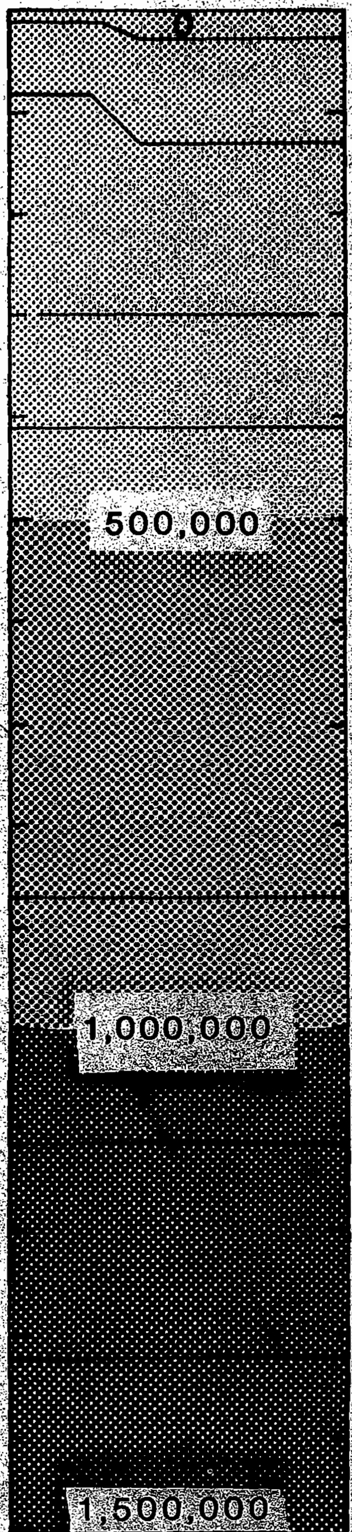
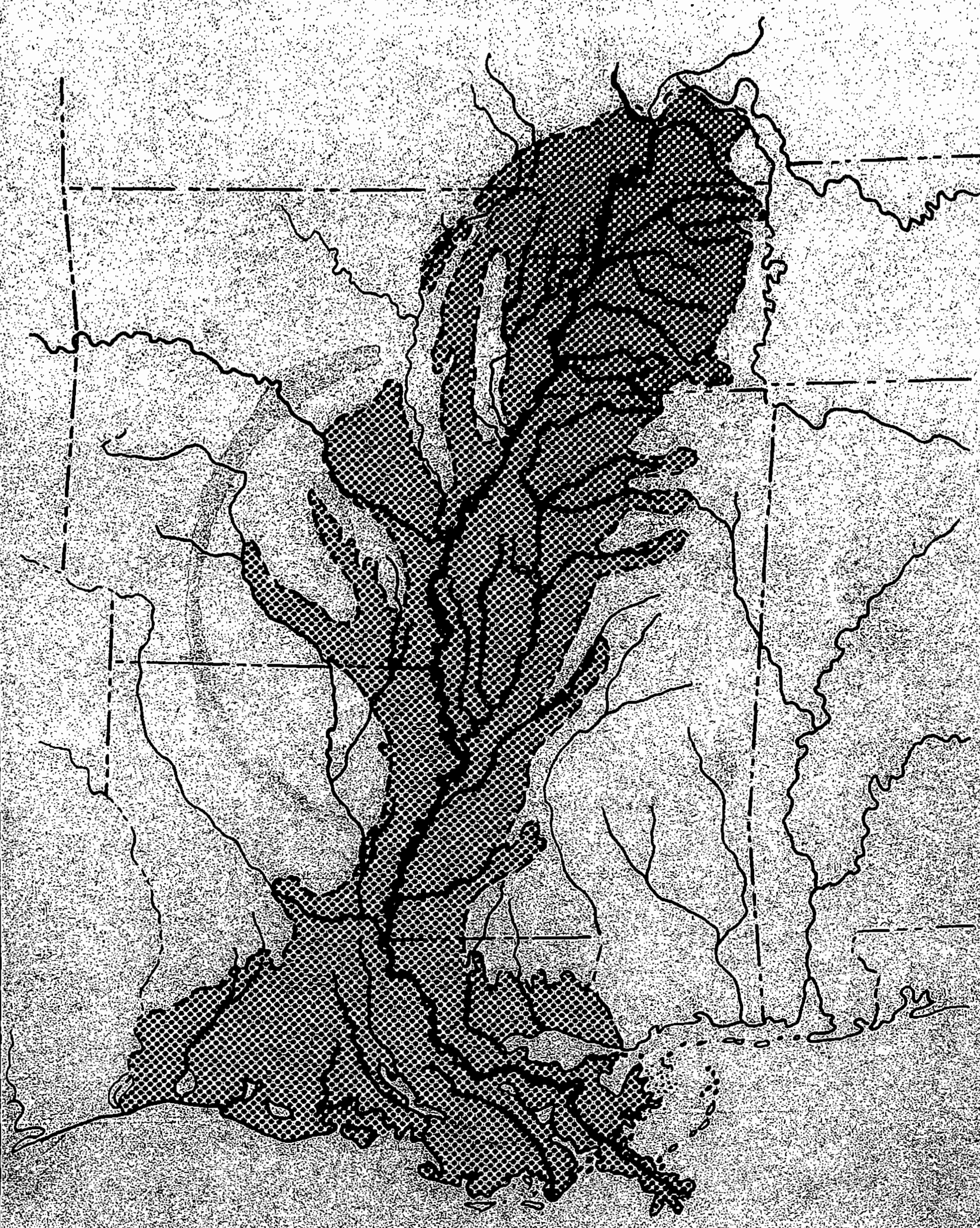
QUATERNARY GEOLOGY OF THE LOWER MISSISSIPPI VALLEY





