cache River of Arkansas | White River | Near Cotton Plant, Ark. | Castor-Whitewater River Near Big Island, Southeast of Poplar Bluff, Missouri | | Cache Lake | | |
| $C_2$ | West of Fisk, Mo. | Black River | Near 90°22' W., 36°37' N. | | Unnamed Slough East of Rombauer, Mo. | Buried by Black River Sediment | | |
| $C_1$ | | | | | | | | |
| $B_3$ | | | | | | | | |
| $B_2$ | | | | | | | | |
| $B_1$ | | | | | | | | |
| $A_3$ | | | | | | | | |
| $A_2$ | Direct to Mississippi River | Mississippi River | Near Wappapello, Mo. | | | | | |
| $A_1$ (-20 ft.) | | | | | | | | |
| -35 ft. | | | | | | | | |
| -60 ft. | | | | | | | | |
| -200 ft. | | | | | | | | |
| -300 ft. | | | | | | | | |
| Entrenched | | | | | | | | |

(Hatched) Indicates not present

* ABANDONED ST. FRANCIS RIVER COURSES LOCATED BY STREAMS NOW OCCUPYING PORTIONS OF OLD MEANDER BELTS

**TABLE 9 — Stages in the Development of the St. Francis River**

St. Francis River, through successive shifts on the alluvial fan, was able to spill into the Eastern Lowland through St. Francis Gap. The diversion of the St. Francis was caused by the partial damming of the Western Lowland by the Black River alluvial fan to the south.

**Present Course of the St. Francis River.** At present the St. Francis River flows through a narrow gap in Crowleys Ridge into the Eastern Lowland where it follows a channel of the $A_1$ stage Ohio River. East of Crowleys Ridge, the St. Francis has smaller meanders and a channel of less capacity than in the Paleozoic highlands to the north of Wappapello, Mo. This contraction is a reflection of natural conditions which existed before the St. Francis was leveed between Wappapello and Crowleys Ridge. Before levees were constructed, much of the flood flow was diverted southward into the Black River Lowland and also northward into Mingo Swamp, so that only a small discharge reached the Eastern Lowland.

**The Lower St. Francis River.** Near Marked Tree, Ark., the St. Francis River is joined by the Little River system (Pemiscot Bayou and Left Hand Chute of Little River). From Marked Tree to the Mississippi River, the St. Francis flows in a channel having meanders of the Little River system, with bends intermediate between those of the Mississippi and the St. Francis. The stream which constructed these meander loops is believed to have received much of its flow from the Mississippi, mainly from overflow into the Morehouse Lowland. (Overflow is reported to have followed this lowland from near Cape Girardeau, Mo., as late as 1908.) Other sources of discharge were the Castor, St. Francis, and Whitewater rivers plus the drainage of the Eastern Lowland collected in Little River and St. Francis Bay. The Pemiscot Bayou-Little River-Lower St. Francis channel constituted a gathering channel for all flood waters of the St. Francis Basin prior to the artificial leveeing of the Mississippi River.

**Ouachita River.** The Ouachita River developed an extensive alluvial fan north of Monroe, La. Scars on its surface indicate its meandering character during the A stages. Since $A_1$ stage, the Ouachita has deeply entrenched its old floodplain as the result of faulting along the active Catahoula Lake fault system.[1] Below Monroe, the present course of the Ouachita occupies abandoned Arkansas and Mississippi channels.

[1] Veatch, A. C., "Geology and Underground Water Resources of Northern Louisiana and Southern Arkansas," U. S. Geol. Survey Prof. Paper 46, pp. 65-66, 1906.

# Part VI

# THE MISSISSIPPI RIVER

## INTRODUCTION

The present Mississippi River evolved through a series of changes in the valley drainage system which were brought about by valley aggradation during and subsequent to the late glacial rise of sea level. Slope, load, discharge, and the nature of bed materials largely control river characteristics. With the possible exception of discharge, these were all greatly modified as the stream system became adjusted to the gradual rise of its base level,[1] but they have not been markedly altered since sea level reached its stand and the river became established in its present course through Thebes Gap. A delicate adjustment between them now keeps the river in a poised[2] condition.

The effect of valley aggradation on the factors controlling river activity has been established from a study of the stream history as recorded in the distribution of the alluvium and in traces of ancient stream courses.

### *Valley Aggradation and River Activity*

**Changes in Valley Slope.** The valley slope of each epoch in drainage history was low near the coast and steep in the headwater tributaries. As valley aggradation progressed inland from the Gulf of Mexico, it caused a gradual lowering of the valley slope within the entire Mississippi River system. Lowering of the major tributary valleys in turn decreased the gradients of smaller tributaries and reduced their capacity to transport coarse load.

**Changes in Load.**[3] Closely related to change in slope was a corresponding change in load. During the early stages of valley aggradation the large volume of coarse sediments caused an overloading of the streams, and discharge was maintained in numerous shallow, constantly flooding, braided channels. As the valley slope near the coast gradually lowered, the master stream was left with a lessened gradient and was unable to carry the introduced coarser part of its load as far as the Gulf. This condition, combined with the widening of tributary valleys at their junction with the alluvial valley, caused the construction of alluvial fans which blocked tributaries and speeded the process of tributary valley aggradation. The consequent loss in carrying power of the major tributaries resulted in a gradual decrease in the size of particles and in the volume of load introduced to the Mississippi River. The dominant introduced load came to be fine sands, silts, and clays, and discharge was concentrated in a single channel.

Even after braiding had ceased in the major tributaries at the margins of the valley, the streams flowing on the relatively steep outer faces of the alluvial fans were still overloaded with sediment locally derived from scouring and redistribution of alluvial fan deposits. Eventually the steep faces of the alluvial fans were gradually destroyed as the overall lowering of valley slope continued to accompany rise in sea level, and areas of stream braiding were finally limited to the northern part of the valley. After sea level had reached a stand and valley slopes had become stabilized, the introduced load of silty sediments formed the dominant load of the Mississippi River and the main element in delta building.

**Changes in Discharge.** There is nothing in the sedimentary record of the Recent alluvium to prove that great changes in discharge of the Mississippi River within its alluvial valley occurred during the aggradation of the alluvial valley. It has been assumed by many writers that during late glacial time the discharge of the river was greatly increased by meltwaters from the continental ice-cap. This assumption is open to serious question. Although meltwaters were undoubtedly large and were carried by the Mississippi, the growth of the glaciers obliterated a large part of the drainage basin area and thus caused a marked decrease in the volume of normal run-off. No accurate data are available, and it is assumed herein that the volume of the river remained practically constant with the increase in the volume from meltwaters balancing the loss in run-off.

The shifting of the confluence of the tributaries with the Mississippi River has generally been northward during the construction of the alluvial plain. This has brought about a general up-valley increase in discharge of the trunk stream.

**Changes in Bed Materials.** The bed materials are principally alluvial deposits the nature of which varies with changes in stream activity during valley aggradation. Their importance rests in the manner in which they control channel scouring, lateral migration of the stream, and the amount of locally derived stream load. The alluvium laid down during early stages in valley aggradation consisted primarily of coarse sands and gravels, the deposits of steep-gradient braided streams. These coarse deposits offered little resistance to river scouring or migration and were continually reworked and redistributed as local load of the streams. As sea level rose and valley slopes were decreased, the finer-grained sediments deposited in the lower slopes of the deltaic plain became thicker and offered an increasing resistance to erosive actions of the rivers. Streams near the coast were unable to pick up an overload of coarse sediments and gradually became confined within deep channels. The thickness of the fine-grained deposits gradually decreases up-valley where they form only a thin cover overlying the coarse sands and gravels of the alluvial fans.

Streams in the north end of the valley were able to obtain a local load of coarse sediments throughout most of the valley history and as a consequence maintained inefficient braided courses. After the Missis-

[1] Local adjustments were also made to compensate for structural movements but these were of secondary importance.

[2] Matthes, Gerard H., "Basic Aspects of Stream-Meanders," Trans. Amer. Geophysical Union, pp. 632-636, 1941. ' ". . . poised . . .(is) used to denote streams having no apparent tendency to either aggrade or degrade, but not synonymously with the morphological term 'graded.' "

[3] Load is derived from two sources: load introduced to the master stream by the tributaries; and load derived locally by erosive action of the river.

sippi was diverted through Thebes Gap, the river flowed across the surface of the Ohio alluvial fan and scoured a shallow valley into sandy deposits of the fan while it adjusted its slope to the shorter course. The abundance and accessibility of the coarse deposits are now important factors in controlling stream load and other characteristics of the meandering in the northern part of the valley.

## THE POISED MISSISSIPPI RIVER

The meandering Mississippi River is considered to be a poised stream because it has shown no tendency to either aggrade or degrade its channel since the Thebes Gap diversion, perhaps since sea level first reached its stand. The poised condition is shown in the similarity of present channel depths and cross sections with those of abandoned meanders, and in the similarity of heights of natural levees along the present and older channels of the meander belt. Further proof is exhibited in the nearly constant length and overall slope maintained by the river throughout the stages of development of its present meander belt (see plate 23). The poised condition implies that a general overall equilibrium exists between the major factors controlling river activity. It should be noted, however, that although the river is poised, its alluvial valley is being slowly aggraded by the deposition of fine-grained sediments in floodwater basins.

### *The Meandering Channel*[1]

Perhaps meanders afford the best known "trademark" of the poised Mississippi River, but they do not mark all sections of the channel. Extensive reach areas are common all along the river, and meanders are absent or poorly developed in the southern segment below Donaldsonville. Their irregular distribution indicates that the meanders are merely an expression of local river adjustment to factors controlling stream activity. Analysis of the effect of controlling factors on the nature and distribution of Mississippi meanders is permitted by the use of empirical data gained from a study of the development of the river. With the constant valley slope, which has existed since the river reached its poised condition, meander growth is directly related to discharges and the bed materials through which the river flows.

Mississippi River meanders are much larger than those of tributary streams in the same area. (See figure 26 for contrast in size of Mississippi and White River meanders where both flow on the same valley slope and in the same type of materials.) The fact that meanders maintained by the Mississippi River throughout its history have had the same general range in size proves that bank-full discharge has remained fairly constant.

Meanders can only be developed in bed materials which permit scouring and bank caving and the downstream transfer of sediments. The lack of large meanders south of Donaldsonville is but an expression of river activity in the thick mass of fine-grained resistant sediments forming the bed of the river there. That the absence of meanders in this area is not related to possible variation in discharge[2] or to the low valley slope on the deltaic plain is shown by the fact that the older Teche course of the Mississippi River had well-developed meanders as far downstream as Franklin. The Teche course flowed on the same valley slope as the present stream but through the generally more sandy sediments which lie close to the western valley wall. Throughout the valley, meanders develop in sandy sediments at a rate which is conditioned by the thickness of the fine-grained topstratum blanketing the sands.

**Bed Materials.** The bed materials through which the Mississippi flows consist largely of alluvial deposits although the river has scoured into resistant bedrock sediments in a few areas (see frontispiece). In the northern and central parts of the valley where coarse sediments lie close to the surface, local thick masses of silts and clays fill abandoned channels in the meander belt and form the resistant hard points, clay plugs,[3] in the river bank. In the southern part of the valley where fine-grained sediments form a widespread thick cover, sandy alluvial fans of minor streams and old point bar deposits form local easily eroded banks.

The bed materials are of utmost importance in determining and maintaining the poised condition of the river. As a factor controlling stream activity, they are interrelated with both stream load and valley slope. The channel is wide and generally shallow in the northern part of the valley where the river slope is steep and where the river flows through sandy deposits. It is deep and narrow where the valley slope is low in the fine-grained erosion-resistant bed materials of the deltaic plain (see figure 56).

The nature of the bed materials determines the relative stability of the river banks and together with variations in stage largely controls the local characteristics of the meandering stream. The relative bank stability controls the rate of bank recession, variations in river stage shift the area of bank attack. During low-river stages the bank attack is along the upstream part of a bend; as the stage increases the attack normally shifts downstream. These two factors shape the bends, regulate bend migration, and thereby determine river alinement and the position of reaches.

**Bed Materials and Local Bank Recession.** The primary cause of bank recession is scouring in the talweg of the river channel which destroys the equilibrium between bottom and bank sediments. This scouring brings about an adjustment of the subaqueous profile by riverward movement of the water-charged sands under the pressure of the overlying bank sediments (see plate 24).

Most banks along the Mississippi River show an alternation of sandy sediments interspaced with relatively narrow areas of silts and clays. The sandy areas slough and form embayments in the bank line called "false coves" whereas the more resistant silts and clays form hard points or "false capes" (see diagrams

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[1] It is beyond the scope of this report to present a discussion of meander phenomena. Factors controlling meandering have been isolated and briefly described by Matthes. See: Matthes, Gerard H., "Basic Aspects of Stream-Meanders," Trans. Amer. Geophysical Union, pp. 632-636, 1941.

[2] A lack of effective stage difference in the lower part of the river is used by Russell to explain the absence of meandering. See Russell, R. J., "Physiography of the Lower Mississippi Delta," Louisiana Dept. Cons., Geol. Bull. No. 8, 1936.

[3] For a brief discussion of clay plugs see Part III (Recent Alluvium), p. 19.

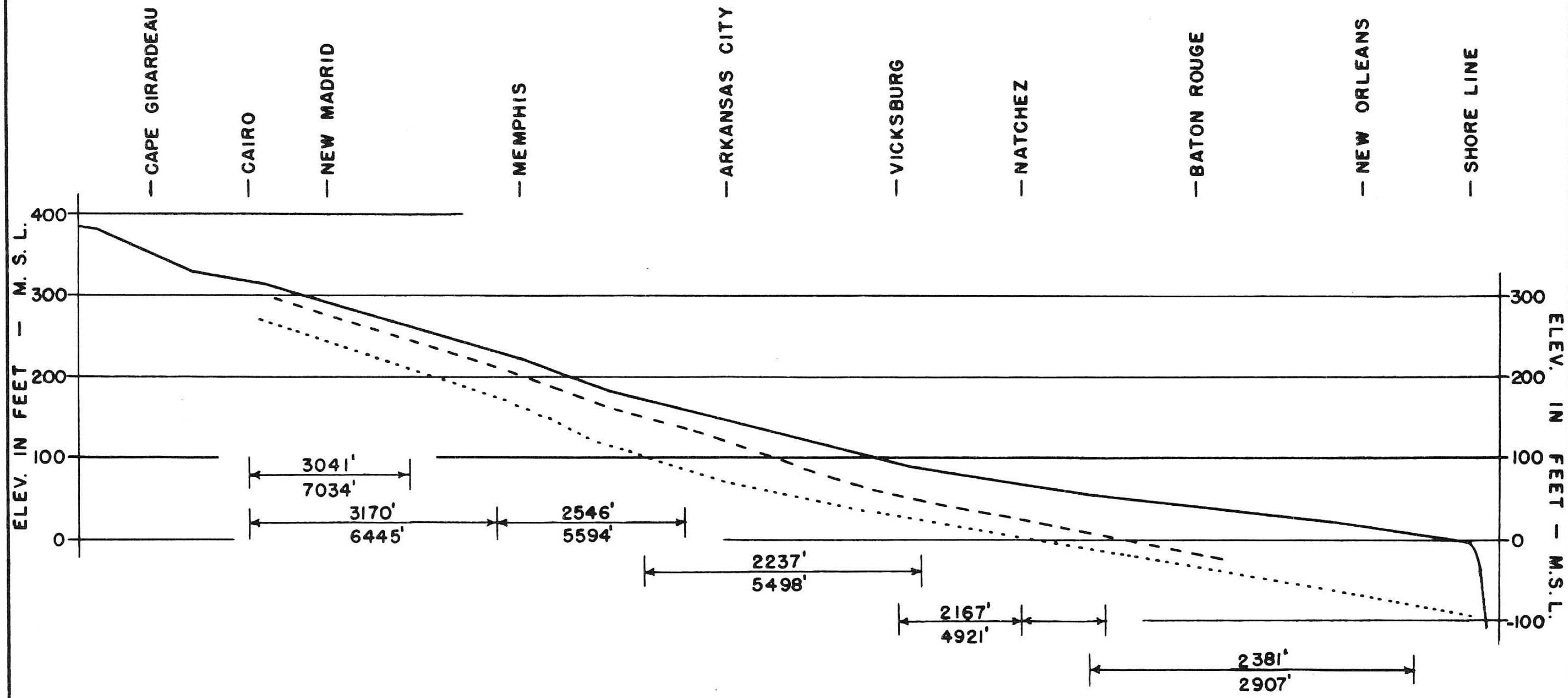


FIGURE 56.- RELATION BETWEEN FLOODPLAIN SLOPE, THICKNESS OF FINE GRAINED DEPOSITS, AVERAGE WIDTH OF RIVER, AND AVERAGE DEPTH OF RIVER CROSSINGS.

——— MISSISSIPPI RIVER FLOODPLAIN (1874)

– – – – TOP OF SAND, BASE OF TOPSTRATUM DEPOSITS

·········· AVERAGE DEPTH OF RIVER CROSSINGS

3041' AVERAGE WIDTH OF RIVER AT LOW-WATER STAGE
7034' AVERAGE WIDTH OF RIVER AT BANK FULL STAGE

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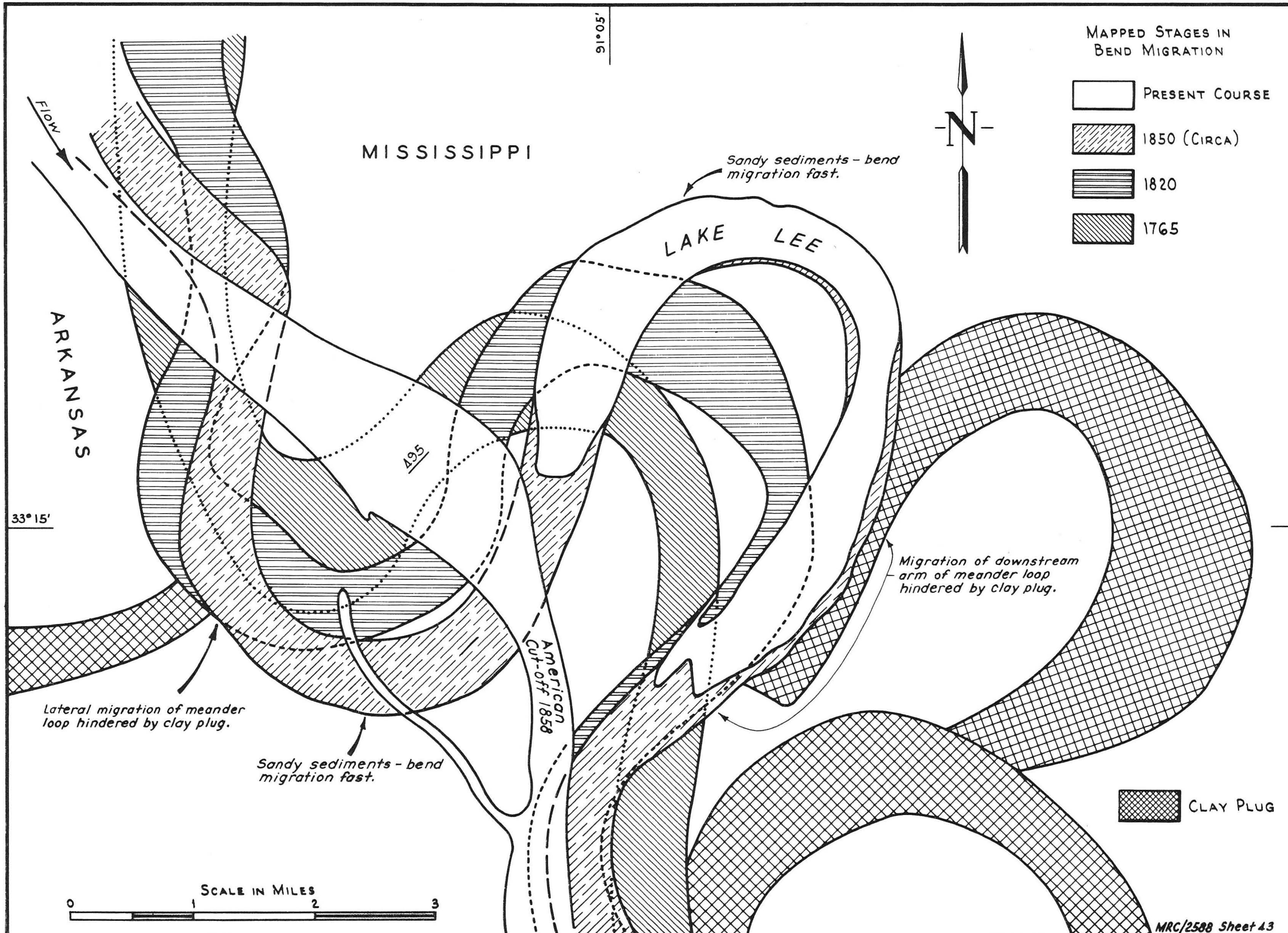
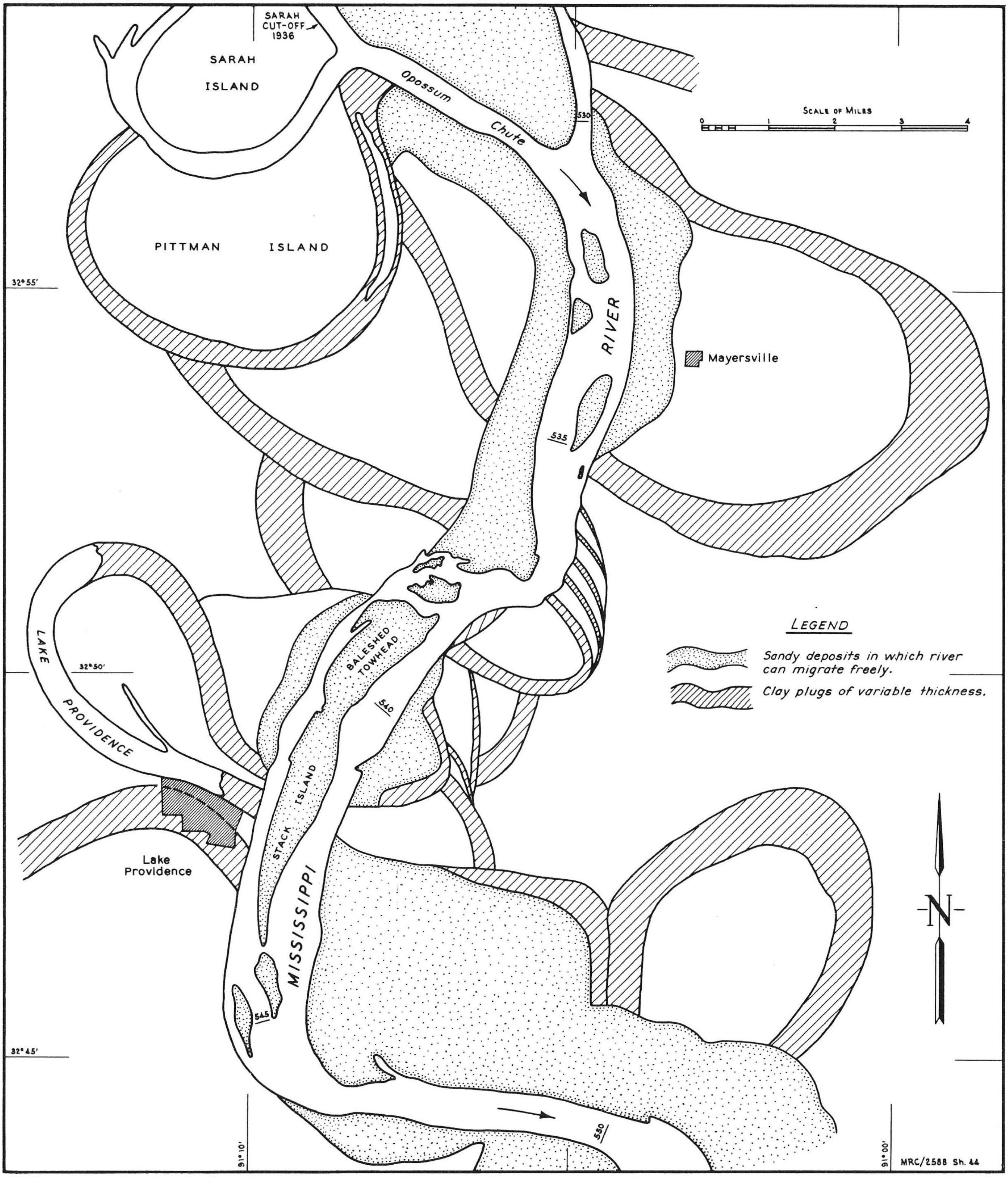
FIGURE 56

FIGURE 57




MISSISSIPPI RIVER — CONTROL OF BEND MIGRATION BY CLAY PLUGS IN THE VICINITY OF LAKE LEE.