By ROGER T. SAUCIER

PRESERVING THE PAST FOR THE FUTURE

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by

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TO
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In 1970 the Arkansas Archeological Survey contracted with the National Park Service to prepare information on the geological, archeological, and early historic resources of the Lower Mississippi Alluvial Valley. This information was used by the U.S. Army Corps of Engineers for their Comprehensive Basin Study of the Valley.

Dr. Saucier is a geographer specializing in the subfields of geomorphology and morphology. His interests focus primarily on the paleogeography and paleoenvironments of the Lower Mississippi Valley and relationships between the natural landscape and prehistoric human occupation and use. He has been employed for more than 20 years by the U.S. Army Engineer Waterways Experiment Station in Vicksburg, Mississippi. He has published numerous articles pertaining to aspects of the geomorphic history of the Mississippi Valley and he actively consults and advises on projects involving the application of geomorphology in cultural resources management.

When the first edition of this report appeared in 1974, it provided insight into the latest thinking and rethinking of the geological processes, past and present, which have affected the Mississippi Valley. It still does. Although there have been a number of significant contributions to the knowledge of the region in the last decade, especially with regard to the geologic evolution of the major tributaries and an understanding of river regime responses to climatic change, there is no single volume compilation or synthesis of these new data and concepts. It is anticipated that such a document will emerge in about five years as a result of studies recently initiated at the Waterways Experiment Station.

There are several benefits likely to result from the second printing and consequent wider distribution of this report. Foremost, it will expand the awareness and appreciation by archeologists and others of the limitations of and misconceptions regarding some of the older and widely accepted "classic" studies of the region. Secondly, it will serve as a basic reference in brief form for those not familiar with the Quaternary geologic framework of the region. Finally, it should serve as a catalyst, as it already has, to bring forth archeologically derived chronological information badly needed to refine the very limited amount of geologically derived chronological data available. The readers of this report are urged to be constantly alert as to how the results of their work can be vital to furthering the understanding of Quaternary events and processes. Dr. Saucier welcomes communications and dialogue.

Charles R. McGimsey III
Director

Quaternary Geology of the Lower Mississippi Valley

INTRODUCTION

The only comprehensive geological investigation of the Lower Mississippi Valley to be conducted was accomplished by Fisk and published by the Mississippi River Commission in 1944. This monumental work concerned itself with processes and patterns of fluvial sedimentation, changes in river regime and behavior, and other aspects of Quaternary geology; however, it was basically concerned with and is most well noted for an elaborate reconstruction of valley history and a detailed chronology of stream channels. In present perspective, it is the discussion of valley history and chronology that has failed to pass the test of time and subsequent investigations, whereas some of the less well-known discussions of sedimentary processes and river behavior are as valid today as when written and should be considered as classic.