CONTROL OF RIVER ALIGNMENT BY CLAY PLUGS IN THE LAKE PROVIDENCE REACH OF THE MISSISSIPPI RIVER.

FIGURE 58

1, 7, plate 24). Fine-grained silty and clayey sediments offer a greater resistance to bank recession than do sandy sediments because of their lower permeability, greater cohesion, and their more compact nature. These properties permit a steeper subaqueous profile of equilibrium to be maintained than do those of sandy sediments. (See plate 24, diagrams 2, 3, and 4 for a contrast between two subaqueous profiles developed in sandy bed and bank materials and one developed in silty sediments in the same area of bank recession on the east bank of the river below Mayersville, Miss.)

Bank recession by slumping causes the subsidence and bankward tilting of bank sediments in blocks or large masses. Slumping is the adjustment caused by the removal of sandy sediments from beneath the more cohesive topstratum (see diagrams 5, 6, plate 24). Cracks caused by incipient slumping, in the areas of relatively thin topstratum landward of the active caving bank, may show a small amount of displacement before slumping takes place. The size of the slump block varies directly with the thickness of the topstratum, and cracks are not present far from the active slump plane in areas of thick topstratum.

Bank recession takes place by continuous sloughing of sands in areas where there is little strength to the topstratum and where sand comes close to the surface, as in river bars. Small blocks may slump into the river; but, after slippage of the mass takes place, these blocks quickly disappear and the shores become generally smooth or broadly arcuate (plate 24, diagrams 6 and 7).

Most of the actively caving banks of the river stand nearly vertical above the mean low-water line. The vertical attitude is maintained by slow attrition as lateral corrasion by the river undermines the bank at the water's edge and permits thin segments of the bank face above water level to fall into the river. This process of undermining is termed "sapping" and appears to be a relatively unimportant means of banks recession (see plate 24, diagram 7).

**Bed Materials and the Shape and Migration of Bends.** A meander of a stream flowing in uniform bed materials exhibits a smooth and regular outline and migrates downstream in an orderly manner. In the Mississippi meander belt, however, most migrating bends encounter local resistant bank sediments which slow the rate of bank recession and change the downstream alinement of the river and the directive of stream attack. Irregularities in migration often result in the formation of a distorted or abnormal meander and eventually lead to the cut-off of the meander loop. The control which is exerted by clay plugs on bend migration and the shaping of bends is illustrated by the development of the meander loops in the vicinity of Lake Lee. Irregularities in channel migration in this area led to the formation of the American Cut-off in 1858 (figure 57).

**Reaches.** Reaches occur along the Mississippi channel in many places where a relatively constant alinement of the river has been maintained. They are found downstream from some of the points where the river impinges against the valley wall. They also occur in floodplain areas below cut-offs and in places where the alinement is controlled by resistant sediments. River history points to the development of some reaches through a succession of cut-offs in a local area where meander loops are developed on both sides of the axis of a meander belt. As successive cut-offs occur, the river position becomes established between infacing cut-off meanders whose arms have been filled with clay plugs. River alinement is controlled by these relatively resistant channel fillings, and as cut-offs continue, channel migration become localized to a zone of decreasing width. A reach is formed when the zone of migration becomes so narrow that meander loops can no longer develop. Lake Providence Reach (figure 58) is considered to have formed in this manner. The effectiveness with which clay plugs confine the zone of river migration and prevent the development of meander bends is determined by the spacing, thickness, and toughness of the old channel fillings bordering the reach.

**Load.** The load of the river varies with stage, slope, and distribution of velocities within the water mass, and with the nature of the bed materials. The principal load of the river, suspended load, has little direct effect upon river activity inasmuch as most of it is in continuous transit to the Gulf. Coarse load is transported mainly as bed load and has a direct effect upon channel cross-section. The stream may become locally overloaded in areas where a large supply of sand is available and it may become "starved" where banks are made up of resistant materials.

There are no measurements to show the quantity of coarse-grained sediments introduced by the tributaries of the Mississippi River. There is, however, no evidence in the nature and distribution of floodplain sediments near the mouths of tributary streams to prove that sands are being introduced by the streams in quantities sufficient to cause local channel aggradation.

The change from a shallow-channel braided stream to a deep-channel meandering stream made it possible for the Mississippi River to scour deeply into coarse alluvium laid down during early epochs in valley history. These coarse sediments, scoured from the channel or derived from bank caving associated with bend migration, form most of the sand load of the river and are carried but short distances from areas of high-water velocity to areas of low-water velocity where they form bar deposits. The downstream movement of coarse sediments is therefore a slow and discontinuous process termed "trading." The local transfer of sands from caving bank to an adjacent downstream bar halts when the bar is isolated from the river by channel migration or cut-off. The speed of the trading process is dependent upon the speed of channel migration which increases with rise in river stage throughout the valley but decreases downstream as banks become less sandy and the valley slope gentler. Gulfward movement of the coarse sediment is extremely slow, owing to the local and intermittent nature of transfer by trading. Sands are "stored" in bars of the meander belt until subsequent migration of the channel permits reworking of the deposits.

The river also derives a small portion of its suspended load through the winnowing of fine-grained topstratum sediments from the floodplain deposits. Not all of the suspended deposits reach the Gulf in continuous transit. Some are trapped in flood basins during overflow, some accumulate in cut-off lakes to form part of clay plugs, and others are laid down in irregularities along the channel during falling river stages.

## Minor Controls of River Characteristics

Local stream behavior is influenced by bedrock[1] and by the regional structure.

**Bedrock.** Where the Mississippi River impinges against the valley walls or scours divide areas of the entrenched valley floor, it encounters bedrock which is better consolidated than the alluvial materials and is considerably more resistant to river attack. Tough bank materials such as occur at Baton Rouge, Vicksburg, and Wickliffe, have slowed down meander migration and have caused the formation of excessively deep and narrow channels. In controlling the local river alinement, the resistant valley walls have in places produced relatively stable reach channels downstream. Bedrock deposits and the distribution of the alluvium above the talweg between Cape Girardeau and the mouth of the river are shown on plate 25.

Between Donaldsonville and New Orleans the tough Pleistocene clays and overlying thick topstratum produce banks which resist bend migration and the river has scoured a deep channel (plate 25 and figure 56). At Diamond Cut-off limestones of the Vicksburg group (similar to those shown on figure 10) occur at shallow depths, between 38 and 45 ft. below mean low water, and may have helped to resist the enlargement of the artificial cut, known to have been retarded in its development by the resistance of overlying tough backswamp clays in the area.

**Structure.** Although local alinement of the Mississippi within its meander belt is virtually independent of regional structure, the alinement of long segments of the river with the trend of the regional fracture pattern indicates that the initial position of the stream course after diversion may have been established along sags overlying major fracture zones. The section of the river between Helena and the mouth of the Arkansas River parallels the Big Creek fault zone. The straight course of the river below English Turn, southeast of New Orleans, parallels the trend of the Red River fault zone. The anomalous bend, English Turn, occurs in the area where the river is confined to a graben within the Lake Borgne fault zone (see plate 17). Short sections of the river between Donaldsonville and New Orleans follow courses parallel with either the Lake Borgne or Red River fault zones.

Active faulting in the Reelfoot Lake area in northwest Tennessee disturbed the local profile of the river as recently as 1812, the time of the New Madrid earthquake.[2]

Prehistoric faulting may have been responsible for the diversions of the river from well-developed meander belts to new lowland courses. This theory is supported by the correlation between the position of an ancient crevasse and the recent faulting at Vacherie, La.[3] Furthermore, although no movement of the earth's surface was observed at the time, several historic crevasses along the river took place at points where regional fracture zones intersect the artificial levees, and the direction of the crevassing is alined with the trend of the faulting. Study of the relationship of regional fracture zones to river crevasses is being conducted by the Mississippi River Commission.

## Channel Segments

Three major segments of the Mississippi River showing transitional channel characteristics correspond roughly with the northern, central and southern divisions of the alluvial plain. They are divisible into shorter sections on the basis of local differences in slope, discharge, bank materials, and channel alinement.

### *The Northern Segment (Commerce to Helena)*

Above Helena the Mississippi has a broad shallow channel with many bars and islands; the valley slope is steeper than in the segments to the south; and channel changes are rapid. The channel is marked by a series of long reaches.

**Commerce-Cairo Section.** The tributary Mississippi, above its junction with the Ohio, constitutes the northernmost section of the river in the alluvial valley. The tributary channel is reach-like in character through most of its length, but two well-developed meander loops have formed immediately above Cairo. Only a few old cut-off loops flank the present channel and the banks in this zone are sandy and unstable; minor channel shifts are frequent.

**Cairo-New Madrid Section.** The reach channel from Cairo to New Madrid lies near bluffs and has developed as the end product of a number of huge loop cut-offs. The valley slope has been slightly decreased through uplift of the Tiptonville Dome along the Reelfoot Lake fault near the lower end of the section and by the deposition of sandy sediment during the excavation of the trench below Thebes Gap. This section and the one below are in the oldest portion of the present meander belt; they have been occupied by the Ohio since its abandonment of the Cache Lowland course. Bank caving at New Madrid is within Ohio alluvial fan materials. Elsewhere, the river is flowing in its own meander-belt deposits which have been reworked from the sandy deposits of the Ohio alluvial fan.

**New Madrid-Richardsons Section.** This section is marked by fewer reaches than are present in adjacent sections. The channel is sinuous, but numerous clay plugs have slowed migration locally and only one cut-off has taken place within historic times. Meandering is best developed at the lower end of the section where the meander belt forks.

**Richardsons-Helena Section.** A series of chute cut-offs, some within historic times, have left the river between Richardsons and Helena in a series of reaches. A number of well-developed meanders exist in the lower part of the section where the river crosses the old Mississippi-Sunflower meander belt. Although the characteristics of the channel in this section are transitional with those of the segment below, the meander belt is here less complex than either upstream or downstream because it has been occupied for a shorter time.

[1] Relatively resistant sediments underlying the alluvial valley fill.
[2] See discussion of Tiptonville Dome, Part IV, and Fuller, M. L., "The New Madrid Earthquake," U. S. Geol. Survey Bull. 494, 1912.
[3] See discussion of Vacherie fault, Part IV, p. 33.

*The Central Segment (Helena to Angola)*

From Helena to Angola the river has a deeper and narrower channel than to the north and fewer bars and islands. The valley slope is intermediate between that of the northern and southern segments. The channel is very sinuous, meandering is rapid, and only a few reaches have developed. The shape of many of the bends is controlled by clay plugs, but most channel migration takes place with a regular rate and direction. Historic cut-offs have been numerous and generally of the loop type.

The river tends to meander most rapidly where it cuts across deposits of older meander belts and alluvial fans. Most of the sand being traded represents reworked Mississippi alluvial fan deposits.

**Helena-Rosedale Section.** The present channel is near the eastern edge of its meander belt in many places and is actively cutting into old Mississippi alluvial fan deposits. The Arkansas and White rivers join the Mississippi near Rosedale.

**Rosedale-Vicksburg Section.** The speed of meandering increases below the mouth of the Arkansas River where the valley slope is locally steepened. Two reaches, Lake Providence and the reach south of Lake Chicot, appear to have been developed as a result of natural limitation of channel migration by clay plugs. A large number of clay plugs also control the shape of the channel in the vicinity of Vicksburg where the river cuts across the old Walnut Bayou and Upper Tensas meander belts.

**Vicksburg-Angola Section.** This is the most recently formed portion of the meander belt north of Donaldsonville. In the northern part of the section the Mississippi River has meandered widely and reworked the bar sands of the Walnut Bayou meander belt. Clay plugs deposited in the abandoned channels confine the river to a comparatively narrow zone of migration close to the eastern valley wall. South of Natchez, bank attack in many bends is directed against thick backswamp clay, and channel migration is slow. The river reworks small graveliferous alluvial fans of many minor eastern tributaries and in places forms islands and bars of these coarse deposits.

*The Southern Segment (Angola to Gulf of Mexico)*

The channel becomes progressively narrower and deeper southward from Angola as the valley slope gradually decreases. Baton Rouge is near the head of deep-water navigation. Channel migration is slow and the growth of abnormal meanders ceases below Donaldsonville. Banks are composed of progressively finer deposits which thicken downstream. Bank attack is generally directed against thick backswamp clays or deltaic plain deposits, and bank caving and trading diminish downstream. The last towhead in the Mississippi River lies just above Donaldsonville and represents the approximate southern limit of low-water sand transfer by the river.

**Angola-Baton Rouge Section.** Although it is transitional with the segment upstream, the Angola-Baton Rouge Section is characterized by a slower rate of meandering because of the thicker topstratum and gentler low-water slope. There are few clay plugs and few cut-offs. Channel migration is locally faster where the Mississippi River is reworking the deposits of Thompson Creek, which introduces gravels and sands to the rivers. These coarse deposits have been "traded" downstream as far as Conrad Point below Baton Rouge.

**Baton Rouge-Donaldsonville Section.** Meandering is slow here and river bends are angular. Steep stream slopes and scouring velocities are limited to higher river stages, and the resulting concentration of bank attack causes angularity of bends. Bank attack is directed against thick backswamp clay on most bends; the banks cave slowly and furnish little sand to the channel below. Point bar growth is extremely slow.

**Donaldsonville-New Orleans Section.** Bank caving is at a minimum from Donaldsonville to New Orleans. The banks are composed of deltaic plain deposits overlain by natural levees of the present stream and underlain at shallow depths by tough Pleistocene clays. The deepest parts of the Mississippi channel are in this section which has shifted its position but slightly since first occupied.

**New Orleans-Gulf of Mexico Section.** The channel of the river in this section is the latest of a series of channels occupied by the river, while constructing its deltaic plain, and the bed materials consist entirely of deltaic plain deposits. The channel is deep and its migration is slight. The river branches into its bird-foot delta at Head of Passes.

## Part VII

## SUMMARY AND CONCLUSIONS

The general configuration of the Mississippi Alluvial Valley is determined by the distribution and attitude of the Central Gulf Coastal Plain strata. Faulting along regional zones determined the local shape and alinement of the valley walls and the position of tributary valleys. Movement along the fault zones represents adjustment to downwarping of the Gulf Coastal Plain margin and has occurred throughout the history of the region. Observed faulting within the alluvial plain, fault escarpments developed in the Recent alluvium, and abnormal drainage patterns all indicate that faulting is still active in the region. Inasmuch as the pattern of the regional fault zones reflects the structural grain of the continent, it is believed that the faults originate at great depth in the basement rocks.

The Mississippi River is a "newcomer" to the Central Gulf Coastal Plain. It first entered the region in early Glacial time when streams of the Central Lowlands of the United States were integrated and diverted southward by the growth of the North American Ice Cap. The river was originally established in a course which approximated the axis of the Mississippi Structural Trough, and it has maintained that general position throughout its history. Oscillations in sea level accompanying the several advances and retreats of the Pleistocene glaciers caused the river alternately to incise the region and to alluviate its valley system. Structural upwarping of the region has left the early deposits to stand as step-like terraces bordering the alluvial valley.

Because of the lowered sea level attendant on the final advance of the Pleistocene ice cap, the Mississippi River system became entrenched in a deep valley system. The tributary Mississippi River west of Crowleys Ridge and the Ohio River east of Crowleys Ridge joined in the central part of the valley. The Arkansas River followed its entrenched valley west of Macon Ridge to Sicily Island where it joined the master stream. The trunk stream extended beyond the present shoreline and probably emptied into the Gulf near the position of the submarine canyon south and west of the present river mouth.

The alluvium with which the entrenched valley system is filled is of Recent age. It was deposited during and subsequent to the wasting of the glaciers. As sea level rose, the slope was decreased and the streams suffered a gradual loss in carrying capacity which is reflected in the upward decrease in grain size of the alluvium.

The greater part of the Recent alluvium is made up of alluvial fan deposits. The widening of a tributary valley at its junction with the master valley, together with the gradual decrease in alluvial valley slope, permitted the tributary stream volume to dissipate, forced deposition of its sediments, and thereby caused the construction of low alluvial fans around the valley mouth. The fans determined the nature of sediments which reached the master stream and, together with faults, controlled the position of floodplain drainage. Alluvial fan remnants above floodplain level indicate a recent incision of their surface by streams. This incision resulted from uplift by faulting and from drainage readjustments necessitated by excessive alluviation at the heads of the alluvial fans.

The characteristics of the Mississippi River result from the integration of the present drainage system by means of a long and complicated series of shifts in the position of both master and tributary streams. While sea level was rising and valley slopes were still steep, the tributary streams maintained braided shallow-channelled courses on their alluvial fans. Only the master stream below the Ohio-Mississippi junction meandered in a single channel at that time. The present hydrographic system became established after sea level had reached its stand and after the Mississippi River was diverted through Thebes Gap to join the Ohio farther north than at any other time in river history.

The lower Mississippi River has shown no tendency to aggrade or degrade its channel since the time of its diversion through Thebes Gap. Although its meander belt history since then has been complicated, the present channel is no deeper and the crest of the natural levees no higher than those of earlier stages of meander belt formation. The overall valley slope has remained constant. This poised condition of the river has resulted from a stand in sea level, a constant position of the junction of the Ohio-Mississippi rivers, and a lack of sufficient coarse load introduced by the tributary streams to cause valley aggradation.

Although changes in valley slope, bed materials, load, and discharge determined the principal characteristics of the present Mississippi River, these factors have remained practically constant since the diversion of the river through Thebes Gap. Today, the bed materials supply the principal sand load to the river and determine the local nature of the river channel. In the northern and central parts of the valley the bed materials are mainly the coarse alluvial fan deposits of the tributaries overlain by a thin topstratum of fine-grained sediments; to the south the topstratum is much thicker, and the bed materials are principally silts and clays. The river is able to meander in the coarse sediment, but it has established a deep channel in the finer-grained deposits where it cannot migrate.

The Mississippi River began to meander below the Ohio-Mississippi junction soon after sea level reached its standing position. The size of the Mississippi River meanders reflects the bank-full discharge of the river, and meander shape is determined by the resistance of sediments to bank caving and the variation in the river stage.

With its diversion through Thebes Gap the Mississippi River established for the first time a comparatively deep-water channel from the head of its alluvial valley to the Gulf of Mexico. From the standpoint of flood control and navigation, this channel is the best that has existed in the history of the alluvial valley.

# Appendix

## GEOLOGICAL SETTING OF THE MISSISSIPPI ALLUVIAL VALLEY

### INTRODUCTION

The Lower Alluvial Valley of the Mississippi River lies wholly within the central portion of the Gulf Coastal Plain of the United States. Its shape, width, and general configuration bear a direct relationship to the attitude and distribution of sediments which make up this large physiographic region.

#### The Central Gulf Coastal Plain

**Location.** The Gulf Coastal Plain, which is coextensive with the Atlantic Coastal Plain on the east, averages more than 200 miles in width between Georgia and the Rio Grande River south of Texas. Where the Central Gulf Coastal Plain is crossed by the Mississippi River it has an extension, the Mississippi Embayment, which projects inland north of the 34th parallel for a distance of 225 miles to Commerce, Mo., about 600 miles from the Gulf of Mexico shoreline (see plate 1). The embayment gradually decreases in width from 225 miles on the south to less than 125 miles in the latitude of Cairo, Ill. It includes a part of northwestern Alabama, northern Mississippi, Tennessee west of the Tennessee River, the Jackson Purchase region of Kentucky, southern Illinois south of the Cache River Lowland, southeastern Missouri, and the lowlands of eastern Arkansas. The coastwise plain and the embayment are separated from the Interior Lowlands of the United States by the lowest and narrowest part of the Interior Low Plateaus, Shawneetown Ridge, in southern Illinois. They are bordered on the northeast by the southern Appalachian Mountains and the Interior Low Plateaus and on the northwest by the Ozark Highlands and the Ouachita Mountains (see plate 1).

**Drainage.** Most of the drainage of the region is tributary to the Mississippi River (see plate 1). All of the drainage from the Ouachita and Ozark uplands finds its way to the Mississippi River by way of the Red, Ouachita, Arkansas, White, or St. Francis rivers. East of the alluvial valley the drainage of Kentucky, Tennessee, and the western half of Mississippi is tributary to the Mississippi River. Before entering the valley to join the Mississippi River, the Ohio River receives the waters of the Tennessee and Cumberland rivers; this system collects the entire drainage of the Interior Low Plateaus and the southwestern slopes of the Appalachian Mountains.

A few streams of the region reach the gulf through courses independent of the Mississippi River. The waters of the southern Appalachians and the eastern part of the Central Gulf Coastal Plain drain to the Tombigbee, Warrior, and Alabama rivers which join to form the Mobile River. The Pearl River and the Pascagoula River with its tributaries, the Leaf and the Chickasawhay rivers, drain the coastal plains of southeastern Mississippi. The Sabine and Trinity rivers drain the coastal plains of the eastern part of Texas and bordering Louisiana. The Calcasieu River and a few minor streams collect the drainage of southwestern Louisiana.

**Elevation and Slope.** The Central Gulf Coastal Plain is everywhere an area of moderate or low relief with elevations ranging from sea level to approximately 800 ft. The 500-foot contour closely follows the interior borders of the plain, and most of the region including the alluvial valley is below this elevation. The highest elevations are along the divide between the Tennessee and Tombigbee rivers in northwestern Mississippi. High points in the northern part of Crowleys Ridge reach an elevation of almost 600 ft. and a few areas in the hill lands of southwestern Mississippi are above 500 ft. No part of Louisiana or coastal plain Arkansas reaches an elevation of 500 ft.

Slopes are gentle from the inland borders of the plains toward the alluvial valley and the gulf. Steep slopes are found only along valley walls and in well-dissected hill lands of moderate relief.

### PHYSIOGRAPHY

The Gulf Coastal Plain is characterized by a belted topography of alined hills and valleys which can be traced as definite units for long distances. In the Mississippi Embayment the topographic units parallel the inland borders of the region; south of the embayment they trend with the gulf shoreline.

Belted topography results from differential erosion of the alternation of erosion resistant and less resistant beds which make up the sequence of coastal plain sediments. The asymmetrical hills or wolds have steep inland-facing broken escarpments overlooking broad-lowland vales or valleys; their gentler backslopes gradually carry the hills under the adjacent valleys. The hills have been eroded from sands and indurated sediments whereas the valleys have been carved from clays, silts, and calcareous sediments. The continuity of the trend of the belts is determined by the lateral extent of the outcrop of each sedimentary unit, and their asymmetrical appearance reflects their structure. The gentle backslopes of the hill belts are determined by the degree of dip of the erosion resistant sediments, and the steeper inland slopes are invariably developed at right angles to the dip of the beds, i.e., along the strike of the outcrop.

For the purposes of this report the Central Gulf Coastal Plain is divided into four physiographic divisions which can be further subdivided into hill and valley belts (see plate 1), each subdivision marking a definite geological formation or formations.