Since many weaknesses and incorrect assumptions and concepts are now known to prevail in Fisk's chronology and valley history reconstruction and since his 1944 monograph is still widely accepted as the most authoritative work on the area, the need has arisen to prepare this present discussion and to offer a new chronology for the Lower Mississippi Valley. This discussion has been prepared primarily for workers in the field of archeology and history who have an immediate need for such a chronology. The results and concepts presented herein have evolved primarily from several years of detailed engineering-geologic quadrangle mapping in all parts of the alluvial valley area by or under the supervision of the writer.

Indications of errors and weaknesses in the Fiskian concepts have been pointed out (Durham, Moore, and Parsons 1967; Kolb et al. 1968; Saucier 1964, 1967, 1969; and Smith and Saucier 1971), but these publications have had very limited distribution. Other indications of need for chronological revisions have been concerned only with specific areas or problems (Cullinan 1969; Saucier 1968; Saucier and Fleetwood 1970). This discussion is the first attempt since 1944 to devise a new chronology for the entire alluvial valley area and to include the results of recent similar work in the Mississippi River deltaic plain and chenier plain in Louisiana (Frazier 1967; Gould and McFarlan 1959; Kolb and Van Lopik 1958; Saucier 1963). It relies heavily upon observations and conclusions resulting from archeological investigations and attempts to synthesize these with geological and geographical evidence. Whereas phases of valley history and conclusions regarding the origin of certain features are well documented, there are others that have little or no supporting evidence. But, since this is an attempt at a complete sequential history, "all pieces of the puzzle have been made to fit."

The focus of this discussion is the geologic map of the Quaternary formations and deposits of the Lower Mississippi Valley (Figure 1, map in back pocket). Only a brief examination of this map will reveal a level of detail significantly less than that presented 30 years ago by Fisk. This lack of detail is not a result of generalization demanded by the small scale of the map, but rather it is a reflection of the confidence of the writer in the validity of the evidence now at hand. Whereas Fisk attempted to subdivide the present Mississippi River meander belt into 20 stages representing 100-year increments, for example, present evidence from radiocarbon dates and archeological remains makes such a subdivision wholly untenable. There are now reasons to believe that the present meander belt was first established only 2,800 years ago in the southern part of the valley but as much as 6,000 years ago in the northern part of the valley. Thus without specific absolute-age information on each or most of the numerous abandoned channels, anything but relative-age assignments is premature.

Outside of the valleys of the Mississippi, Arkansas, and Ouachita Rivers and excluding the coastal terraces, little or no recent geological work has been done. The distribution of alluvium and terraces along smaller streams in the uplands has been taken from published sources (Bicker 1969; Branner 1937; Fisk 1938, 1940; Hardeman 1966; Jillson 1929) and has not been reevaluated.

GEOLOGICAL CONTROLS

Cyclic Pleistocene glaciation has been directly or indirectly responsible for the origin, character, and distribution of virtually all of the Quaternary deposits and formations shown in Figure 1. Although continental ice sheets did not actually extend into the Lower Mississippi Valley area, they nevertheless were responsible for deranging preglacial drainage and creating the southward-trending river and valley which subsequently has carried large volumes of glacial meltwater and outwash on several occasions. Equally important controls were exerted by the cyclic glaciation in the form of major changes in base levels of erosion and deposition and in the form of climatic changes.

Each cycle of advancing and retreating or waxing and waning glaciation has involved generally the same sequence of changes. The sequences have been repeated five times during the Quaternary, a period of time estimated to have lasted about 1,500,000 years (Figure 2).

Coincident with each waxing continental glaciation was a eustatic fall in sea level and a resultant seaward retreat of the Gulf of Mexico shoreline. The drop in sea level caused entrenchment of the lower reaches of streams directly discharging into the Gulf and a steepening of stream gradients. In the case of the Mississippi River, the stream response due solely to falling sea level was probably manifested no farther inland than the latitude of Vicksburg, Mississippi, and in the case of the last (Late Wisconsin) glaciation, no farther inland than the latitude of Alexandria, Louisiana.