**The Eastern Hills Section.** This section occupies the northeastern part of the Central Gulf Coastal Plain and is limited landward by the Appalachian Mountains and the Interior Low Plateaus (plate 1). Its western boundary is the bluff line of the alluvial valley and its southern one is the lowland belt of the Jackson Prairie which is the northernmost element of the coastwise belted topography of the Southern Hills.

The Eastern Hills section has been subdivided[1] into several alternating hill and valley belts. The Fall Line Hills belt, a hilly region eroded from the sandy strata at the base of the Upper Cretaceous deposits, is adjacent to the Appalachian Mountains and Interior Low Plateaus (plate 1). The Black Belt next to it is a prairie or valley region eroded in the calcareous upper parts of the Upper Cretaceous. The Pontotoc Ridge and the Flatwoods, a valley belt, are eroded from deposits of the Midway, lithologic differences giving rise to a ridge at one place and a prairie belt elsewhere (plate 1). West of these belts is a generally hilly region which is eroded from sandy Wilcox and Claiborne deposits. Northward within the Mississippi Embayment the various belts gradually lose their identity because the lithology of the formations is similar.

Included for convenience within the Eastern Hills section are the distinctive Bluff Hills or Loess Hills which lie within a zone 5 to 25 miles wide along the western margin of the section and extend southward across the Southern Hills section almost to the Louisiana-Mississippi state line. This zone of hills has been eroded from terrace deposits which follow and obscure the previously developed topography of the Eastern Hills section in the Mississippi Embayment. The Bluff Hills cut across the topographic belts of the Southern Hills and merge with the high coastwise terraces of that section. They are well-dissected along the border of the alluvial valley and are characterized by a mantle of loess which provides a distinctive topography (see photograph, figure 59).

**The Western Hills.** The Western Hills extend northward to the Arkansas River and southward to the Jackson Prairie (plate 1). Their landward boundary is formed by the Ouachita Mountains and their eastern border is the western bluff wall of the alluvial valley. Within the Mississippi Embayment region the belted topographic features are obscured but their original outline is maintained in the outlines of Crowleys Ridge and the surrounding lowlands.

The belted character of this section is, in general, not as distinctive as that of the Eastern Hills section. The lithology and thickness of the underlying formations differ from place to place, and structural movements in the region have changed the strike and dip relationships of the beds. Most of the section has been eroded from lithologically similar Tertiary deposits, and belts of hills with discontinuous ridges have been developed over much of the area. The Nacagdoches Wold forms the only continuous hill belt and outlines the Sabine Uplift area of northwestern Louisiana and bordering parts of Texas. This uplift has reversed the normal gulfward dip of the beds and the wold encircles the structure (plate 1). Mesozoic deposits consisting mainly of calcareous beds give rise to several prairie belts in the northwestern part of the section.

**The Southern Hills Section.** The Southern Hills make up the southern third of the Central Gulf Coastal Plain. They include the hill and valley belts parallel to the Gulf shore and the coastwise seaward-sloping terraces (plate 1). Most of the Southern Hills is separated from the Gulf shore by a low coastwise plain of variable width, but at a few places the section touches the gulf shoreline. Continuity is interrupted by the alluvial valley, but the trend of the hill and valley belts clearly shows that the section can be properly considered a unit.

The Southern Hills is a predominantly hilly region with hilly areas separated from plains by seaward facing scarps. The northernmost element of the section is the Jackson Prairie, a lowland belt eroded from clays of the Jackson group. The most prominent hill belt south of the Jackson Prairie consists of the Grand Gulf Hills east of the alluvial valley and the Kisatchie Wold west of it. These hills have been eroded from the basal sandy sediments of the Grand Gulf group. The Grand Gulf Hills merge southward with the high Coastwise Terraces, a belt of hills developed on gulfward-sloping graveliferous terrace deposits. The Kisatchie Wold is separated from the high Coastwise Terrace hill belts by the Fleming Prairie, a lowland developed on calcareous facies of the Grand Gulf sediments. This prairie narrows and gradually disappears to the east where it is overlapped by the terrace deposits. The Prairie Coastwise Terrace is a little-dissected alluvial plain which slopes seaward and becomes buried beneath the coastal marshlands.

**The Alluvial Valley Section.** The broad Mississippi River Alluvial Valley lowland lies across the Central Gulf Coastal Plain from north to south (plate 1) and divides it about in half. It occupies the western half of the Mississippi Embayment area and is almost centrally located in the Southern Hills section. The deltaic plain of this section merges with the low Coastwise Plain marshland along the coast. (For a detailed discussion of the physiography of the alluvial valley section see Part IV.)

**The Continental Shelf.** The continental shelf is a submarine area which extends seaward for as great a distance as 100 miles off the present shoreline. The gulf bottom in this region is characterized by low slopes and its outer margin is outlined by the 50 fathom (300-foot) contour. South of the margin of the shelf the slopes steepen abruptly in the continental slope zone and plunge into the deeps of the Gulf of Mexico.

In the otherwise rather smooth continental shelf along the central Gulf Coast, soundings have revealed the presence of a deep valley heading into the continental shelf and extending gulfward as a canyon to the 500 fathom (3,000-foot) contour. Marked as Submarine Canyon on plate 3, this feature corresponds to similar canyons[2] along other coast lines.

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[1] For complete discussion and bibliography see Fenneman, N. M., "Physiography of Eastern United States," McGraw-Hill Book Company, 1938.

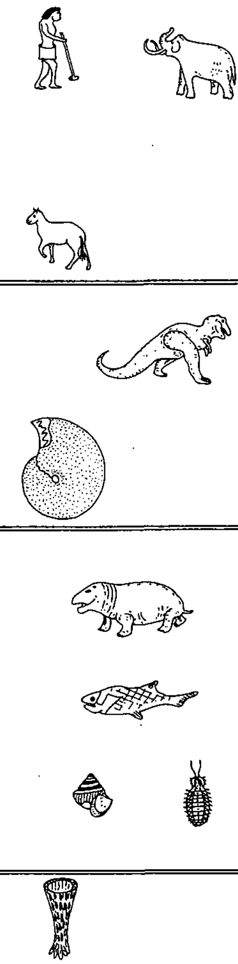
[2] For the origin of submarine canyons see Bucher, W. H., "Submarine Valleys and Related Geologic Problems of the North Atlantic," Bull. Geol. Soc. Amer., vol. 51, pp. 489-512, 1940.
Daly, R. A., "The Floor of the Ocean," Univ. of North Carolina Press, pp. 99-157, 1942.
Johnson, Douglas, "The Origin of Submarine Canyons," Columbia Univ. Press, 1939.
Veatch, A. C. & Smith, P. A., "Atlantic Submarine Valleys of the United States and the Congo Submarine Valley," Geol. Soc. Amer., Spec. Paper 7, 1939.

FIGURE 59

LOESS DEPOSITS IN CUTS ALONG U. S. HIGHWAY 61 SOUTH OF VICKSBURG, MISSISSIPPI. THE TOPOGRAPHY IS TYPICAL OF THE WELL DISSECTED BLUFF HILLS FORMING THE EASTERN MARGIN OF THE MISSISSIPPI ALLUVIAL VALLEY.

TABLE 10

# GEOLOGIC TIME

| ERA | PERIOD | EPOCH | GEOLOGICAL TIME IN PERCENT | TIME REFERRED TO 1 YEAR: DAYS | HOURS | MIN. | SEC. | SUCCESSION OF LIFE | AGES | | CRUSTAL MOVEMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CENOZOIC 55 000 000 YRS | QUATERNARY 1 000 000 YRS | RECENT 30 000 YRS | 0.0014 | 0 | 0 | 7 | 12 |  | AGE OF MAMMALS | AGE OF MODERN SEED PLANTS |  |
| | | PLEISTOCENE OR GLACIAL AGE 970 000 YRS | 0.0456 | 0 | 3 | 43 | – | | | | CASCADIAN REVOLUTION |
| | TERTIARY 54 000 000 YRS | PLIOCENE 6 000 000 YRS | 0.290 | 1 | 1 | 24 | – | | | | |
| | | MIOCENE 12 000 000 YRS | 0.573 | 2 | 2 | 12 | – | | | | |
| | | OLIGOCENE 16 000 000 YRS | 0.770 | 2 | 19 | 25 | – | | | | |
| | | EOCENE / PALEOCENE 20 000 000 YRS | 0.960 | 3 | 12 | 5 | – | | | | LARAMIDE REVOLUTION |
| MESOZOIC 135 000 000 YRS | CRETACEOUS 65 000 000 YRS | UPPER: GULF 40 000 000 YRS | 1.920 | 7 | – | – | – | | AGE OF REPTILES & AMMONITES | | |
| | | LOWER: COMANCHEAN 25 000 000 YRS | 1.200 | 4 | 9 | – | – | | | | |
| | JURASSIC 35 000 000 YRS | | 1.680 | 6 | 5 | – | – | | | AGE OF ANCIENT SEED PLANTS | JURASSIDE DISTURBANCE |
| | TRIASSIC 35 000 000 YRS | | 1.680 | 6 | 5 | – | – | | | | PALISADE DISTURBANCE |
| PALEOZOIC 350 000 000 YRS | CARBONIFEROUS: PERMIAN 25 000 000 YRS | | 1.200 | 4 | 9 | – | – | | AGE OF AMPHIBIANS | | APPALACHIAN REVOLUTION |
| | CARBONIFEROUS: PENNSYLVANIAN 35 000 000 YRS | | 1.680 | 6 | 5 | – | – | | | AGE OF SPORE-BEARING PLANTS | |
| | CARBONIFEROUS: MISSISSIPPIAN 40 000 000 YRS | | 1.920 | 7 | – | – | – | | | | CULMIDE DISTURBANCE |
| | DEVONIAN 50 000 000 YRS | | 2.400 | 8 | 18 | – | – | | AGE OF FISHES | | ACADIAN DISTURBANCE |
| | SILURIAN 40 000 000 YRS | | 1.920 | 7 | – | – | – | | AGE OF INVERTEBRATES | AGE OF SEA WEEDS | CALEDONIAN DISTURBANCE |
| | ORDOVICIAN 90 000 000 YRS | | 4.310 | 15 | 18 | – | – | | | | TACONIC DISTURBANCE |
| | CAMBRIAN 70 000 000 YRS | | 3.360 | 12 | 7 | – | – | | | | GREEN MTS DISTURBANCE |
| PROTEROZOIC 550 000 000 YRS | KEWEENAWAN | | 26.330 | 96 | – | – | – | | RISE OF INVERTEBRATES | | KILLARNEY REVOLUTION |
| | HURONIAN | | | | | | | | | | |
| | TIMISKAMINGIAN | | | | | | | | | | ALGOMAN DISTURBANCE |
| ARCHEOZOIC 1 000 000 000 YRS | KEEWATIN | | 47.760 | 174 | 8 | – | – | | | | LAURENTIAN DISTURBANCE |

MINIMUM AGE OF EARTH 2 090 000 000 YEARS
MAXIMUM AGE OF EARTH 3 000 000 000 YEARS (?)

## STRATIGRAPHY OF THE CENTRAL GULF COASTAL PLAIN

Sedimentary deposits exhibiting a wide range in geologic age are found within the terrain of the Central Gulf Coastal Plain or are encountered in borings in the subsurface. A study of these sediments shows that the area has been the site for the accumulation of a great seaward-thickening sedimentary wedge composed principally of deltaic deposits. The wedge reaches a maximum thickness of at least 20,000 ft. near the present coast line. It has accumulated upon a basement or floor of older rocks which are the age equivalent of those outcropping in the uplands adjacent to the coastal plains and which have been downbowed under the load of the sedimentary wedge.

The history of coastal plain sedimentation has been one of a general slow outbuilding of shallow-water delta deposits into the sea. This gradual encroachment of the land upon the Gulf of Mexico has been punctuated by long periods of slackened sedimentation during which the sea advanced far inland across low-lying deltaic plains. The widespread marine deposits laid down during these transgressions of the sea, together with thin marine facies incorporated in the advancing deltaic masses, contain fossils which make it possible to correlate strata of widely separated areas. Drillers' logs, electrical logs, and samples from a large number of borings drilled within the coastal plains permit examination of deeply buried strata. From these data the stratigraphic succession of beds can be established. The present report considers only the more important stratigraphic units and the general character of the rocks which are essential to an understanding of the depositional and structural history of the region.

**The Geological Time Scale.** A widely accepted reference scale of geological time established from worldwide studies has long been in use by geologists. The broader units of the scale, the eras, are universally used and are based on the type of fossils present in the rocks. Periods and epochs are also widely used and are separated on the basis of diastrophism, movement of the earth's crust, and upon the faunal and floral succession. Ages, stages and substages are smaller units of time classification used locally in correlation; they correspond to lithologic units which are, respectively, groups, formations, and members of rock series. These lithologic divisions are used to designate and describe restricted sections of rock strata. Formations are the most commonly recognized units and are of local importance in that they represent rock divisions which can be mapped.

The geological time scale shown in table 10 indicates the different eras and periods, succession of life, times of major crustal movements, duration of each unit of geological time, and the relative length of time involved in the development of the complete worldwide stratigraphic sequence. It can be noted that eras of geological time are of progressively shorter intervals and that the latest era, the Cenozoic, is a very short one. Most of the rocks of the Central Gulf Coastal Plain have been deposited during the later eras, or within the last 10 percent of geological time. Thus these sediments are very young as compared to rocks of the adjacent highland areas of the Paleozoic and pre-Paleozoic eras, which presumably form the basement of the Gulf Coast.

The stratigraphic sequence which has been developed from study of Gulf Coastal Plain rocks is simple in its broad aspects because it is controlled by repetitious patterns of deltaic sedimentation, but it is extremely complex in details of the arrangement of beds within each deltaic mass. Terminology used to designate minor lithologic units varies widely in different sections of the Coastal Plain and cannot be shown in detail. Therefore, only generalizations and terms essential to an understanding of regional stratigraphy are used herein, and emphasis is placed upon the relationship between groups of strata and the environment in which they were deposited. The generalized stratigraphic section of the Central Gulf Coastal Plain rocks shown in table 11 presents the main epochs of deposition of the Mesozoic and Cenozoic eras, includes the broad lithologic groups of Cenozoic sediments, and indicates the sequences of major events in the geological history of the region.

**Deltaic Sedimentation.** Characteristics similar to those of the modern deltaic plain deposits are exhibited by the Mesozoic and Cenozoic sedimentary rocks exposed at the surface and penetrated at depth in the subsurface of the Central Gulf Coastal Plain. One of the principal similarities is the shape of the sedimentary mass. The modern deltaic mass is shaped like a ladle[1] with a greatly thickened portion near the shoreline representing the bowl of the ladle and thinner floodplain deposits inland representing the handle. Another similarity lies in the fact that all sediments incorporated in the modern and older deltaic masses were laid down close to sea level. As the bowl of the ladle developed, sediments were buried and depressed by the weight of each subsequent layer.

The distribution of sediments within both the Recent deltaic mass and older deltaic masses reflects the three interfingering environments of deposition found within the present deltaic plain and has permitted the modern deltaic plain to be compared with a leaf.[2] The veins of the leaf represent the fluviatile deposits, i.e., channel sands and natural levee silts; the intervenous areas are marsh deposits consisting of organic mucks with clays and silts. The serrated margin of the leaf is compared with estuarine bays and salt-water lakes which are minor marginal embayments of the sea. These are marked by sand and silt deposits which merge seaward with sandy beach facies of sediments at the outer edge of the leaf. The fine suspended river sediments carried seaward from the river mouth are deposited beyond the deltaic plain border in shallow marine waters as "pro-delta" clays.

The modern deltaic plain was developed as the river shifted its mouth and site of deposition. Such shifts changed the position of established environments by introducing sediments to new areas; without influence of accumulating river sediment, abandoned areas could not withstand the attack and advance of the sea. Slow but active subsidence of the margin of the land, combined with shifts in the sites of deposition, resulted in the development of a thick deltaic mass, with a structure similar to that of a pile of superposed leaves.

The Mesozoic and Cenozoic sedimentary rocks represent the outgrowth of many great deltaic masses into the Gulf of Mexico. They exhibit the "pile of leaves" structure and ladle shape characteristic of the modern deltaic mass and differ from it principally in regard to the degree of induration of their component

[1] Russell, R. J., "Quaternary History of Louisiana," Geol. Bull., Soc. America, vol. 51, p. 1228, 1940.
[2] Russell, R. J., and Russell, R. D., "Mississippi River Delta Sedimentation," Recent Marine Sediments, Amer. Assoc. Petrol. Geologists, 1939.

beds. The organic mucks of the marshes have been compacted to form clays and silts and carbonaceous shales carrying a high content of plant remains and marked by brackish-water fossil faunas. The fluviatile sands and silts occur as sandstones or siltstones which interfinger with marsh sediments in lenticular and tongue-like masses. The marsh deposits feather out seaward into thin widespread marine deposits of glauconitic, sandy marls and argillaceous limestones.

Although the older deltaic deposits represent environment similar to those of present-day deltaic deposition and are characterized by fossils marking these environments, they differ somewhat as to nature and size of the sedimentary particles. Such differences are, at least in part, the result of the relative distance from the delta to the source areas of sediments. Older delta masses, which formed close to the mountains, contain in places coarser fluviatile sediments. Volcanic debris is found in many beds, and segregations of diagnostic mineral grains within beds of restricted areas have been distinguished. Evaporite deposits of salt and anhydrite occur in certain sedimentary units. Such differences do not alter the basic pattern of deltaic sedimentation, but they do present tools for unravelling the geological history.

**Outcrop, Structure, and Isopachous Maps.** A large number of deep borings (figure 60) have been made in search for petroleum in the Gulf Coast region, and the sediments and fossils encountered in them have been extensively studied. Data accumulated from these deep borings and their electrical logs have permitted correlation between subsurface and surface beds; maps showing the distribution, thickness and structure of different groups of sediments appear on figures 61 to 70 inclusive. The maps show the surface outcrop area of major divisions of Mesozoic and Cenozoic sediments and indicate their distribution in the subsurface. Contours show the elevation of the top of specific groups of strata in the subsurface and point to the structural deformation which has taken place since the time of deposition. Isopachous contours, i.e., lines connecting points of equal thickness, are superposed on the subsurface contour maps. The combined depth and thickness maps show the position and shape of the deltaic masses and the relation between the delta masses and the regional structures. They provide convenient means for interpreting the geological history because they illustrate the slow seaward progression of deltaic masses and indicate the regions from which the sediments were derived.

### *Paleozoic Rocks*

The border of the Central Gulf Coastal Plain consists of Paleozoic rocks which are traceable into the subsurface beneath deposits of younger age. These rocks consist of generally well-indurated shales, sandstones and limestones and are considered as the basement of the coastal plain region because they form the floor upon which younger deposits have accumulated. The surface distribution and subsurface elevation of the Paleozoic rocks indicate that the basement plunges steeply toward the axis of the Mississippi Embayment (figure 61) and toward the coast line as far as the 10,000-foot contour, the depth of deepest penetration. No attempt has been made to subdivide the subsurface Paleozoic rocks in this report. The contours indicate only the position of the basement and do not establish the attitude of the Paleozoic rocks which portray an extremely long and complicated history on the surface.

## Mesozoic Deposits

**Upper Jurassic Series.** Little is known about the lower Mesozoic sediments in the Central Gulf Coastal Plain. Neither Triassic nor Jurassic beds outcrop; Upper Jurassic deposits are recognized in the subsurface in northwestern Louisiana where they reach a thickness of over 5,000 ft.[1] These upper Jurassic beds represent a typical deltaic sequence of sandstones, siltstones and limestones, and they include thick sections of red sandstones, shales, and anhydrite and salt deposits.

Insufficient borings penetrate the Jurassic to permit the construction of a contour map on its upper surface. A rough approximation of depth to the uppermost beds at the base of the Cotton Valley formation, however, can be gained from figure 62 which shows the thickness of sediments of Lower Cretaceous age.

### *Lower Cretaceous Series*

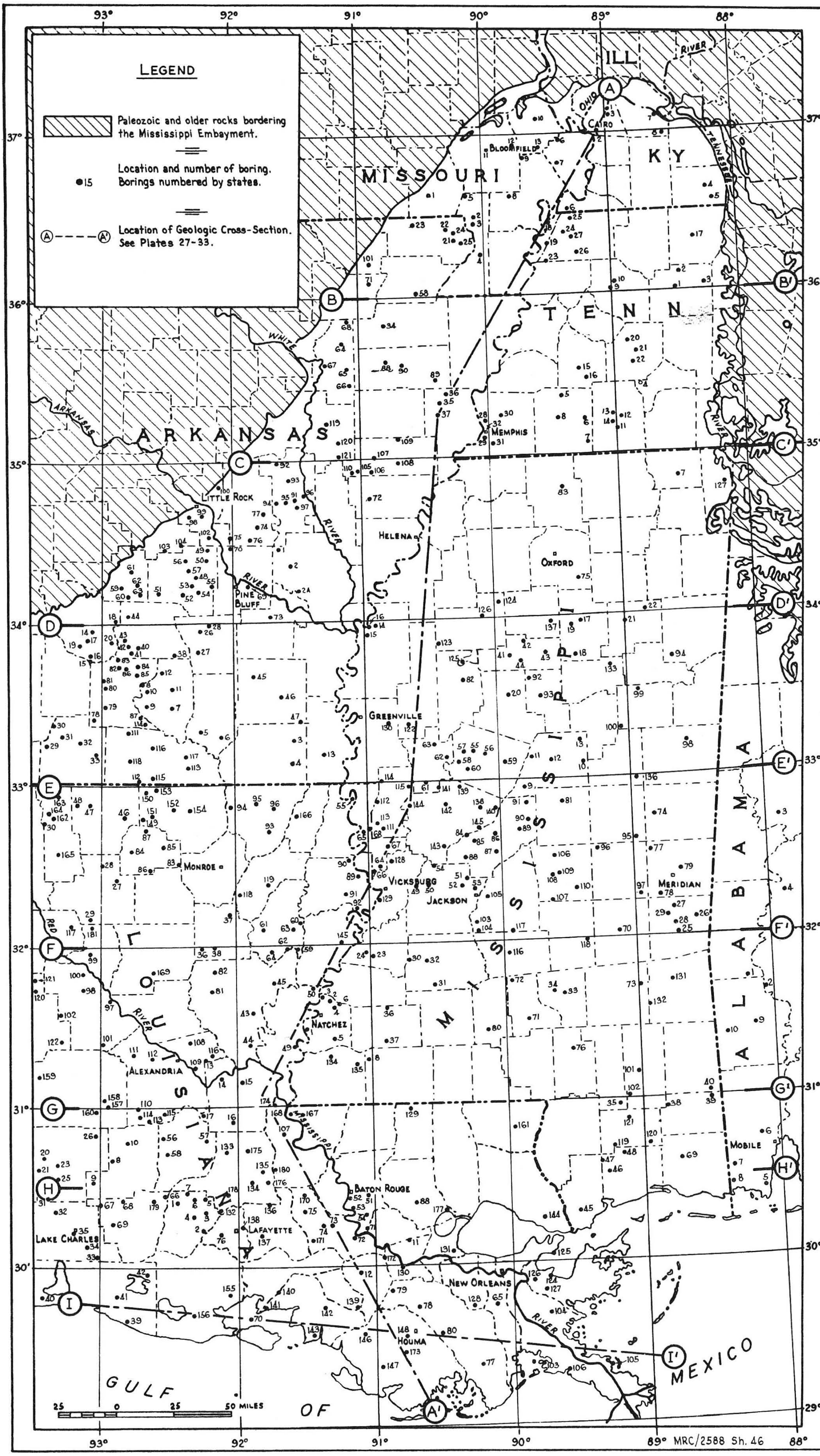
Lower Cretaceous outcrops in the Central Gulf Coastal Plain are restricted to a small area near the Paleozoic border in southwestern Arkansas. These beds were not deposited in the Mississippi Embayment area and are confined to a basin south of the region. The sediments are predominantly of deltaic origin and consist of coarse sandstone, sandy shales, and some thin limestone lentils. The subsurface section which has been penetrated in many places is made up principally of shales, many of which are red; it also includes some sandstone, limestone, salt and anhydrite. The distribution of these deposits is shown on figure 62. The few borings which have completely penetrated the Lower Cretaceous sediments indicate that the deltaic mass reaches a thickness of over 6,000 ft. in northwestern Louisiana and over 3,000 ft. in central Mississippi. Thickness of the Lower Cretaceous deposits indicated for some of the wells may include beds considered by some to be of Jurassic age inasmuch as the similarity between the Lower Cretaceous deposits and the underlying Jurassic beds has led to many difficulties in separating the two series of rocks.

Both the Monroe Uplift region in northern Louisiana and the Jackson Uplift region in Mississippi are located within the basin of Lower Cretaceous deposits, and both were being actively uplifted during this epoch of deposition. As a result, some of the Lower Cretaceous beds are missing in these structural areas and the entire section over the uplifts is extremely thin.

### *Upper Cretaceous Series*

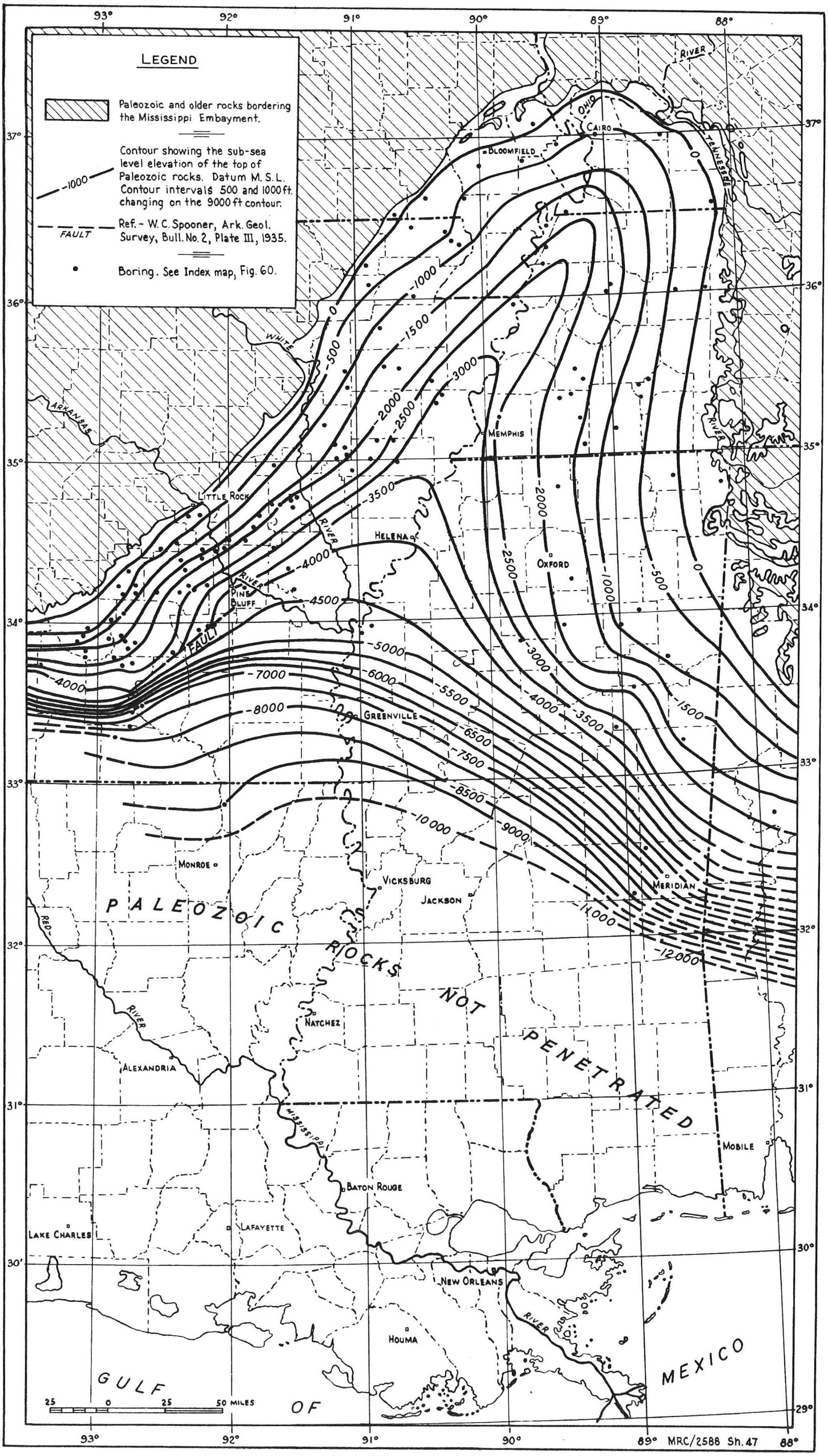
Upper Cretaceous beds outcrop over wide areas around the landward margin of the Central Gulf Coastal Plain and have been penetrated at depth in many wells (figure 63). They mark the farthest inland advance of the Mesozoic and Cenozoic seas. The deposits consist of gray and red shales, sandy shales, sand, local

[1] Imlay, R. W., "Jurassic Formations of Gulf Region," Bull. Amer. Assoc. Petrol. Geologists, vol. 27, pp. 1407-1533, 1943.



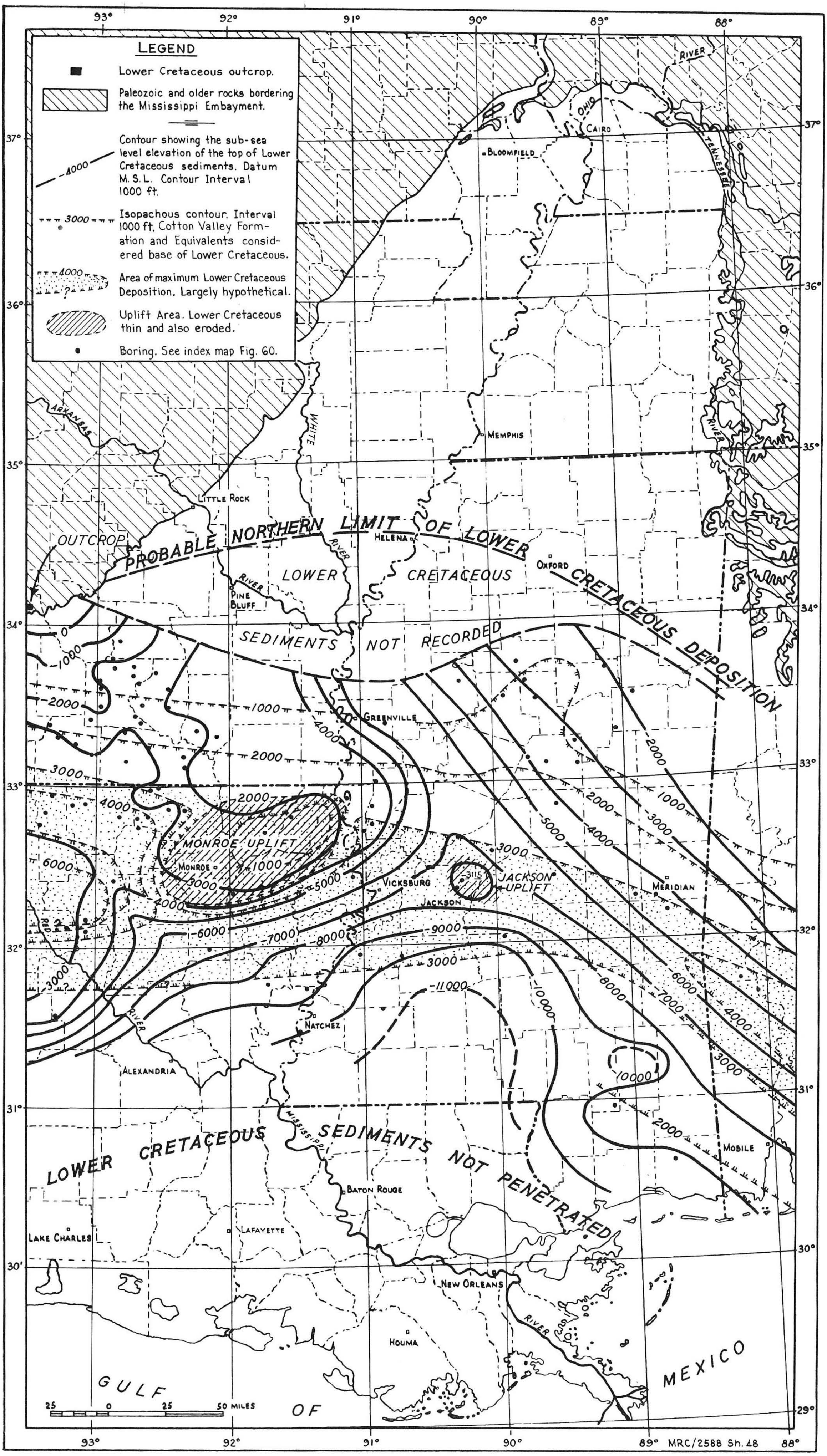

INDEX MAP SHOWING LOCATION OF GEOLOGIC CROSS-SECTIONS AND DEEP BORINGS IN THE CENTRAL GULF COASTAL PLAIN.

FIGURE 60




Map Showing the Sub-Sea Level Elevation of the Top of Paleozoic Rocks in the Central Gulf Coastal Plain.

FIGURE 61




Map Showing Distribution, Thickness, and Sub-Sea Level Elevation of the Top of Lower Cretaceous Sediments in the Central Gulf Coastal Plain.

FIGURE 62

thicken rapidly seaward from the outcrop and a thickness of over 8,000 ft. has been penetrated by wells near the coast in southern Louisiana (figure 68). The manner in which the deltaic mass thickens indicates that at least 12,000 ft. of Miocene sediments were deposited near the present gulf shoreline.

*Miocene-Pliocene* (?) *Series*

In the subsurface a section of deltaic sediments over 4,000 ft. thick (figure 69) is found between the top of beds containing **Rangia johnsoni** and the base of the chert-bearing graveliferous deposits. These beds are lithologically similar to the alternation of underlying Miocene series upon which they rest conformably. They contain marine fossil beds but definite correlation of fossils has not been established. The beds do not outcrop.

## QUATERNARY SYSTEM

The Quaternary System is characterized by graveliferous formations and is made up of the Recent alluvium and four similar but uplifted Pleistocene sequences of sediment underlying stream and deltaic plain terraces. Basal graveliferous beds within the Pleistocene are considered by many geologists to be of Pliocene age.[1] The distribution of the gravels, their position within terrace deposits, and their repetitious occurrence are sufficient proof of their Quaternary age.

**Pleistocene Series.** The generalized surface and subsurface distribution of the Quaternary deposits in the Central Gulf Coastal Plain is shown on figure 70. The distribution of the Pleistocene deposits as shown on figure 5 has been mapped in Louisiana,[2] but elsewhere no detailed mapping has been conducted for this report and the deposits are not subdivided into formations. In central Louisiana the Pleistocene sediments mapped in detail are composed of four similar formations, the Williana (oldest), Bentley, Montgomery, and Prairie. Each formation underlies a fluvial or deltaic plain surface which has been uplifted to form a terrace. Each exhibits a gradation from a basal gravel and coarse sand facies through a predominantly sand facies into and upper silt and clay facies. The Williana and Bentley terrace deposits vary from a few feet to 220 ft. in thickness. The Montgomery and Prairie formations are somewhat thicker (see plate 26) with a maximum known thickness of about 250 ft. The writer and Professor R. J. Russell were able to trace the terraces and formations inland to the head of the Mississippi Embayment and to establish a direct correlation with Louisiana deposits over a long distance.

The Pleistocene fluviatile terrace deposits dip southward and merge with thick deltaic prisms underlying the coastwise plain (plate 26). The sequence of sediments in the deltaic deposits is similar to that of their thinner fluvial extensions. They have been mapped in the subsurface of Louisiana but no attempt is made herein to separate the subsurface Pleistocene units. The contour map (figure 69) showing depth to the top of the Miocene-Pliocene (?) beds indicates the thickness of the entire Quaternary section. The contour map (figure 70) showing the depth to the base of the graveliferous Pleistocene sediments indicates that the gravel facies were concentrated in definite basins within the deltaic plain.

**Recent Alluvium.** The area covered by Recent alluvium, except for those deposits which occur along most smaller streams, is shown in plate 1. The Recent deposits reach a thickness of over 350 ft. in the latitude of Houma, La., and thicken at an unknown rate within the deltaic plain south of Houma where over 600 ft. may have accumulated. The alluvium is lithologically similar to the Pleistocene terrace formations and is therefore considered to have been deposited under the changing conditions of the latest epoch of the glacial age.

### Other Deposits

The loess of the lower Mississippi Valley has attracted much attention, and many ideas have been advanced concerning its origin. The main belt of loess deposits is found in the Bluff Hills (plate 1) along the eastern wall of the alluvial valley, but other loess deposits are present on Crowleys Ridge and on Sicily Island which lies near the western valley wall. Recent work has shown that the thicknesses assigned to the loess deposits by earlier workers were often greatly overestimated; actually the loess in the Mississippi Valley region is a surficial mantle less than 50 ft. thick in most places.

Loess along the alluvial valley walls exhibits characteristics associated with loess in many places throughout the world. It has a sharp limitation in grain size, a tendency to split along vertical joints and to stand with steep faces, and a calcareous content large enough to cause effervescence with acid; it is marked by the presence of land-snail shells.

Many geologists consider loess an eolian deposit, but Russell[3] has recently demonstrated that in the alluvial valley region it is a soil developed from calcareous back-swamp deposits of the Pleistocene terraces through loessification, a process involving weathering and colluvial movement.

### Igneous Rocks

Igneous rocks, the result of intrusions of magma into the earth's crust, make up a very minor fraction of the area of the coastal plain.

Surface or near surface igneous rocks are found south and west of Little Rock, Ark., near the western margin of the Gulf Coastal Plain. The rock is a nepheline syenite and is probably Cretaceous in age. Igneous rocks encountered in a number of wells in southeastern Arkansas, northeastern Louisiana, and adjacent parts of Mississippi have been identified as a nepheline syenite and nepheline basalt, a fact which indicates their probable close relationship to the rocks near Little Rock. Igneous rocks have also been found in wells in and around the Jackson Uplift of Mississippi.

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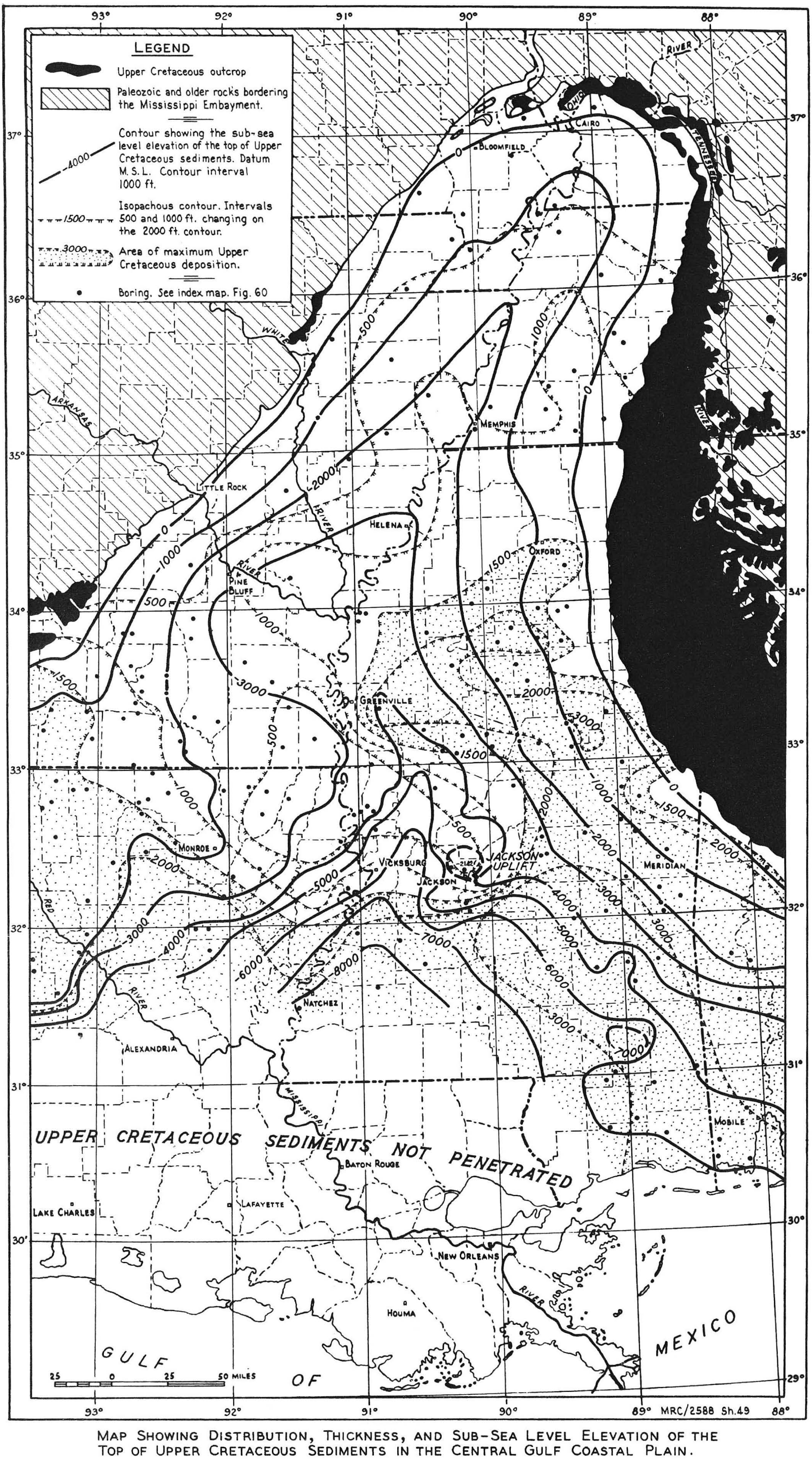
[1] The Citronelle gravels.
[2] Fisk, H. N., "Depositional Terrace Slopes in Louisiana," Jour. Geomorphology, vol. II, No. 2, pp. 181-200, 1939.
[3] Russell, R. J., "Lower Mississippi Valley Loess," Bull., Geol. Soc. Amer., vol. 55, pp. 1-40, 1944.




Map Showing Distribution, Thickness, and Sub-Sea Level Elevation of the Top of Upper Cretaceous Sediments in the Central Gulf Coastal Plain.

FIGURE 63

Weathered volcanic ash deposits (bentonites) interbedded with Tertiary strata are known at many localities throughout the Central Gulf Coastal Plain. They are most widespread in the Miocene deposits of Texas and Louisiana. Igneous ejecta of this nature give a good indication of the close proximity of Tertiary centers of volcanic activity to the region.

## STRUCTURE OF THE CENTRAL GULF COASTAL PLAIN

A knowledge of the structural relationships of the Central Gulf Coastal Plain is a prerequisite to an understanding of the part which regional deformation of the strata has had in controlling the development of the present topography and drainage. The location of the alluvial valley and the belted character of the coastal plain topography are closely related; both have been controlled in their development by the growth of two great structural downwarps, the east-west trending Gulf Coast Geosyncline and the north-south trending Mississippi Structural Trough. The broad curvature of the alluvial valley results from the deformations of the Mississippi Structural Trough by two major upwarps, the Monroe-Sabine Uplift on the west and the Southern Mississippi Uplift on the east. The local outlines of the valley, the alinement of drainage, and the parallelism of tributary valleys closely follow the pattern of minor structural features, the fault systems, which trend either northeast-southwest or northwest-southeast.

The structural features developed slowly while the deltaic masses were being built out into the gulf or into its late Mesozoic and early Tertiary extension within the Mississippi Embayment area. Sinking of the earth's crust in the downwarped areas progressed simultaneously with the accumulation of sediment; the existing axes of downwarping directly follow the lines of maximum thickness. Uplift of the limbs of the structural troughs progressed landward as the axial areas sank and it appears, therefore, to have taken place as an isostatic adjustment to downbowing. The principal effect of the uplift has been to raise gradually the landward margins of the troughs and to cause the incision of the drainage.

Uplift of the land is accompanied by fracturing along great fault zones which follow the "structural grain" of the continent. The zones parallel the continental slope margins outlining the deep portion of the gulf and they also parallel the strike of faults and folds within the Appalachian highlands to the east or are alined at right angles to it. This relationship strongly suggests that inland adjustments to downbowing at the gulf shore follow lines of weakness established at a much earlier date in the geological history of the continent.

### Major Structural Features

**Mississippi Structural Trough.** The Mississippi Structural Trough is a well-defined north-south trending downwarp. It is the major structural feature of the northern part of the Central Gulf Coastal Plain where it is coincident with the Mississippi Embayment region. To the south, however, its axis is traceable as the line along which secondary downwarping of the north limb of the Gulf Coast Geosyncline has taken place. Although the Mississippi Structural Trough does not involve as great a deformation of the earth's crust as the Gulf Coast Geosyncline, it has, nevertheless, played a most important part in shaping the history of the area in which the alluvial valley developed.

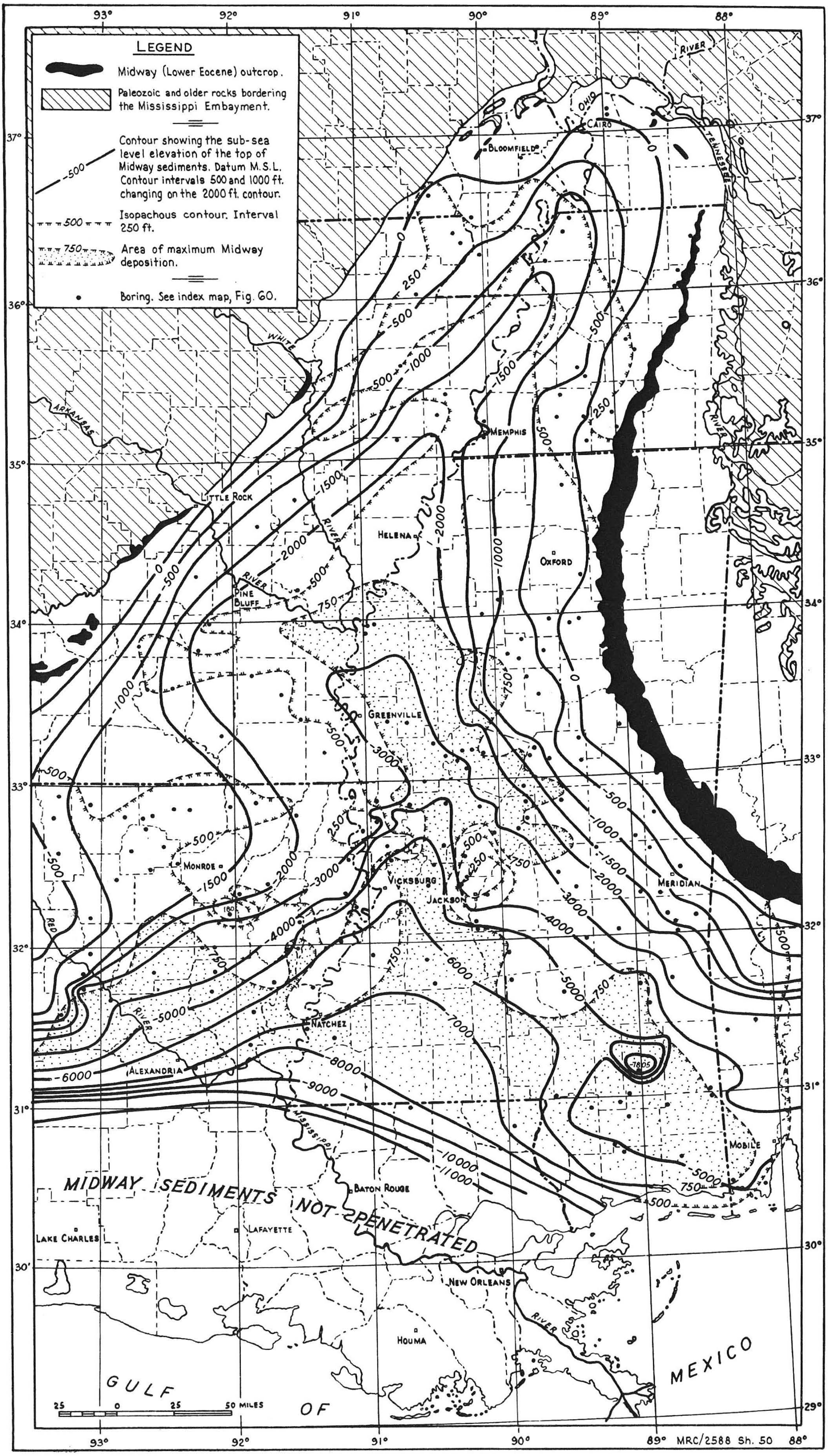
The general configuration of the structural trough is shown in the east-west cross-sections drawn along lines of latitude (plates 27 to 32 inclusive). Borings used in the construction of these cross sections are indicated on figure 60. The cross sections show the thickness of the principal stratigraphic units and their attitude in the subsurface. They are not drawn through the major uplift areas and therefore do not show local thinning and upwarping of the beds which is indicated on the isopachous contour maps previously considered.