While entrenchment and valley deepening were occurring near the Gulf, valley widening and deepening from another cause were occurring coincident with alluviation in the upper part of the Lower Mississippi Valley. Whereas Fisk postulated that the alluvial valley was deeply entrenched throughout and "swept clean" of alluvium during waxing glaciation, it now appears that considerable valley fill was deposited by way of braided streams carrying coarse-grained glacial debris. These braided streams, although aggrading the valley, also accomplished appreciable valley widening through lateral planation and valley deepening through periodic scouring of the underlying "bedrock."

Two additional geologic controls were manifested shortly before and near the time of maximum glacial advance during the last glaciation, and it is assumed these same controls were present during earlier glaciations. One control was the occurrence of sufficient wind-action, probably restricted to the cool season and caused by strong anticyclonic conditions, to result in the deflation of large volumes of silt from active braided-stream channels in the area of glacial outwash (i.e., valley train) deposition. This material was redeposited as loess in the uplands east of the alluvial valley, in uplands within the alluvial valley, and on older alluvial deposits within the valley (Snowden and Priddy 1968). The second geologic control was the occurrence of pronounced pluvial conditions probably brought about by heavy warm season precipitation and occurring coincident with somewhat cooler temperatures. These conditions caused appreciable increases in the discharges of major Mississippi River tributaries and resulted in valley degradation or lowering and consequent terrace formation (Saucier and Fleetwood 1970). One would not expect to find and indeed does not find evidence of the effects of the pluvial climate in the main Mississippi Valley area because of the already braided character of the Mississippi River at this time and its substantial discharge.