The position of the axis of the Mississippi Structural Trough is indicated by the belted topography which marks a succession of beds dipping toward the alluvial valley. Cross sections of the embayment area (plate 27 and section DD, plate 28) show that the trough has an asymmetrical form with slightly steeper dips and thinner deposits along the western limb. This distribution of deposits indicates a westward shift of the axis of downwarping during the deposition of successively younger strata. The axial line of the area lies directly under the thickest part of the deltaic mass of the Eocene, Midway, Wilcox, Claiborne, and Jackson sediments. The Paleozoic rocks forming the floor of the trough are not only deformed toward the axial area of downwarping but are tilted southward; at the southern limit of the Mississippi Embayment they are at least 5,000 ft. beneath the surface.

The distribution of surface and subsurface sediments within the Mississippi Embayment area shows that the Mississippi Structural Trough did not become active until the beginning of Upper Cretaceous time (see contour maps, figures 12 and 13). That down-faulting of inland areas initiated development of the trough is indicated by the straightness of the outline of the western valley margin, the angularity of the salients within the wall, and the abrupt termination of the Upper Cretaceous and lower Eocene (Midway) outcrop along the valley wall.

The northward bulge of the outcrops of beds as young as the upper Eocene (Jackson group) marks the position of the axis of downwarping within the coastwise plains area; the subsurface relationship of the sedimentary units within the structural trough in this area are shown on the cross sections (plates 30 to 32). The thickening of the sediments within the trough can be traced seaward to the point where its axis intersects that of the Gulf Coast Geosyncline.

**The Gulf Coast Geosyncline.** The east-west trending Gulf Coast Geosyncline holds approximately 20,000 ft. of Mesozoic and Cenozoic sediments and is the dominant structural feature of the Central Gulf Coastal Plain region. Knowledge of its presence is largely the result of deep borings made in search of petroleum inasmuch as its size and shape, unlike those of the Mississippi Structural Trough, are not indicated on the surface. The deepest part of the geosyncline lies south of New Orleans and trends westward into Texas. Very few deep borings have been made in southernmost Mississippi and southeasternmost Louisiana, and




Map Showing Distribution, Thickness, and Sub-Sea Level Elevation of the Top of Midway (Paleocene) Sediments in the Central Gulf Coastal Plain.

FIGURE 64

little is known of the shape and configuration of the trough in those areas. There is some evidence to show that the geosyncline shallows eastward, and the Mesozoic and Cenozoic in southern Alabama may be less than 15,000 ft. thick.

A longitudinal cross section of the Central Gulf Coastal Plain region between Cairo, Ill., and the deep part of the Gulf of Mexico shows the attitude of the beds in the geosyncline where penetrated by deep borings. Inasmuch as the cross section is drawn along the axial position of the Mississippi Structural Trough, it also shows the relationship of sedimentary units in that region to those of the geosyncline (plate 33). The insert diagram on plate 33 shows the hypothetical position of the southern limb of the geosyncline as reconstructed from the shape of the deltaic masses filling the geosyncline. It has not been actually determined by drilling.

The axis of downwarping in the Gulf Coast Geosyncline has gradually shifted seaward from its Lower Cretaceous position south of the Mississippi Embayment area (figure 62). Shifting has been irregular and has been determined by the position in which the deltaic masses were localized. Sedimentation was localized in two principal centers of deltaic accumulation until the end of the Eocene epoch (figures 62 to 67). Since then deposition has fluctuated within a belt or zone nearly parallel with the gulf shore. The position of the modern deltaic plain is nearly coincident with the position of the axis of Miocene downwarping (figure 68), as were the positions of the Miocene-Pliocene (?) and the Quaternary deltaic plains.

## Major Upwarps

Several prominent uplifted areas are located within the northern limb of the downwarped Gulf Coast Geosyncline. The various upwarps show considerable variation in extent and amount of uplift, and they were not all uplifted during the same geological time interval. Each, however, has influenced the structure of the Central Gulf Coastal Plain and is reflected in the present topography and drainage.

**Sabine and Monroe Uplifts.** A large area in eastern Texas, northwestern Louisiana, and southeastern Arkansas has been subjected to upwarping along the Sabine-Monroe Uplift axis (figure 5). Uplift is centered in two broad dome-like areas separated by a structural sag. The domes are 75 to 100 miles in diameter, and both have had a long and complicated structural history[1] and are expressed in surface outcrops. The Sabine Uplift at the western end of the axis is not considered in this report because its structure has had little control on the development of the alluvial valley. The Monroe Uplift is partly defined from surface evidence and partly covered with alluvial valley deposits.[2] Subsurface data indicate that the uplifted area extends under the Mississippi River alluvial plain into western Mississippi where it may form the Sharkey Platform.[3] The Monroe Uplift is shown by a flattening of the dip on the Mesozoic and lower Eocene subsurface deposits and by thinning of these deposits over the top of the area uplifted. This thinning is due in part to less deposition and in part to erosion. There is evidence to indicate that the Monroe Uplift stood above gulf level during a part of the Lower Cretaceous and was not again submerged until late in the Upper Cretaceous epoch.

**Southern Mississippi Uplift.** The broad belt of hill lands across southern Mississippi marks the axial position of the wide Southern Mississippi Uplift (figure 5). This region is the highest in the southern part of the Central Gulf Coastal Plain with an elevation approaching 500 ft. above sea level. The south flank of the uplift is bordered by a very sharp downflexing of beds known as the Mobile-Tunica Flexure,[4] and the main portion of the uplift is an outcrop area of relatively flat Miocene and Quaternary sediments.

Reconnaissance studies of the terrace formations which make up the gravel-capped central hills of the uplift region have been made by Professor R. J. Russell and the writer. The high terraces are flattened over the uplift and dip slightly northward on the northern flank (plate 26). On the southern and western flanks of the uplift, the terraces are sharply downwarped into the deep basins filled with graveliferous Quaternary deltaic deposits which reach a thickness of 4,000 ft. near New Orleans (figure 70). The relationship between basins and uplifts and the position of the steeply dipping beds flanking the uplift strongly suggest that the Southern Mississippi Uplift has been an isostatic adjustment to the downwarping in the basin directly south of the area.

The Southern Mississippi Uplift is a very important structural element in the Central Gulf Coastal Plain because movement of the area has been recently active in shaping the alluvial valley. The upward movement caused the narrowing of the valley south of Natchez and the development of the eastward curvature of the Mississippi Structural Trough which the valley closely follows.

## Other Uplifted Areas

**"Five Islands" Structural Uplift.** The region of the "Five Islands" in south-central Louisiana has long been considered a structural area because of the fact that the "islands" are the surface expression of salt domes alined in a northwest-southeast direction. Barton[5] referred to them as the Iberian Structural Axis which he considered to be a geosynclinal area in which uplift had occurred. He believed that this uplift had controlled the shape of the old Mississippi River course, Bayou Teche.

Studies of the Quaternary deposits in southern Louisiana show a marked parallelism between the alinement of the basins of Quaternary graveliferous sediment and the axis of the "Five Islands" Structural Uplift (figure 5). The uplifted area is marked by a subsurface ridge along which the base of the Quaternary gravels lies considerably above the base of gravels in the basins on either side. The only known surface reflections of the uplift lie in the parallelism of the southernmost western bluff line of the alluvial valley and in the surface expression of the alined salt domes.

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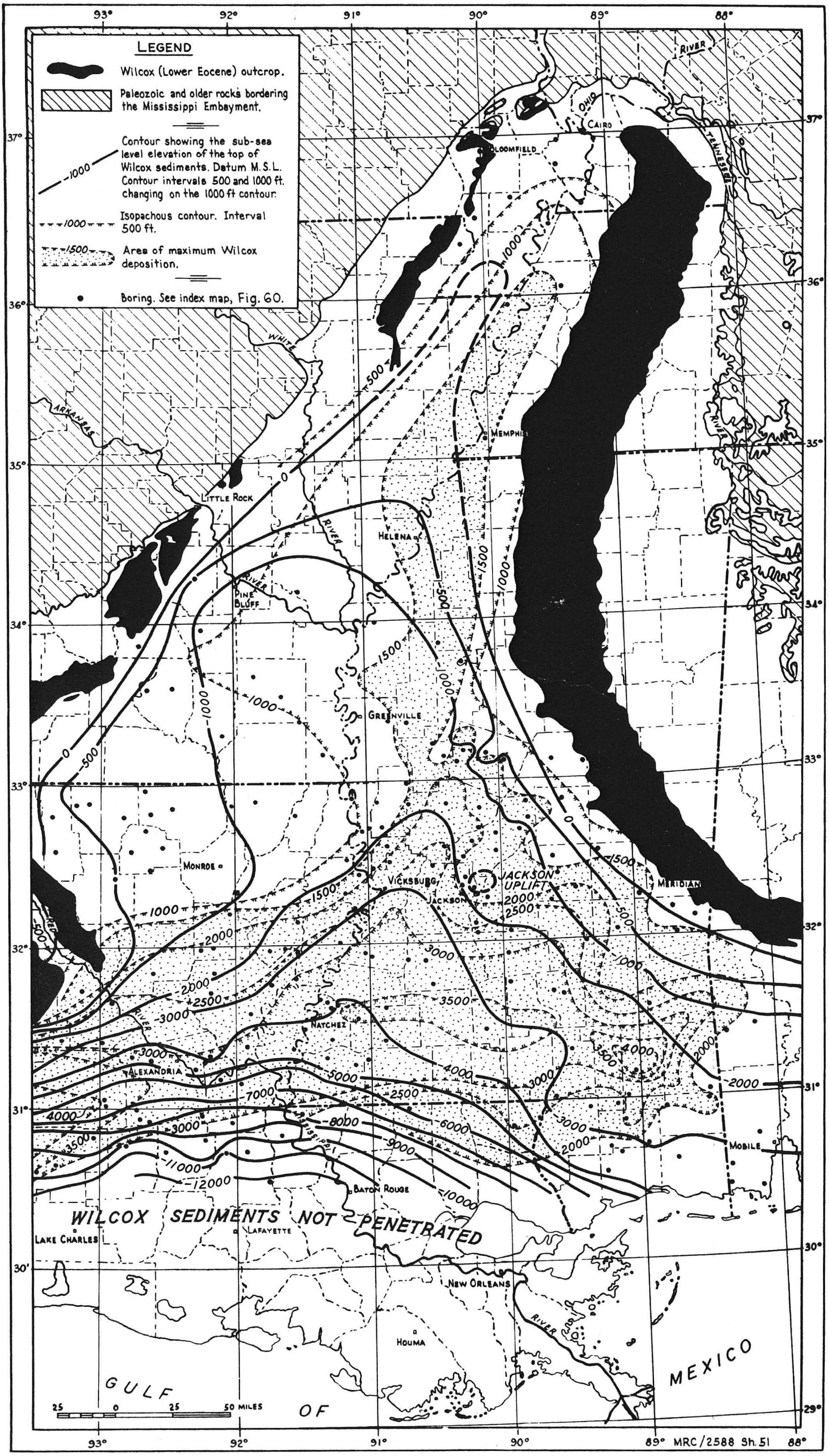
[1] For Sabine Uplift history, see Moody, C. L., "Tertiary History of Region of Sabine Uplift, Louisiana," Bull. Amer. Assoc. Petrol. Geologists, vol. 15, pp. 531-551, 1931.

[2] Fergus, Preston, "Monroe Gas Field, Louisiana," Geology of Natural Gas, Amer. Assoc. Petrol. Geologists, pp. 741-772, 1935.

[3] McGlothlin, Tom., "General Geology of Mississippi," Bull. Amer. Assoc. Petrol. Geologists, vol. 28, No. 1, p. 29, 1944.

[4] Howe, H. V., "Louisiana Petroleum Stratigraphy," Am. Petroleum Inst., Paper 901-12B, 27 pp., 1936.

[5] Barton, D. C., "The Iberian Structural Axis," Jour. of Geol., Vol. XLI, pp. 225-242, 1933.




Map Showing Distribution, Thickness, and Sub-Sea Level Elevation of the Top of Wilcox (Lower Eocene) Sediments in the Central Gulf Coastal Plain.

FIGURE 65

**Jackson Uplift.** A large localized area of uplift centered near Jackson, Miss. (figure 5), is evident in the surface outcrop of the Tertiary sediments. It is noteworthy because of the sharply elevated nature of the uplift and the occurrence of igneous rocks, probably intruded at the time of the uplift. The depositional record indicates that movement occurred at least as early as Lower Cretaceous and continued into middle Tertiary time.[1] Its history indicates that development of the Jackson Uplift was closely associated with the major movement which caused the Monroe Uplift to the west.

**Salt Domes.** Many minor uplifts and downwarps have been mapped in the Central Gulf Coastal Plain. Most of these features are associated directly with the intrusion of salt plugs.

### Gulf Coast Fracture Pattern

**Faults.** Faulting has exerted an important control in the development of Central Gulf Coastal Plain features and has been particularly active in shaping the region of the Mississippi Alluvial Valley. The principal faults occur in a definite rectangular fracture pattern with one set of faults trending northeast-southwest throughout the region and the other trending northwest-southeast. This fracture pattern has not been previously recognized in the alluvial valley region, although many of its local units have been mapped either from surface indications or from their subsurface expression.

The parallelism of the fracture system in the Central Gulf Coastal Plain to the mapped systems of faulting within the Interior Highlands (the Appalachians on the east and the Ozark-Ouachita mass on the west) and to faulting of the adjacent coastal plains areas is indicated on figure 71. The fractures are also alined parallel with the submarine outlines of the deep portion of the Gulf of Mexico as defined by the angularity of the continental slope below the 100 fathom line. The fact that the fault system of the Central Gulf Coastal Plain is but a part of the fracture pattern of the entire southern United States is direct evidence that all faulting in the region has been controlled by weakness in the earth's crust which antedates the formation of any single feature.

The existence of the fracture pattern within the Central Gulf Coastal Plain was determined principally from a study of aerial photographs. Evidence for mapping the fracture patterns from aerial photographs is found in the presence of scarps offsetting meander scars (figure 72) of abandoned stream courses, in peculiarities in the drainage obviously controlled by adjustments of the land along extended lines,[2] and in sharply defined soil changes along definite lines (figure 73).[3] Field studies of several faults in the alluvial valley region have been made and their subsurface displacement has been determined by borings. Confirmation of the existence of others has been found in direct correlation with subsurface faults mapped by geophysical methods[4] or from study of well records in petroliferous areas.[5] Many isolated faults, which have long been known and are referred to in the literature of the Gulf Coast states, follow the trends of the fracture pattern. Only those fracture zones which can be readily isolated from a study of aerial photographs, and which provide control for the development of the regional fracture pattern are shown on figure 71. Several times as many faults as are plotted are known to exist within the Central Gulf Coastal Plain. Attention is directed to a few isolated north-south and east-west faults which are related to another fault system not well-defined in the region.

Surface displacement within a well-defined fracture zone was observed in the development in April 1943[6] of a fault near Vacherie, La., and in faults which accompanied the New Madrid, Mo., earthquake of 1811-1812. In most of the alluvial valley area, however, the faults are not indicated by measurable surface displacement but are manifested in ill-defined elongate topographic sags trending across floodplain accretion features. In some places these sags are 2,000 ft. wide. Many of them exhibit insufficient relief to be shown on topographic maps (with an interval of 5 ft.) but nevertheless have localized floodplain drainage and have ponded small streams to form minor lakes (figure 73). The sags are marked by soil and vegetation differences, and some have secondary limitations parallel with the trend of the major feature. It is probable that the topographic sags represent a structural zone in which the loose superficial alluvial sediments became adjusted to deep-seated movement along subsurface fault planes. Settlement in the alluvium was accomplished through the development of a multitude of minor fractures, each of which exhibits only a small amount of displacement.

The courses of the streams within the Central Gulf Coastal Plain are parallel in many places to the principal fault systems, and western tributaries of the Mississippi maintain a common alinement parallel to the fault zones. The main zones of northwest-southeast faulting are named for the Red, Ouachita, Arkansas, and White rivers (figure 6). The main zones of northeast-southwest faulting are named for features within the alluvial valley; the Lake Borgne fault zone of the south and the Catahoula Lake and Big Creek zones represent the basic sets of the system. The northeast-southwest set of faults has controlled the direction of flow in the Homochitto, Big Black, upper Pearl, Tallahatchie, Coldwater, and Obion rivers.

Salt domes may be alined along the principal fracture zones but the relationships are not as yet clearly demonstrated except in the "Five Islands" area where faulting parallels the structural axis. Igneous intrusions near the western valley wall in the vicinity of Little Rock are definitely alined in the direction of the northeast-southwest fault set. Such occurrences point to the deep-seated nature of the faulting and indicate that the fault movement must originate in the basement rocks.

**Origin of Fracture System.** A direct correlation can be drawn between the warping of the fracture pattern and the gradual change in trend of the axes of successive deltaic accumulations in the Central Gulf Coastal Plain. The trend of the axes of the deltaic masses diagonally crosses the rectangles formed by the

[1] Monroe, W. H., "The Jackson Gas Field, Hinds and Rankin Counties, Mississippi," U. S. Geol. Survey Bull. 831, pp. 1-17, 1932.

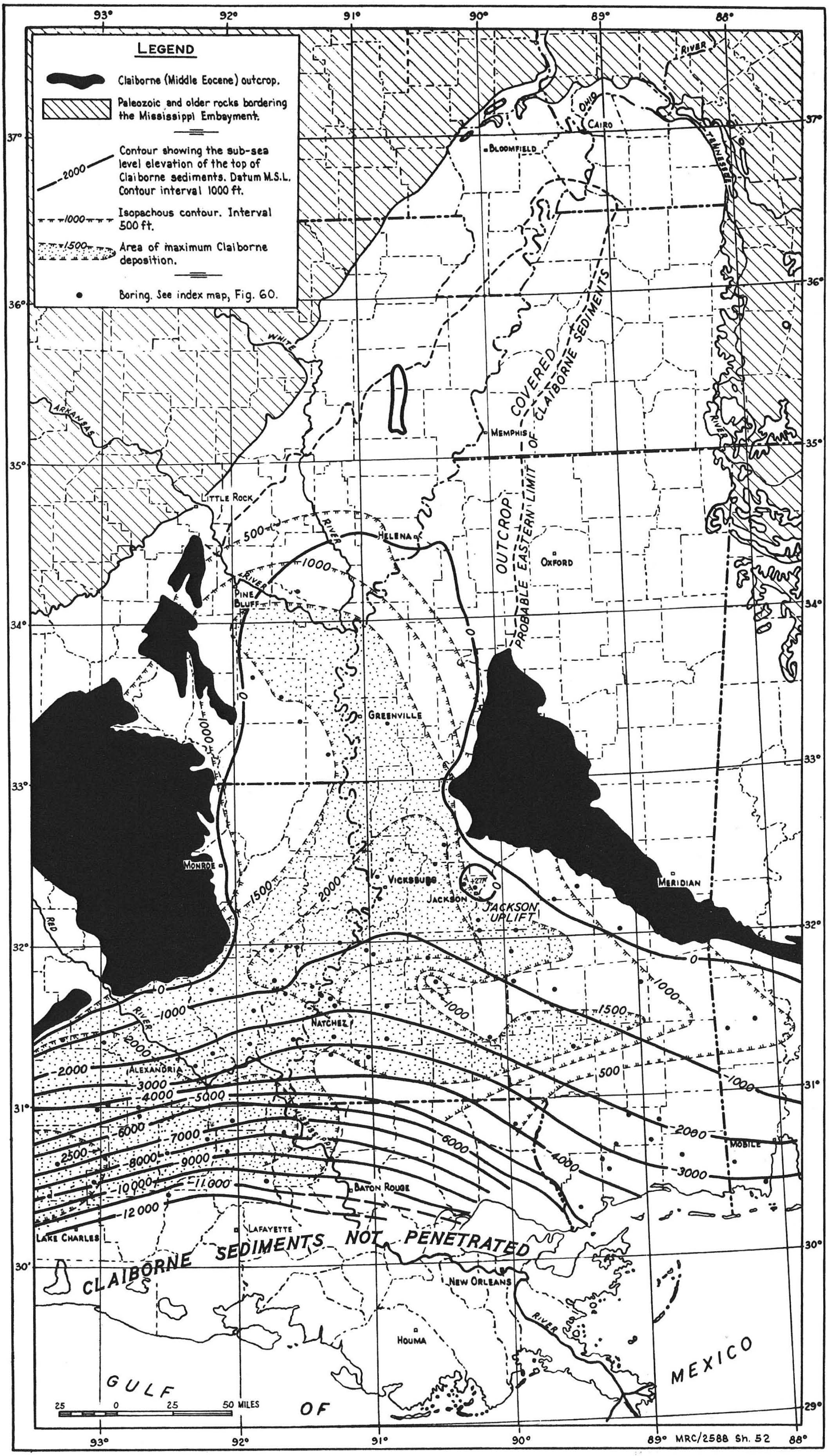
[2] Barton, Donald C., "Surface Fracture System of South Texas," Bull. Amer. Assoc. Petrol. Geologists, vol. 17, pp. 1194-1212, 1933. Barton describes relation of drainage in south Texas to fracture pattern from study of aerial photographs of the region.

[3] Surface evidence of movement on some of the fault sets is indicated not only by displacement of meander scars but by disruption or ponding of drainage (figure 73).

[4] Magnetometric and gravity maps of Missouri and Alabama, published and unpublished geophysical records of oil companies.