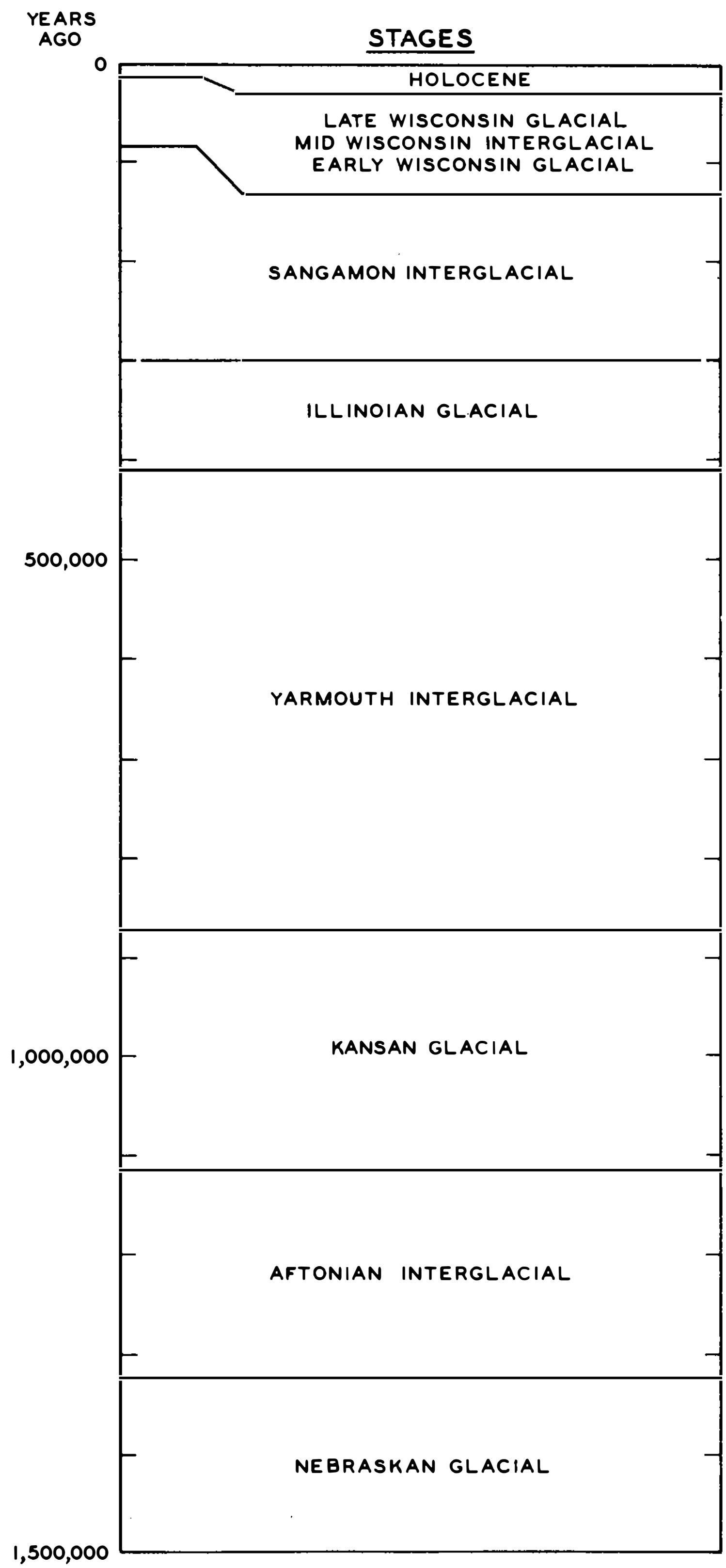

Figure 2. Quaternary glacial nomenclature and chronology. Synthesized from various sources and based largely on oceanographic evidence.

During all glacial cycles, the maximum lowering of sea level was generally coincident with the maximum extent of the continental ice sheets. Since this lowering was of the magnitude of 350 to 400 feet, all coastal and deltaic landforms that developed several thousand years before and after this event were either destroyed by subsequent erosion or are deeply buried beneath younger deposits. Shoreline advance and retreat at rates of tens of feet per year and over distances of tens of miles must have occurred because of the wide and relatively flat nature of the continental shelf.

Sedimentation rates evidently reached their highest levels in the upper part of the Lower Mississippi Valley during the early stages of waning glaciation. Waves of alluviation spread southward with diminishing effects and are manifested in the subsurface at least as far south as the present Gulf Coast. Aggradation in the northern part of the valley appears to have lasted no more than a few thousand years. Apparently after this time, the ratio of sediment to meltwater declined to the point where valley degradation occurred, although a braided-stream regimen still existed. This condition was responsible for the creation of the braided-stream terraces or levels such as survive in the valley from two glacial cycles (Saucier 1964). In regard to the Mississippi River tributaries, only the Arkansas River carried outwash from alpine or mountain glaciation. Deposition of this material in the Mississippi Valley beyond the mouth of the Arkansas Valley at Little Rock, Arkansas, occurred on at least two occasions during the Wisconsinan Stage (Saucier 1968). Little is known about the regimes of tributaries not carrying glacial outwash; however, certain ones appeared to have begun meandering and aggrading in response to rising base levels in the Mississippi Valley quite early in the waning glaciation stage.

During each glacial cycle, a stage was reached when stream discharge and sediment load declined to a point where the ancestral Mississippi River changed from braided to a meandering regimen. This apparently first occurred nearest the Gulf Coast and proceeded upvalley. In the case of the last cycle, the Mississippi River is known to have changed from braided to meandering quite abruptly about 12,000 years ago south of the latitude of Baton Rouge, Louisiana (Saucier 1969), while it did not do so until possibly 6,000 years ago north of the latitude of Memphis, Tennessee. During the preceding cycle, there may not have been an interglacial stage of sufficient duration for the change in regimen to take place other than near the coast. When sufficient time was available, however, and meandering dominated, slow valley aggradation prevailed.

Termination of a glacial cycle occurs with a full interglacial stage. In most if not all of the five interglacial stages, sea level was at least as high as and probably higher than at present and it maintained a relatively constant level. This permitted the formation of well-developed deltaic plains and possibly also chenier plains by either or both the Mississippi and Red Rivers. Where sedimentation was less active and marine processes prevailed over fluvial processes, the coastline was characterized by either a well-developed mainland beach or a barrier island-lagoon situation. Partly because of a net shoreline progradation during the Quaternary and topographic separation of base levels, coastline features of all types remain well preserved and distinguishable on coastwise terraces.

The geologic controls discussed thus far are all related to climate, sedimentary volumes, and base level changes. No mention has been made of structural controls which would include faulting, earthquake activity, and regional warpings. In general, it can be stated that structural controls have been truly insignificant in governing the nature or distribution of the Quaternary formations north of the Mississippi River deltaic plain. Faulting may well have influenced the positions and configurations of tributary streams and the streams which the ancestral Mississippi River occupied when first flowing southward in the early Quaternary; however, the Quaternary deposits along these streams have been largely unaffected. Most of the Quaternary faults that have been mapped on the basis of physiographic evidence (Krinitzsky 1950) have not been verified by sub-surface evidence when explored in detail. Similarly, many faults are known to have affected the Tertiary bedrock but apparently have had no effect on the overlying Quaternary deposits. The configuration of the Lower Mississippi Valley itself, often cited as evidence for fault control, appears to be related far more to preglacial drainage patterns and the relative resistance to erosion of the bordering Tertiary formations. There is not a single known case, including the Mississippi River, where evidence has been found to substantiate that faulting has caused a diversion of a stream or the creation of a distributary.

North of Memphis, Tennessee, in the Mississippi Valley earthquake region, many of the cases of uplift or doming and subsidence or sunk land formation attributed to the New Madrid earthquake series of 1811-1812 have been shown either to not exist or to be of other origins (Saucier 1970). Certain anomalies such as Mississippi River meander belt asymmetry do occur; however, their causes have been unexplored and are currently unexplainable.

Whereas the alluvial valley area has been structurally quiescent during the Quaternary, the deltaic plain has been quite active. In general, the Holocene deposits have been relatively unaffected; however, Pleistocene terrace formations have been substantially modified, particularly by normal faults trending east-west. Vertical movements of several tens of feet are known to have occurred during the last 50,000 years (Saucier 1963) and, in some cases, appreciable movements have been recorded during historic times (Wintz, Kazmann, and Smith 1970). In fact, faulting has been sufficiently active and widespread to cause problems and confusion in the correct identification of terraces (Durham, Moore, and Parsons 1967). In addition to faulting, active structural control in the coastal area includes upward movements of salt domes. In the case of the "Five Islands" of central Louisiana (the most notable examples of salt dome uplift), Prairie terrace deposits have been vertically displaced in excess of 150 feet (Van Lopik 1955). The deltaic plain area has also been significantly influenced by subsidence, another type of vertical movement which, in part, involves faulting or structural control. Subsidence is primarily a result of the consolidation of both Holocene and Pleistocene sediments, however, and involves movement rates from a minimum of about 0.4 feet per century near the edge of the deltaic plain to a maximum of over 10 feet per century near the active delta (Kolb and Van Lopik 1958). This type of movement is the only one to be of direct significance in archeological and historical investigations.

PROCESSES AND LANDSCAPES

The Quaternary deposits and formations shown in Figure 1 can be discussed in regard to their mode of origin, composition, and present and past configurations in 11 units or divisions. Although each unit may involve more than one causal process and include a variety of landscapes and lithologies, each is nevertheless a distinctive and definable unit. Geologic age, however, is not a criterion since several units involve two or more separate periods of time.

Undifferentiated terraces

This mapping unit principally involves what are possibly the most controversial deposits in the entire Lower Mississippi Valley area as far as age, origin, and correlation are concerned. As reviewed by Durham, Moore, and Parsons (1967), these deposits, located mainly in southwestern Mississippi and central and southwestern Louisiana, have been variously identified as Citronelle formation of either Tertiary or Pleistocene age and/or the Bentley and Williana terrace formations of Pleistocene age. Although no one can question their lithologic nature, which is essentially one of well-oxidized, cross-bedded, fluvial coarse sands with extensive irregular zones or layers of chert gravels, it is much debated whether these materials were carried southward from the Southern Appalachians (i.e., nonglacial in origin). In either event, deposition as a widespread blanket over a dissected Tertiary age landscape by swiftly flowing braided streams is indicated (Wallace 1966). Because of subsequent erosion, the blanket has been reduced to discontinuous ridge and hilltop caps of graveliferous material that vary in thickness from a few feet to as much as 150 feet. An intriguing aspect of the problem of the origin of these deposits involves the ability of certain investigators to find mappable physiographic terrace levels in certain areas, while other equally competent investigators, in the same or different areas, are unable to recognize such levels.