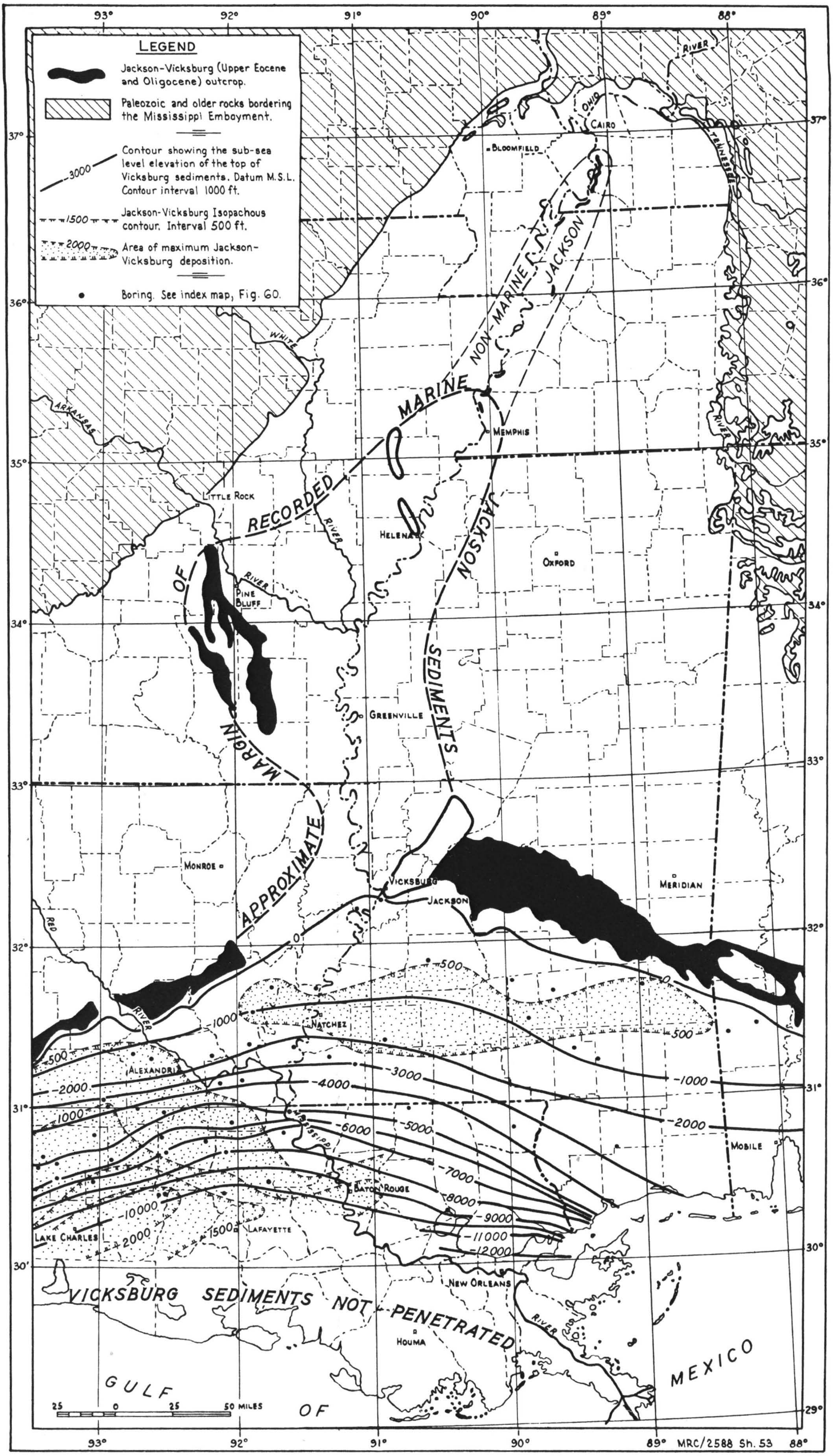
[5] Wallace, W. E., Jr., "Structure of South Louisiana Deep-Seated Domes," Bull. Amer. Assoc. Petrol. Geologists, vol. 28, No. 9, pp. 1249-1312, 1944.

[6] "Geological Investigation of Faulting at Vacherie, Louisiana," Report to Brig. Gen. M. C. Tyler, President, Mississippi River Commission, by H. N. Fisk, Consultant, May 1943.



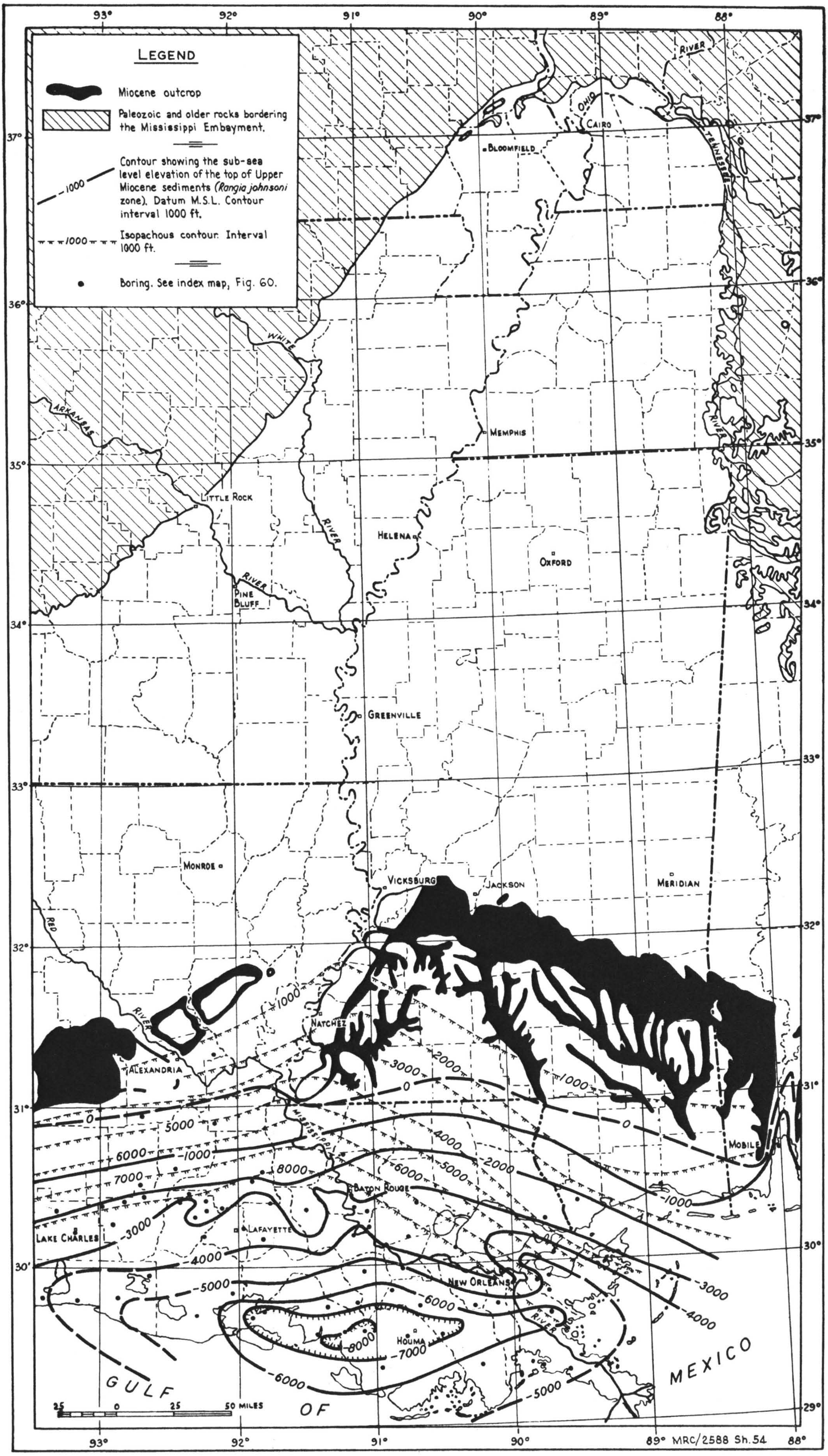

Map Showing Distribution, Thickness, and Sub-Sea Level Elevation of the Top of Claiborne (Middle Eocene) Sediments in the Central Gulf Coastal Plain.

FIGURE 66



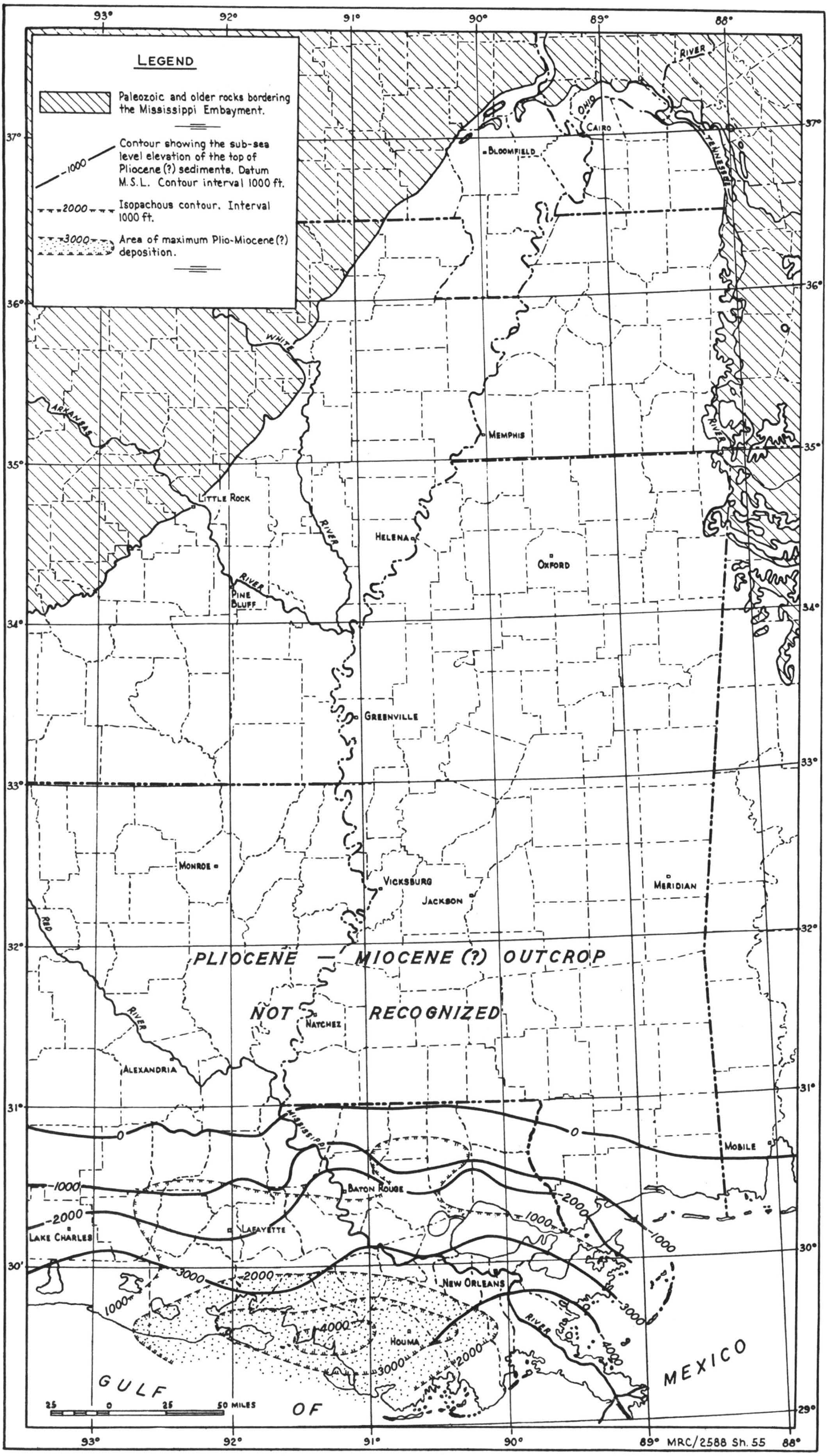

Map Showing the Distribution and Thickness of Jackson-Vicksburg (Upper Eocene and Oligocene) Sediments and the Sub-Sea Level Elevation of the Top of Vicksburg (Oligocene) Deposits in the Central Gulf Coastal Plain.

FIGURE 67



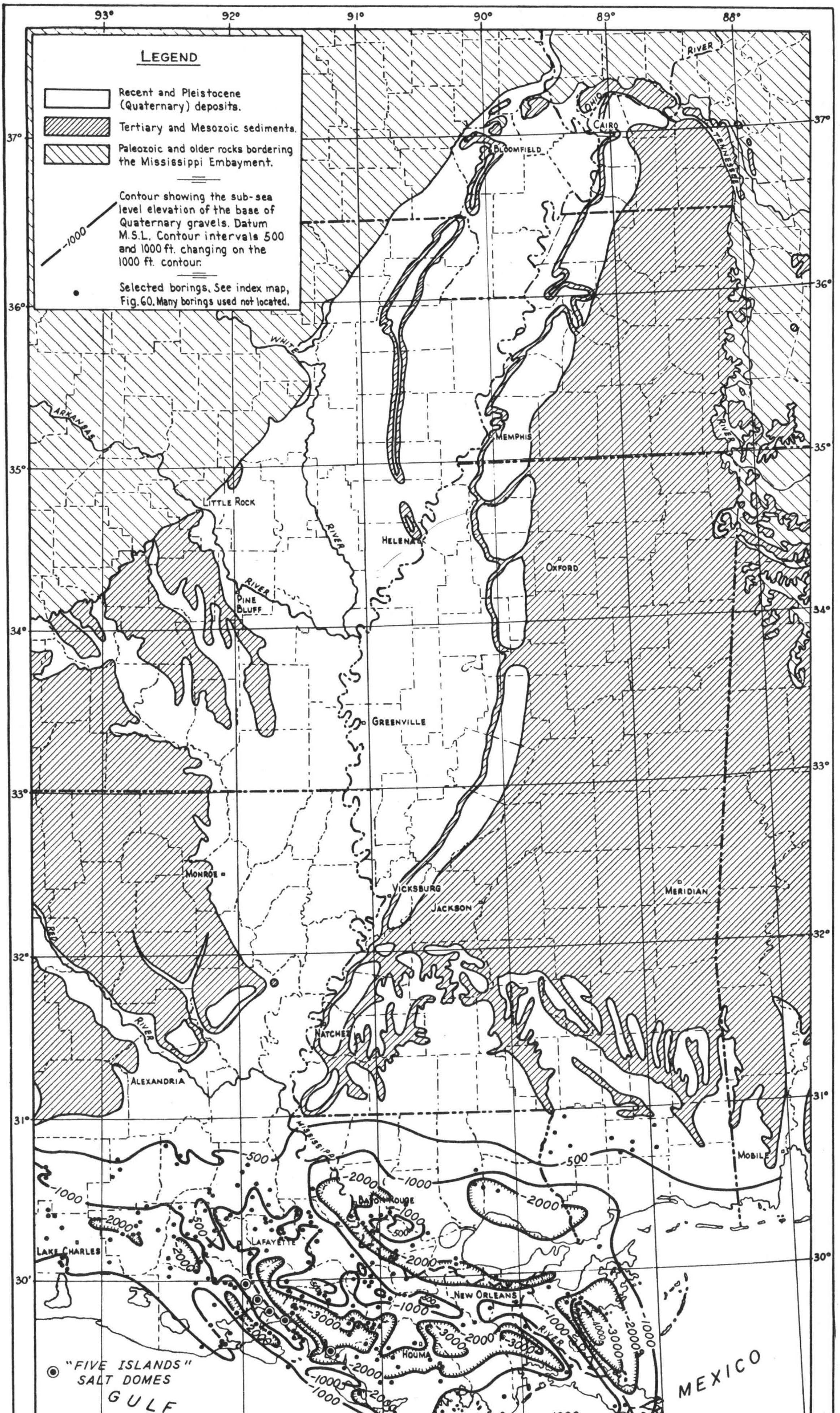

Map Showing the Distribution and Thickness of Miocene Sediments and the Sub-Sea Level Elevation of the Top of Upper Miocene Sediments (*Rangia Johnsoni* Zone) in the Central Gulf Coastal Plain.

FIGURE 68




Map Showing Sub-Sea Level Elevation of the Top of Pliocene (?) Sediments and the Thickness of Plio-Miocene (?) Sediments in the Central Gulf Coastal Plain.

FIGURE 69




Map Showing the Distribution of Quaternary Deposits and the Sub-Sea Level Elevation of the Base of Quaternary Gravels in the Central Gulf Coastal Plain.

FIGURE 70

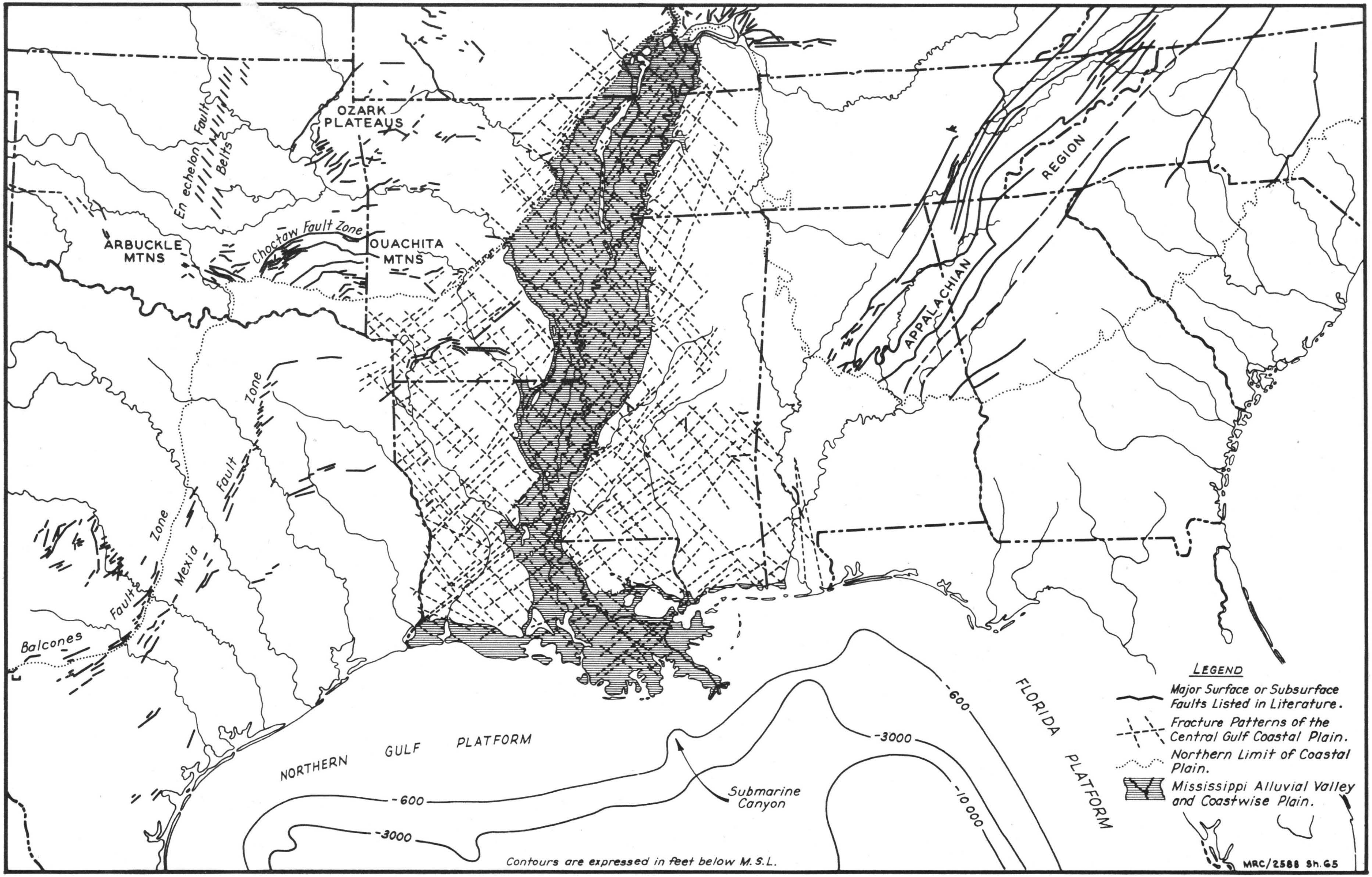



FIGURE 71

RELATION OF FAULT ZONES WITHIN THE CENTRAL GULF COASTAL PLAIN TO THE REGIONAL FRACTURE PATTERNS OF THE SOUTHERN UNITED STATES.


FIGURE 72 Late Pleistocene Amite River Meander Scars Displaced by Fault. (Point A is in Sec. 48, T. 7 S., R. 3 E., Livingston Parish, La.). Amount of Displacement Indicated by Elevation of Surface, i.e., 35'.


FIGURE 73 Fault Traces Marked by Differences in Soils. Near Kingtown, Ark., (Sec. 22, T. 2 N., R. 2 E.).

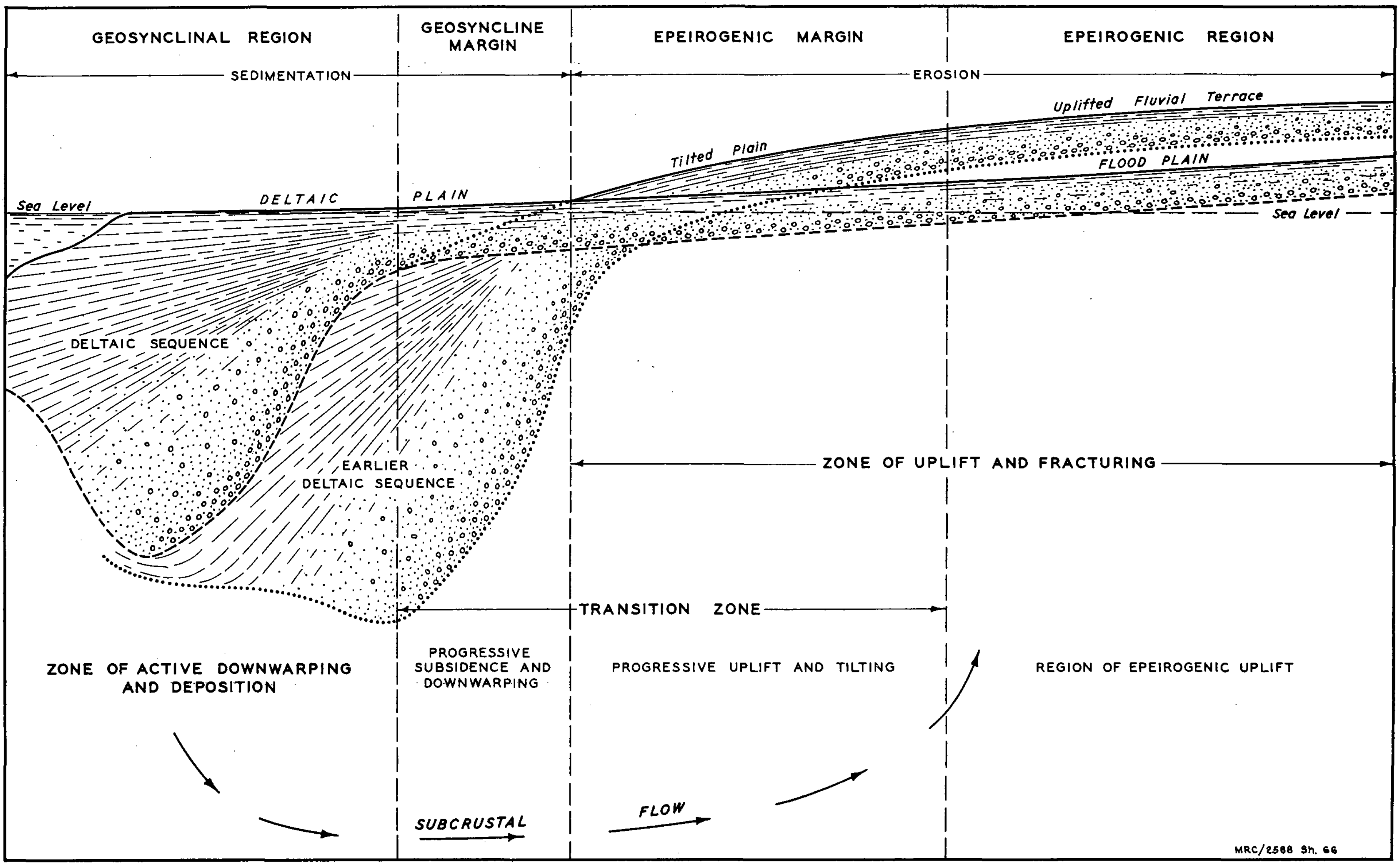



FIGURE 74

CROSS SECTION SHOWING HYPOTHETICAL STRUCTURAL RELATIONS IN AN AREA OF ACTIVE DELTAIC SEDIMENTATION.
(MODIFIED AFTER FISK, 1939).

intersection of the two principal fracture sets. The fault zones trend approximately N 50° E (and at right angles) within the Mississippi Embayment area and are warped to N 35° E near the coastline. The trend of the axes of successive deltaic masses makes a comparable angular shift between the southern limit of the Mississippi Embayment and the present axis of the Gulf Coast Geosyncline (see figures 61 to 69). The fracture pattern appears, therefore, to be directly related to the distribution of the Mesozoic and Cenozoic sediments and may result from the release of stresses set up in the earth's crust as thick masses of deltaic sediments accumulated.