Unidentified or uncorrelated low and relatively flat fluvial terraces along small streams in east-central Louisiana and southeastern Arkansas are also included in the undifferentiated terrace mapping unit. Because of their topographic position, they would appear to be more appropriately correlated with the Deweyville or Prairie terraces than with the older deposits discussed above. Terraces in southern Illinois that appear to be related to more recent Mississippi Valley events are also included (Alexander and Prior 1968).

Discontinuous upland mixed sand and gravel deposits which have also variously been identified as Citronelle or Lafayette formation deposits or Bentley and Williana terrace deposits underlie the loess deposits as mapped in Figure 1. These are generally no more than 20 or 30 feet thick and occur throughout much of western Kentucky and Tennessee, all of Mississippi where loess is present, and practically all of Crowley's Ridge. Since they are effectively blanketed by loess and can be studied only in occasional outcrops, less is known about them than those discussed previously. A non-glacial, Appalachian source for these deposits is favored by most investigators who have worked in Kentucky and Tennessee; however, occasional ice-rafted boulders (glacial erratics) have been found in the deposits in Mississippi, Arkansas, and Louisiana where a glacial origin is generally favored.

Montgomery terrace

The principal occurrence of the Montgomery terrace is in the form of a coastwise terrace of fluvial and possibly deltaic origin located in southeastern and southwestern Louisiana. Small areas of the terrace have been mapped in Arkansas but are of considerably more questionable identity.

In its 10- to 15-mile-wide outcrop belt, the coastwise terrace is composed of well-oxidized, brightly colored, silty to sandy clays which grade downward into sands and eventually sands and gravels. Although the terrace is characterized by a maturely dissected, hilly landscape with 50 or more feet of local relief, the basal graveliferous deposits are seldom exposed. The terrace formation is probably 300 to 400 feet thick, and it slopes to the south at an average rate of 3 to 5 feet per mile. Subsurface exploration suggests the formation is generally continuous below the younger Prairie terrace to the south at steadily increasing depths seaward.

Prairie terrace

Next to the Holocene alluvial deposits and the deltaic plain of the Mississippi River, the Prairie terrace comprises the largest area of Quaternary deposits of essentially one age. It also ranks second to the Holocene in terms of the degree of preservation of relict geomorphic features on its surface. Largely because of these features, it is possible to subdivide the Prairie terrace into three zones based on the primary mode of deposition. The first zone includes the areas of Prairie terrace in Arkansas which are relict alluvial plains of the Arkansas and Ouachita Rivers and the areas north and east of the Red River in Louisiana which are relict alluvial plains of the Red and Mississippi Rivers. The second zone includes most of the terrace in southwestern Louisiana south and east of the Calcasieu River which is partly a relict deltaic plain of the Red River and partly a relict upper deltaic plain or lower alluvial plain of the Mississippi River. The latter lies south and east of a line connecting Lafayette, Louisiana, with White Lake. The third zone includes the Prairie terrace west of the Calcasieu River in southwestern Louisiana and all of the terrace in southeastern Louisiana. These areas are relict lagoons, barrier islands, and shallow offshore zones created under the dominance of marine processes.

A large amount of subsurface exploration in the Grand Prairie region of Arkansas has indicated that this area and nearly all of the Prairie terrace in Arkansas (first zone) is largely relict backswamp and meander belt deposits. Clays and silty clays of both Mississippi and Arkansas River origin are the dominant sediments to a depth of 60 to 100 feet. The terrace along the Ouachita River is of course of a different origin, but the sediments are lithologically similar and differ only in that they are somewhat thinner. Whereas the Prairie terrace surface south and west of the present course of the Arkansas River, including the Ouachita River area, is essentially amorphous and quite flat, the segment which comprises the Grand Prairie region is characterized by distinct and well-preserved meander belt features. These include several abandoned courses of the Arkansas River plus associated abandoned channels (cutoff meanders) and natural levee ridges which are reflected in the topography and drainage of the terrace surface. Although opinions differ, pedologists familiar with the area feel that the upper few feet of silty sediment that is frequently present is a thin veneer of loess.