Studies of the relationship of the slopes of Pleistocene terrace surfaces in Louisiana[1] to the Recent deltaic deposits show that the terraces have been simultaneously uplifted inland and downdragged near the shoreline. The inferred mechanism whereby terraces are deformed may provide an explanation for the development of the fracture patterns and general regional deformations which have accomplished downbowing of the earth's crust in the Gulf Coast Geosyncline.

The hypothetical structural relations in an area of active delta growth are shown on figure 74. It is indicated that active downwarping at the delta is accompanied by landward uplift and that a transition zone with steepest surface slopes exists between areas of downwarping and areas of uplift. Stresses set up in the landward area, probably by the flowage of subcrustal substance from the area of active subsidence, are relieved by the faulting within the zone of fracturing. The orientation of the fault zones with fractures in adjacent regions indicates that the faults are adjustments along previously existing lines of weakness following the "structural grain" of the continent.

### SUMMARY OF PRE-PLEISTOCENE GEOLOGICAL HISTORY

Since the initiation of the Mesozoic Era the Central Gulf Coast region has gradually advanced into the Gulf. Marine and deltaic sedimentation alternated in three similar cycles. Each started with a period of widespread marine conditions and, with little evidence of fluviatile activity. Fluviatile activity then increased and reached a maximum as deltaic masses were rapidly constructed in the middle of each cycle. The last part of each cycle witnessed a gradual decrease in the influx of fluviatile sediments; it is characterized by an alternation of marine and fluviatile deposits marking the fluctuating shoreline of very shallow seas which slowly advanced inland. A brief summary tabulation showing the principal events of the geological history of the region is presented in table 11.

The control of the cycles of sedimentation is the supply of sediments brought to the gulf by streams. Periods of great delta growth must, therefore, represent epochs when the inland areas stood high and the streams draining them had steeper gradients. Greatest deltaic accumulations occurred during the upper Jurassic-Lower Cretaceous, Wilcox, and Miocene-Recent epochs, when the land masses of the continental interior are known to have been rejuvenated by orogenic movements.

As indicated by the shape and thickness of the deltaic masses and the nature of the deposits, most of the sediments came from two sources, the existing Ouachita Mountains on the north and west of the Central Gulf Coastal Plains and the existing Appalachian Mountains on the east. The Appalachians are known to have supplied sediments to huge deltaic masses in the Eastern Gulf Coastal Plain throughout the Mesozoic, but it was not until the Mississippi Embayment region was initiated by faulting at the end of the Lower Cretaceous that drainage from the Appalachian region brought sediments to the Central Gulf Coastal Plain area. Streams from the Appalachian region supplied sediments to the Mississippi Structural Trough and the Gulf Coast Geosyncline throughout Upper Creataceous and lower Eocene time, but they were not active in the final cycle of delta building.

The initial or Mesozoic cycle started with the deposition of late Jurassic sediments and continued until the late Cretaceous seas had extended northward to the head of the Mississippi Embayment. The second or early Tertiary cycle began with Midway seas occupying the Central Gulf Coastal Plain. Slow outbuilding of the land began with Wilcox deposition, gradually slackened during the Claiborne, and ended as the Jackson sea advanced inland beyond Memphis, Tenn. Uplift of the landward margins of the coastal plain coincident with the downwarping of the Mississippi Structural Trough and the Gulf Coast Geosyncline forced a seaward progression of the deltaic masses and caused the final withdrawal of the sea from the Mississippi Embayment area. The last cycle, the late Tertiary-Recent cycle, began with the seas over the coastal plain south of the embayment in Vicksburg time. Continued uplift during Miocene time subjected the embayment area to weathering and stream erosion and initiated the belted topographic features of the region. The cycle was interrupted by the advent of Pleistocene glaciation which brought about the integration of the Mississippi and Ohio river systems and witnessed the diversion of this drainage into the Central Gulf Coastal Plain. During this last cycle, the present features of the region were shaped and the thick masses of deltaic sediment extended the land area gulfward. The land advance which began in Miocene time is continuing at present and the cycle appears to be at its climax of delta building.

## THE PLEISTOCENE EPOCH

### INTRODUCTION

World-wide glaciation during the Pleistocene epoch introduced new conditions to the history of the Central Gulf Coastal Plain. Climatic changes during this epoch, which is commonly called the "Great Ice Age," permitted periodic world-wide advance and retreat of the ice sheets. Each ice advance upon the continents, called a glacial stage, was followed by a period of warm climate, an interglacial stage, during which

[1] Fisk, H. N., "Depositional Terrace Slopes in Louisiana," Jour. Geomorphology, vol. II, pp. 181-200, 1939.
Fisk, H. N., "Geology of Avoyelles and Rapides Parishes," Louisiana Dept. Cons., Geol. Bull. No. 18, 1940.

glaciers retreated from the continents. The main periods of ice advance and retreat are believed to have been nearly synchronous in Europe and North America. Four glacial stages and four interglacial stages, the last of which is considered as Recent time, are known to have occurred in Europe. In North America four advances and retreats are also recognized but a significant retreat during the last ice advance gives it a dual nature. Therefore, many authorities in North America consider that there were five glacial and five interglacial stages, the last of which is set off as the Recent. The names applied to these stages are indicated on figure 75.

Cyclic changes in sea level accompanied the glacial and interglacial stages. Sea level was lowered by the accumulation of glacial ice derived from oceanic water; it was raised during interglacial stages by the melting of the ice. These changes had a profound effect upon the regimen of streams outside of the glaciated areas. During glacial stages, streams entrenched their courses to accord with the lowering base level. With a rise in sea level during the interglacial stages, streams alluviated the valleys entrenched in the preceding glacial stage.

The variation in the level of the oceans during Pleistocene time has been considered by several authors.[1] Most estimates of the fluctuation of sea level have been based on the probable extent and thickness of the ice sheets. Approximately 20,000,000 square miles[2] of the earth's surface are considered to have been covered by ice in the maximum stage of Pleistocene glaciation (figure 75). The thickness of the ice sheets is difficult to estimate; from the occurrences of glacial deposits, extent of glacial scouring in mountain areas, and known slopes of ice sheets, it is believed that the ice may have had an average thickness of about one mile. Estimates of the amount of water locked up in the present glaciers and ice caps, about 5,000,000 cubic miles,[3] indicate that this volume would be sufficient to raise sea level about 150 ft. Thus, with 20,000,000 cubic miles of ice in existence at the time of maximum glaciation, sea level was lowered about 450 ft.

The above value for the lowering of sea level is greater than most calculations indicate but accords well with data from the entrenched valley system. At Houma, La., the base of the Recent alluvium is 350 ft. below the present floodplain. Houma is only a few feet above sea level and is about 40 miles from the present shoreline and over 100 miles from the edge of the continental shelf. It is in an area which is believed to have suffered little sinking or disturbance by faulting, inasmuch as the slope of the entrenched valley upstream is constant for a long distance (plate 11). South of Houma the slope of the entrenched valley on which the Mississippi River carried gravels must have been nearly as great as that of the entrenched valley above Houma, about 0.8 ft. per mile. On this slope and one hundred miles to the south, the trench could have been 430 ft. below the present sea level. Recent gravels exist at depths of 600 ft. below sea level a short distance south of Houma, but this depth is believed to be due to structural deformation (faulting within the Lake Borgne graben). Although there is no direct evidence for the total amount of lowering of sea level, the above data all indicate that it was between 400 and 450 ft.

**Pleistocene Glaciation in North America.** The extent of maximum Pleistocene glaciation on the North American continent is shown on figure 76. In the United States the glacier fronts advanced as far south as the approximate position of the Missouri and Ohio rivers. Nearly 4,000,000 square miles of the continent were covered by ice during the maximum ice advance. In the glaciated areas the pre-existing drainage lines, particularly those streams draining northward, were forced to take new paths, and the interior lowland rivers made extensive readjustments.

**Pre-Glacial Drainage.** During late Tertiary time the Central Lowlands of the northern United States were drained principally by streams flowing northward into Canada. The late Tertiary reconstructed drainage (figure 76) indicates that the existing northern tributaries of the upper Missouri and Ohio were pre-glacial streams which drained north and eastward into Canada.[4] The northern tributaries of the Missouri, i.e., the Big Horn, Yellowstone, Little Missouri, Cheyenne, Grand, and White River of South Dakota, drained northward into Hudson Bay. The principal tributaries of the present Ohio River, i.e., the Monongahela, Allegheny, Muskingum, Kanawha, Scioto, Miami, Licking, Kentucky, Green, and Wabash rivers, had north-flowing pre-glacial courses across Pennsylvania, Ohio, or Indiana, and were tributaries of the St. Lawrence system. There is little information about the Missouri tributaries south of the Platte River. It is possible that some of these streams drained southward into the Central Gulf Coastal Plain during late Tertiary time.

**Effects of Glaciation on Drainage.** The present Mississippi River system is the product of drainage integration during the advance of the earliest ice sheets (figure 76). In early Pleistocene time the streams which were flowing northward were ponded at the front of the advancing ice sheet. Ponded waters of various streams were united and diverted southward across the lowest part of the interior high lands, Shawneetown Ridge in southern Illinois, into the Mississippi Embayment. It is possible the diversion may have followed drainage lines established in pre-glacial time by the present lower Missouri River tributaries, the Osage and Gasconade rivers. The Ohio system was diverted across the eastern end of the Shawneetown Hills through a gap near the present Tennessee-Ohio junction.

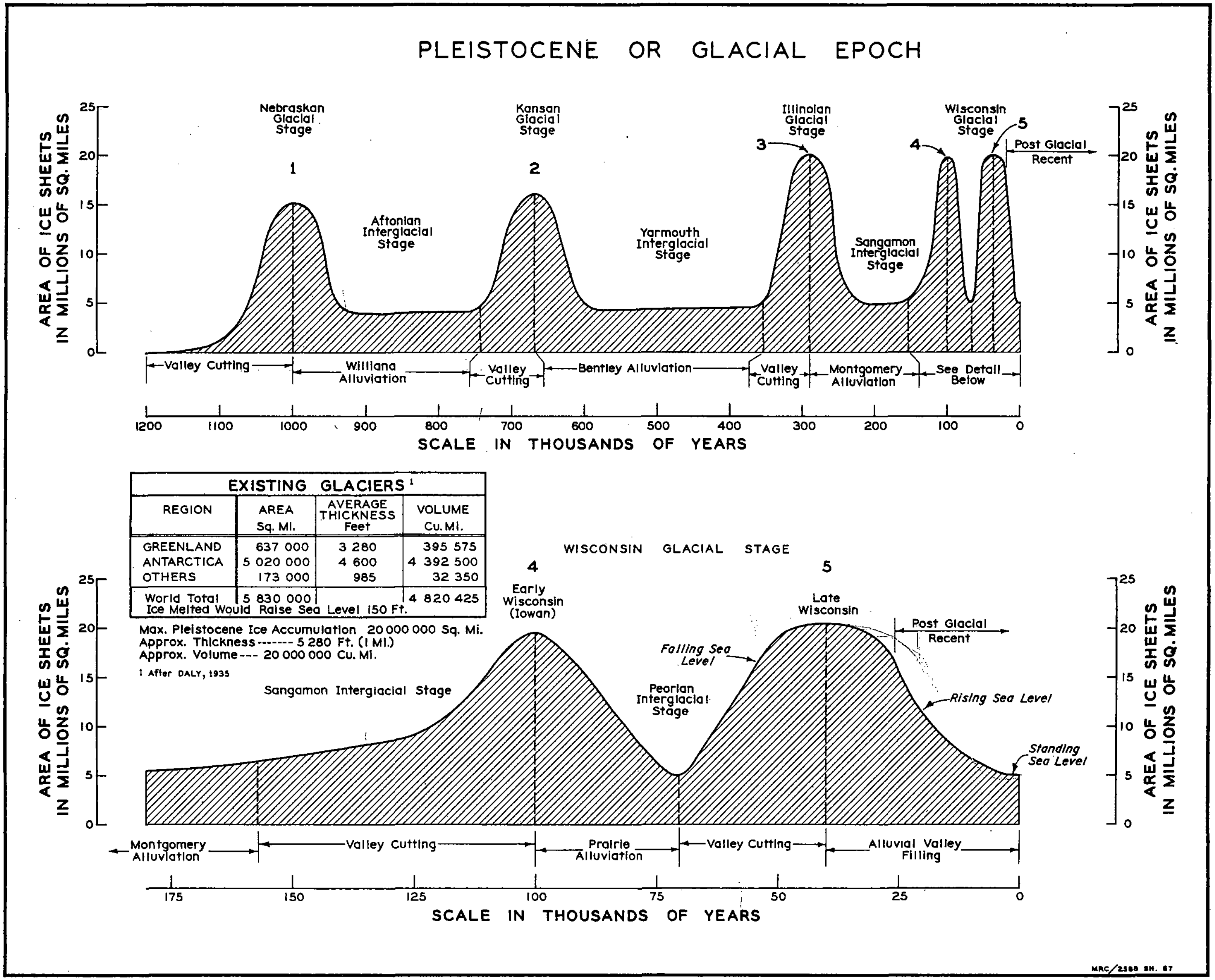
The Mississippi River established its course in a belted lowland lying close to the western margin of the Mississippi Embayment. Ohio River drainage was established in a course in a lowland belt along the eastern margin of the Mississippi Embayment and reached the Gulf of Mexico independently of the Mississippi River. It probably flowed southward in a course approximately coincident with that now occupied by the northward-flowing lower Tennessee River and reached the Gulf near Mobile, Ala., by a course now occupied by the Tombigbee and Mobile rivers (plate 1). Changes during subsequent glacial stages shifted the Ohio River course westward to its present position.

[1] Daly, R. A., "The Changing World of the Ice Age," Yale Univ. Press, New Haven, Conn., pp. 47-48, 1935.
Antevs, Ernst, "The Last Glaciation," Amer. Geographical Soc., Research Series No. 17, pp. 81-82, 1928.
Wright, G. F., "The Ice Age in North America," Bibliotheca Sacra Co., Oberlin, Ohio, p. 503, 1911.
[2] Schuchert, Charles, and Dunbar, C. O., "Outlines of Historical Geology," John Wiley & Sons, Inc., p. 160, 1941.
[3] Daly, R. A., op. cit., pp. 5-12.
[4] Alden, W. C., "Physiography and Glacial Geology of Eastern Montana and Adjacent Areas," U. S. Geol. Survey Prof. Paper 174, 1932.
Leverett, Frank, "Pleistocene of Northern Kentucky," Kentucky Geol. Survey, Ser. VI, Bull. 31, 1929.
Spencer, J. W., "Origin of the Basins of the Great Lakes of America," Amer. Geol., vol. 7, pp. 86-97, 1891.
Todd, J. E., "The Pleistocene History of the Missouri River," Science, new ser., vol. 39, 1914.

TABLE 11

GEOLOGICAL HISTORY OF CENTRAL GULF COASTAL PLAIN.

| Era | Period | Epoch | Duration | Age | Important Characters and Events |
|---|---|---|---|---|---|
| CENOZOIC | Quaternary | Recent | 30,000 years | Alluvium | Cyclical changes in sea level associated with advance and retreat of continental ice caps cause alternating entrenchment and alluviation by rivers. Recent floodplain represents end of latest cycle. Epirogenic uplift inland and subsidence of coastal margin throughout the period. |
| | | Pleistocene | 970,000 years | Prairie<br>Montgomery<br>Bentley<br>Williana | |
| | Tertiary | Pliocene-Miocene (?) | 20,000,000 years | | Separation of deposits from Miocene questionable. Belted coastal plain topography continuing development. |
| | | Miocene | | Grand Gulf | Period of maximum delta growth. Shoreline retreated gulfward. Over 8,000 ft. of deltaic sediments accumulated in southern Louisiana and constitute the thickest known single deltaic mass in Gulf Coast Geosyncline. Epirogenic uplift initiated development of belted topography. |
| | | Oligocene | 16,000,000 years | Vicksburg | Widespread marine conditions gradually superseded by delta growth and seas gradually retreated from coastal plain. Thickest deltaic masses in southwestern Louisiana and adjacent parts of Texas. |
| | | Eocene | 20,000,000 years | Jackson | Marine advance to vicinity of Memphis marks cessation of fluviatile sedimentation in Mississippi Embayment. |
| | | | | Claiborne | Fluctuation of shoreline as sedimentation slackened. Deposits characterized by alternation of marine and deltaic deposits. Thickest deltaic masses in southwestern Louisiana and adjacent parts of Texas. |
| | | | | Wilcox | Delta growth and retreat of shoreline. Thick deltaic deposits located in southeast Mississippi and in central western Louisiana and Texas. Land areas standing high; geosyncline sinking. |
| | | Paleocene | | Midway | Widespread thin marine beds show marine conditions existed inland to head of Mississippi Embayment. Land areas low during period. |
| MESOZOIC | Cretaceous | Upper Cretaceous | 40,000,000 years | Gulf | Mississippi Embayment formed by down faulting. Fluctuating shoreline with the seas reaching inland to head of Mississippi Embayment. Deltaic accumulations thinner than those of the Lower Cretaceous and mark a gradual slackening of sedimentation. |
| | | Lower Cretaceous | 30,000,000 years | Comanchean | Delta growth and retreat of shoreline. Centers in northern Louisiana and Arkansas and in Alabama. Sediments derived from highlands in Ouachita region of Arkansas and southern Appalachians of Alabama. Salt and other evaporite deposits present. Land areas high; sinking in geosynclinal region. |
| | Jurassic | | 40,000,000 years | | Several thousands of feet of deltaic sediments penetrated by a few borings in the Central Gulf Coastal Plain. Marginal land areas probably rising. Salt and other evaporite deposits present. Coarse sediments mark position of shorelines. |

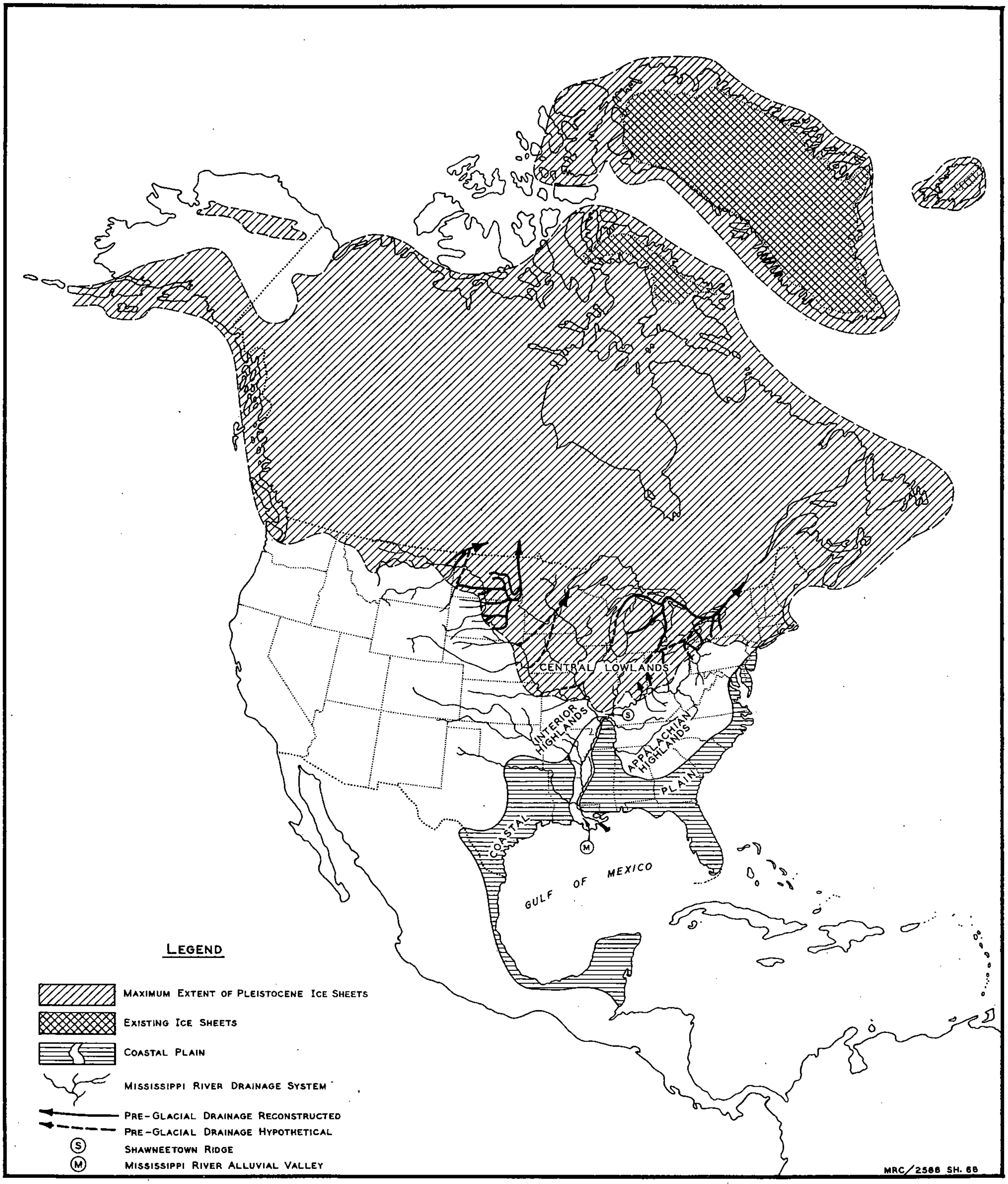



**EXISTING GLACIERS** [1]

| REGION | AREA Sq. Mi. | AVERAGE THICKNESS Feet | VOLUME Cu. Mi. |
|---|---|---|---|
| GREENLAND | 637 000 | 3 280 | 395 575 |
| ANTARCTICA | 5 020 000 | 4 600 | 4 392 500 |
| OTHERS | 173 000 | 985 | 32 350 |
| World Total | 5 830 000 | | 4 820 425 |

Ice Melted Would Raise Sea Level 150 Ft.

FIGURE 75




DISARRANGEMENT OF PRE-GLACIAL DRAINAGE AND THE FORMATION OF THE MISSISSIPPI RIVER SYSTEM BY ADVANCE OF PLEISTOCENE GLACIERS INTO THE CENTRAL LOWLANDS OF NORTH AMERICA. (RECONSTRUCTED PRE-GLACIAL DRAINAGE AFTER: ALDEN, 1932; LEVERETT, 1929; SPENCER, 1891; TODD, 1914).

FIGURE 76

*Correlation of Central Gulf Coastal Plain Deposits and Glacial Stages*

Although the Central Gulf Coastal Plain was not covered by ice during the glacial stages, the results of oscillation of sea level associated with the advance and retreat of the ice sheets are very evident in this region. Each stream flowing through the region is bordered by a step-like sequence of four fluviatile terraces which merge gulfward with their corresponding widespread coastwise deltaic-plain equivalents. An idealized relationship of the fluviatile terraces is indicated on figure 77. Each terrace surface is underlain by a basal graveliferous sandy facies which grades upward through sands into an upper facies of silts and clays. These deposits make up a formation in which the variation in lithology from base to top reflects the change in conditions as sea level rose with the melting of the ice. Each of the four interglacial formations is emplaced in an entrenched valley system excavated during the previous epoch of falling sea level. The major features of the valley eroded by the Mississippi River system, as sea level was falling during late Wisconsin time, are shown on figure 78. The character of this entrenched valley, as established from the records of many borings, probably differs only in minor details from that of the valleys cut during each of the preceding glacial stages.

**Terrace Relationships.** Uplift of the land occurred contemporaneously with the changes in sea level associated with the advance and retreat of the ice. It caused the separation of the terraces, facilitates the recognition of their underlying deposits, and makes possible the establishment of a general chronology of events. The relationship of the four uplifted Pleistocene depositional terraces to the present alluvial plain in areas where field studies have been made is shown on plate 26. Section A-A′, an approximately west-east section across the Mississippi Alluvial Valley near Forrest City, Ark., shows the elevation of the terraces and the nature of the Pleistocene and Recent formations. The highest terrace, the Williana, has been uplifted about 350 ft. above the level of the present alluvial plain. The Bentley has been uplifted 200 ft., the Montgomery more than 100 ft., and the Prairie terrace about 40 ft. above the flood plain of minor streams. The relation of the terraces to the present floodplain in the southern part of the alluvial valley between east-central Louisiana and southern Mississippi near Natchez is shown on section B-B′ of plate 26.

The gulfward increase in slope of the coastwise deltaic plain terraces is shown on the north-south sections C-C′ and D-D′ of plate 26. Measurements of the slopes of the terrace surfaces in central and southern Louisiana[1] indicate that the oldest terrace, the Williana, has the steepest slope, 8 ft. per mile, as compared to 5 ft. per mile for the Bentley, 1.5 ft. per mile for the Montgomery, and 0.5 ft. per mile for the Prairie Terrace. The fact that these slopes appear to have been formed by continuous uplift, indicates that the interval of time between the deposition of each terrace was progressively less. From this, it is reasoned that the lengths of the glacial stages have not been the same, but that the more recent ice advances and retreats have been separated by shorter interglacial stages. The terrace slope relationships bear out the belief of glacialogists that the longest interglacial interval was the Yarmouth stage.

Studies of the thickness of the fluviatile terrace formations indicate that the older terraces, the Williana and Bentley, have thinner deposits than the younger terraces. Accurate comparisons of thickness of the deltaic plain deposits, equivalent to the fluviatile terraces in age, have not been made. Each fluviatile terrace, however, thickens greatly as it merges with deltaic plain deposits (see plate 26). In central Louisiana the maximum known thickness of the fluviatile Williana and Bentley formations is 220 ft. in contrast to the 250 ft. thickness of the younger terrace deposits (section D-D′, plate 26). This fact suggests either that less ice accumulated upon the continents during the Nebraskan and Kansan glacial stages (and consequently sea level was higher than in the later glacial stages), or that the earlier ice sheets did not waste away as completely as the later ice sheets.

**Length of Pleistocene Epoch.** The relative duration of the stages of valley cutting and valley filling and the stages of the advance and retreat of the ice during Pleistocene time as indicated on figure 75 are interpretations deduced from a study of coastal plain features and from an accepted length of Quaternary time, slightly over 1,000,000 years. The figure 50,000-60,000 years, which is allowed for the advance and retreat of each ice sheet, is also an accepted unit of glacial time.

Studies of the terraces confirm studies made in glaciated regions which indicate that Quaternary time is divisible into two parts, the older including that portion up to the end of the Yarmouth interglacial stage, and the younger part continuing in the present (figure 78). The fact that Recent deposits differ in no major respect from deposits of interglacial stages suggest that the Recent epoch is similar to an interglacial stage. This epoch is considered to have begun with the initiation of the last ice retreat and to cover a period of 25,000 to 30,000 years.

## PLEISTOCENE HISTORY OF THE CENTRAL GULF COASTAL PLAIN

At the beginning of Pleistocene time, the belted topography of the Central Gulf Coastal Plain had lower relief than it possesses today. The inner belts were established, but the belts formed on the Miocene deposits were not yet in existence. In the Mississippi Embayment the main drainage was along the margins following the inner topographic belts of the Central Gulf Coastal Plain, and only minor streams drained the central part of the embayment. The surface of the coastal plains, and also of the continental interior, was probably deeply weathered as a result of the milder climate which had endured for a long period during late Tertiary time.

When sea level began to drop as ice accumulated upon the continents in the Nebraskan time (the first glacial stage), the streams of the Central Gulf Coastal Plain cut down to keep their junctions accordant with the falling base level. Downcutting began at the Gulf and worked headward, resulting in stream gradients which steepened gulfward; a similar gulfward steepening is shown by the slope in the late Wisconsin entrenched valley (plate 11).

[1] Fisk, H. N., "Geology of Grant and La Salle Parishes," Louisiana Dept. Cons., Geol. Bull. No. 10, pp. 67-75, 1939.

The streams flowing along steep slopes which existed within the entrenched valley system were able to transport the abundant coarse debris made available from erosion in the deeply weathered surface of the stream basins. The gravels[1] which form the basal facies of the terrace deposits consist chiefly of brown cherts derived from the weathered limestone formations of the continental interior and of minor amounts of igneous and metamorphic rocks derived from the St. Francis, Arbuckle and Wichita mountains on the west, the Appalachian Mountains on the east, and the Lake Superior region of the north. Although the gravels form only the basal phase of the terrace sequence, there is no reason to attribute their presence here to an increase in transporting power resulting from an increase in the volume of streams. Gravels carried by streams originating in the non-glaciated drainage basins of the Red and St. Francis rivers, and of minor streams, are as large and occur in quantities similar to those transported by streams issuing from the glaciated regions. The steeper gradients of the entrenched streams afford sufficient explanation of the cause for the transportation of large amounts of gravels during each glacial stage.

Melting of the ice in each of the interglacial stages raised the base level of the streams. As the base level rose, the gradient of the streams was decreased and their ability to transport coarse sediment was lost. Boulders, cobbles, and pebbles were the first sediments to be dropped, but the continuing rise of sea level resulted in the deposition of finer sediments. Along with the decrease in the carrying power of the streams, the decrease in the gradients, and change in the character of the alluvium deposited, the stream channels themselves were changed. From the steep-gradient shallow, braiding channels of the glacial stages, which flooded their valleys almost constantly, the stream channels changed in late interglacial times to narrow, deep, meandering types which flooded their valleys only seasonally.

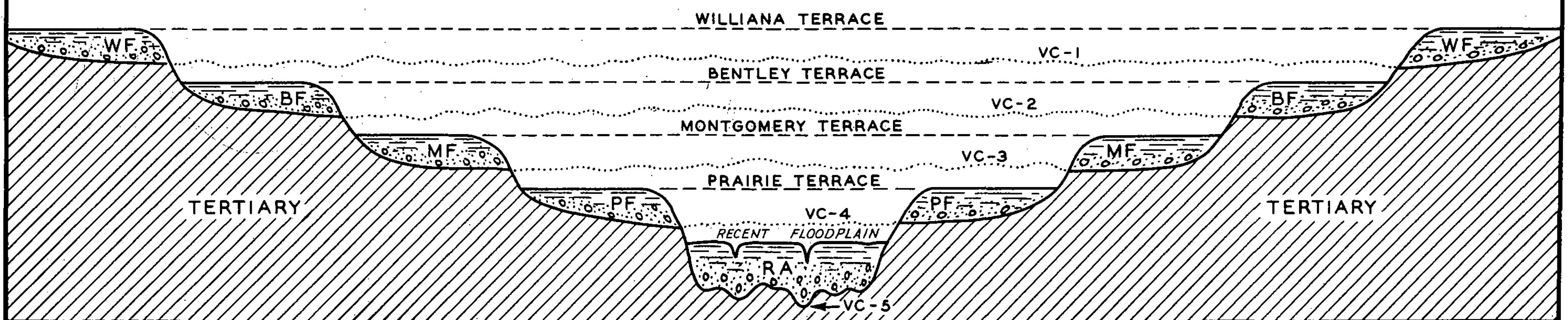
When sea level reached a stand in interglacial stages, the streams had built up broad alluvial plains on which they left traces of their presence in meander scars and drainage lines similar in pattern to those on the present alluvial plain. Studies of the drainage patterns on terrace surfaces permit reconstruction of meander belts comparable in size to those of the present Mississippi River. Meanders on the Bentley fluviatile surface have been reconstructed from the drainage pattern on the terrace south of Memphis (figure 79). Meanders identical in size with those of the modern Mississippi River can be clearly seen in the topography of the Prairie deltaic plain terrace in southern Louisiana (figure 80). The similarity of these old meanders to those of the modern Mississippi River indicates that a similar volume-slope relationship was attained during each interglacial stage of the Pleistocene.

The older glacial stages, the Nebraskan and Kansan, were widely spaced and probably involved a smaller accumulation of ice upon the continents than did the younger glacial stages (see figure 75). The valleys entrenched in these stages consequently are not as deep as those of later glacial stages. The younger glacial stages, the Illinoian and the early and late Wisconsin, had greater accumulations of ice but were separated by shorter interglacial stages. The valleys were entrenched deeper during these younger stages, and thicker deposits were accumulated in the interglacial stages. There appears to have been a speeding up of the cycles of glaciation with an increase in the volume of ice which perhaps reached its largest accumulation during the late Wisconsin stage. It was during this last growth of ice sheets in the Pleistocene epoch that the entrenched valley beneath the present Mississippi alluvial plain was eroded, but its filling and the development of the alluvial plain are part of the Recent epoch.

[1] Fisk, H. N., "Igneous and Metamorphic Rocks from Pleistocene Gravels of Central Louisiana," Jour. Sedimentary Petrology, vol. 9, pp. 20-27, 1939.

| GLACIATED AREA | | | | | LOWER MISSISSIPPI VALLEY |
|---|---|---|---|---|---|
| GLACIAL STAGES | | | INTERGLACIAL STAGES | | INTERGLACIAL TERRACE DEPOSITS |
| Each glacial stage characterized by accumulation of ice upon continents and lowering of sea-level with resultant entrenchment of streams and valley cutting. | | | Each interglacial stage characterized by retreat of ice sheets from continents and rise of sea-level with alluviation of valleys cut during previous glacial stage. | | Each terrace deposit is of interglacial age, fills valleys cut during preceeding glacial stage, and constitutes a geologic formation. Continued uplift during Quaternary Period has raised terrace deposits above level of present floodplain. |
| QUATERNARY PERIOD | RECENT EPOCH | | | | RECENT ALLUVIUM (RA) |
| | PLEISTOCENE OR GLACIAL EPOCH | Late Wisconsin (youngest) | | | Valley cutting VC-5 |
| | | | Peorian | | PRAIRIE FORMATION (PF) |
| | | Early Wisconsin | | | Valley cutting VC-4 |
| | | | Sangamon | | MONTGOMERY FORMATION (MF) |
| | | Illinoian | | | Valley cutting VC-3 |
| | | | Yarmouth | | BENTLEY FORMATION (BF) |
| | | Kansan | | | Valley cutting VC-2 |
| | | | Aftonian | | WILLIANA FORMATION (WF) |
| | | Nebraskan (oldest) | | | Valley cutting VC-1 |

IDEALIZED RELATIONSHIP OF TERRACES

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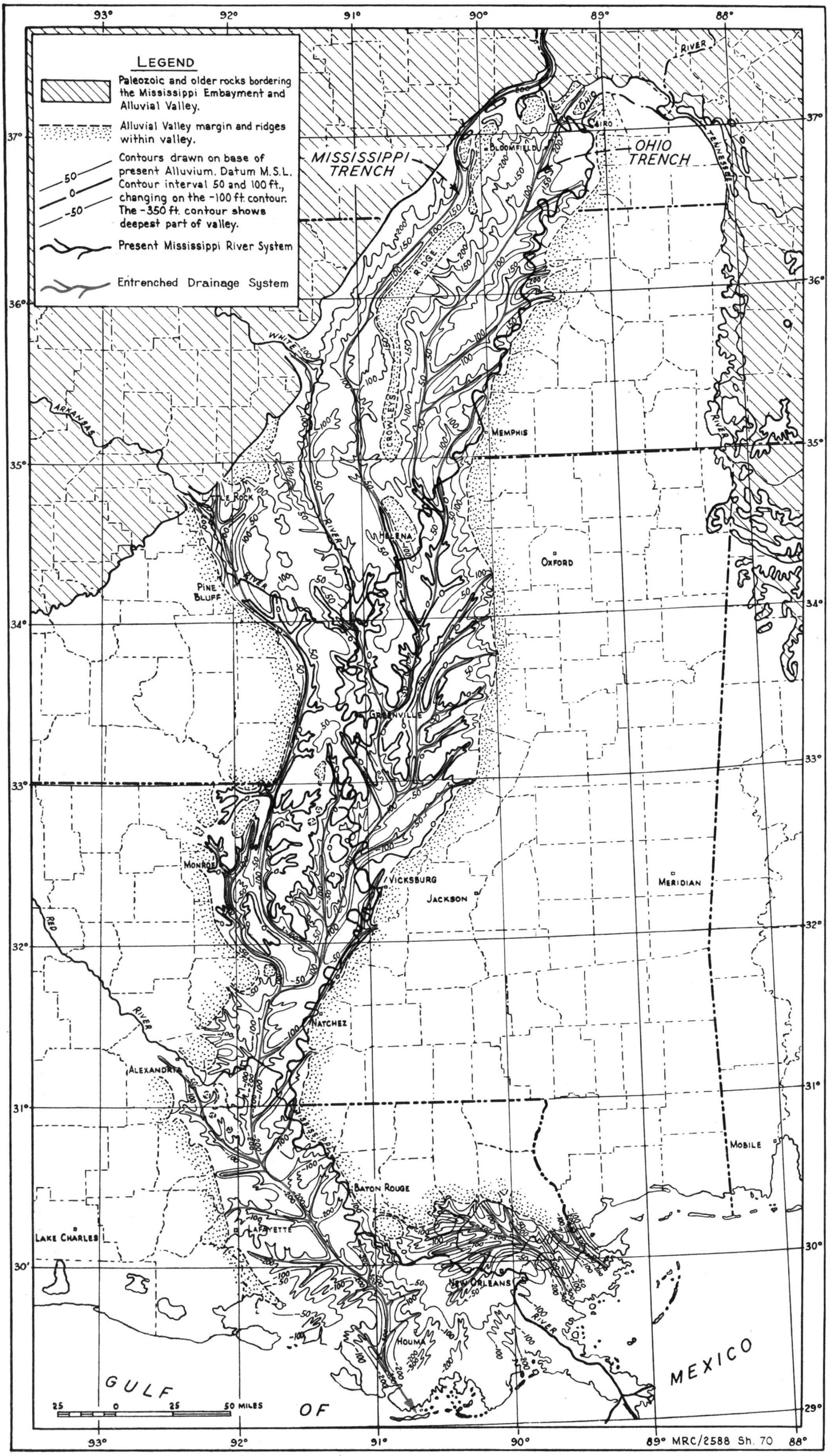
PLEISTOCENE HISTORY OF THE CENTRAL GULF COASTAL PLAIN.

FIGURE 77




GENERALIZED CONTOUR MAP OF THE MISSISSIPPI RIVER ENTRENCHED VALLEY SYSTEM DURING THE LATE GLACIAL (LATE WISCONSIN) STAGE.

FIGURE 78

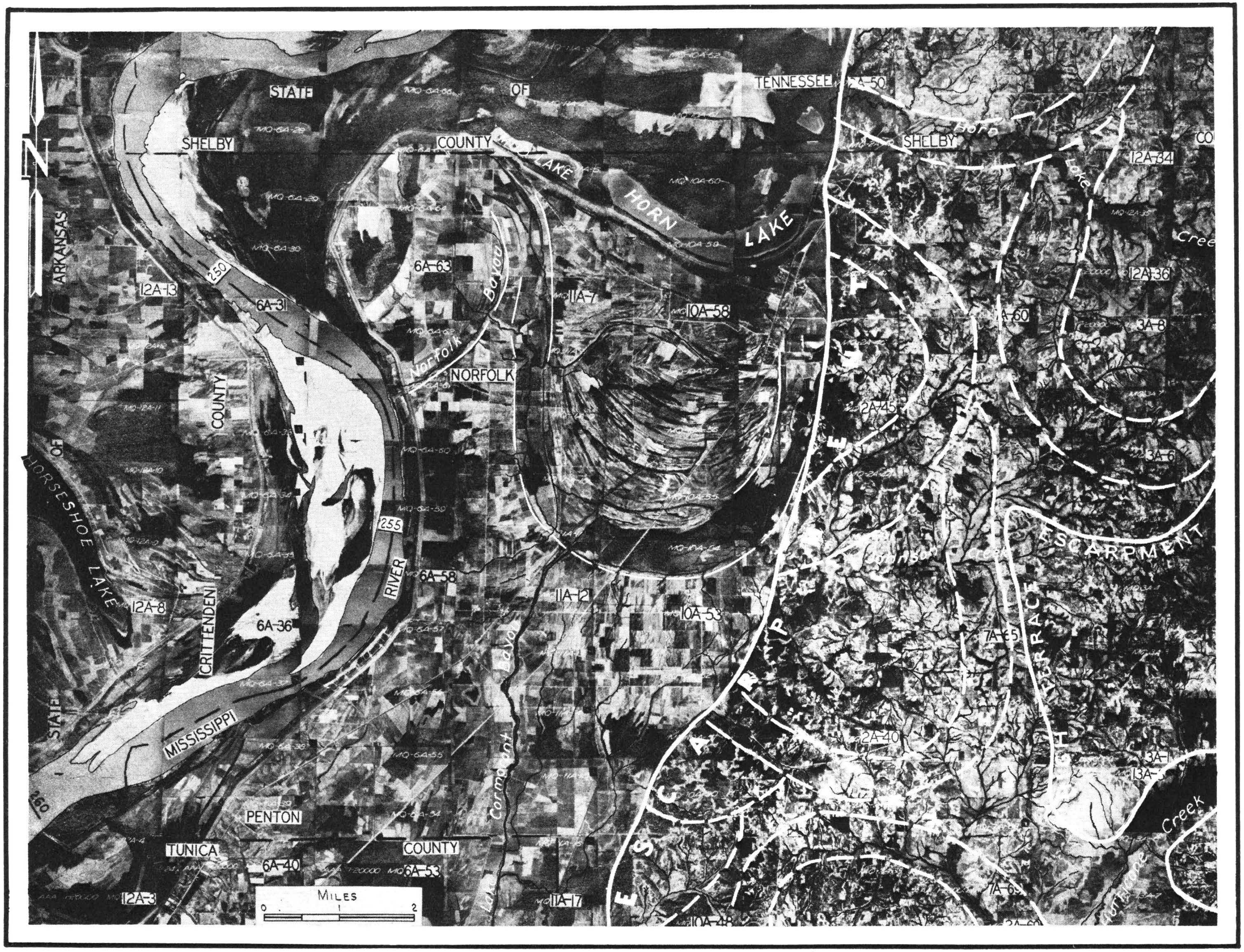



FIGURE 79

DRAINAGE OF THE MISSISSIPPI RIVER FLOOD PLAIN AND TERRACED UPLANDS WITH RECONSTRUCTED PLEISTOCENE MISSISSIPPI RIVER MEANDERS

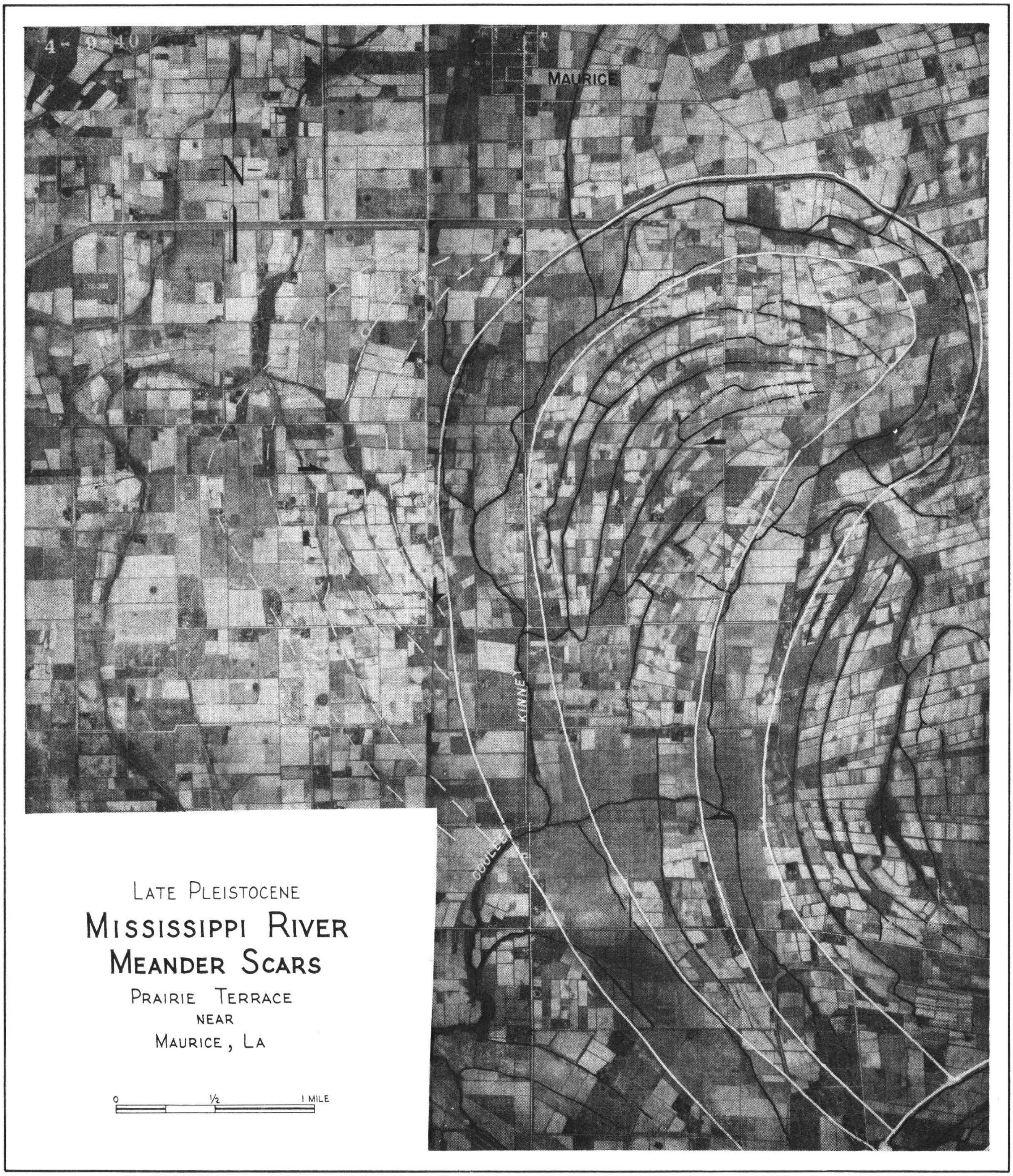

4-9-40
N
MAURICE
KINNEY
COULEE
LATE PLEISTOCENE
MISSISSIPPI RIVER
MEANDER SCARS
PRAIRIE TERRACE
NEAR
MAURICE, LA
0
½
1 MILE

FIGURE 80

NOTE.—The abbreviations shown in the Index are as follows: P for Plate, (example P-2 indicates Plate 2); F for Figure, (example F-27 indicates Figure 27); and T for Table, (example T-5 indicates Table 5).