In south central and southwestern Louisiana east of Lake Charles, Louisiana (second zone), meander belt features are equally well preserved on the terrace. Between Lake Charles and Lafayette numerous segments of southwest-trending Red River meander belts are present, some of which can be traced as low ridges for tens of miles. Because of the relatively large number of abandoned courses, the extraordinary flatness of the area (both locally and regionally), and the prevailing clayey nature of the deposits, this area is interpreted as a relict deltaic plain of the Red River (Bernard and LeBlanc 1965). As a reflection of the lack of regional slope (1 foot per mile or less), the low relief (frequently less than 10 feet), and the clayey soils, drainage is poorly developed and surface flooding is common.

In the Lafayette-Abbeville, Louisiana, area and in the Marksville, Louisiana, area, the Prairie terrace is characterized by a distinctive meander belt with numerous abandoned channels and at least one abandoned course of such dimensions as to indicate a Mississippi River origin. Since very few subsurface data exist, it can only be assumed that typical meander belt soils distribution patterns occur (see section on Mississippi Valley meander belts) within this southwest trending meander belt and that it is flanked by several tens of feet of clayey and silty backswamp or deltaic plain deposits. As in the case of the Grand Prairie region, pedologists are inclined to regard the uppermost silty material as loess (Daniels and Young 1968); however, arguments for a fluvial origin (i.e., natural levees and related deposits) are equally tenable.

North and west of Lake Charles, the most conspicuous features of an otherwise featureless Prairie terrace surface is a barrier island complex trending east-west that can be traced for at least 30 miles. This complex is typically a distinctive topographic ridge that has strongly influenced the position of local drainage. No subsurface data from the complex have been reported, but it is assumed that sand is the prevalent material to a depth of several tens of feet. On the basis of relative position rather than definitive lithologic evidence, the area to the north of the barrier island complex is assumed to be a relict lagoon, whereas the area to the south is assumed to be a relict continental shelf.

In southeastern Louisiana, the equivalent of the barrier island complex has been strongly influenced by faulting and is now buried beneath several tens of feet of Holocene deltaic deposits. However, its location beneath Lake Pontchartrain and surrounding swampland is fairly well known from subsurface evidence (Saucier 1963). On the basis of both stratigraphic and lithologic evidence, it appears that much of the uppermost Prairie terrace in southeastern Louisiana as mapped in Figure 1 is the relict lagoon that existed north of the barrier island complex. This is substantiated by the nature of the deposits (lenticular clays, silts, and sands), faunal remains, and the low regional slope and relief of the surface. Beneath the marine lagoonal sediments, near the Pearl River, and just south of the Montgomery terrace, where coarse-grained sediments (sands and gravels) occur, the terrace is probably composed of the relict alluvial and/or coastal plains that bordered the lagoon.

The low, circular mounds several tens of feet in diameter that have been variously called pimple mounds, mima mounds, prairie mounds, and other names are one of the more striking surface expressions of the Prairie terrace. They occur by the hundreds of thousands if not millions in Arkansas and particularly southwestern Louisiana, whereas they are totally absent in southeastern Louisiana. Although they occur on other Quaternary deposits both older and younger, they are not nearly as well developed as on the Prairie terrace. Dozens of theories of origin have been advanced for these ubiquitous features; however, none is wholly satisfactory. On the basis of unpublished observations on their geographic distribution, relative densities, relationship to soils types, association with meander belts, and temporal distribution (none are known to be associated with deposits less than 2,000 years old), the writer strongly favors a biological origin.

Loess

The typically tan-colored eolian silt and clayey silt deposits in the uplands east of the Mississippi Valley and on Crowley's Ridge within the Valley are symmetrically draped over the hills and ridges of the preloess topography (Snowden and Priddy 1968). The thickest accumulations, as much as 90 to 100 feet in the Natchez-Vicksburg, Mississippi, area and on the southern end of Crowley's Ridge, are almost always beneath ridge crests, while valley areas have little or no loess. Although loess has considerable strength when undisturbed because of a natural calcareous cementation, it loses this strength when leached and weathered and is quite susceptible to gullying (Krinitzsky and Turnbull 1967). Gullying and erosion have been severe in the areas of thick loess accumulation and have led to the formation of extremely rugged topography with 75 to 100 feet of local relief being common.

In the uplands east of the Mississippi alluvial valley, loess deposits progressively decline in thickness with increased distance eastward from the valley wall or bluffs. If noncalcareous brown loam deposits are considered as true loess, the extreme eastern edge of the deposits lies an average distance of 100 miles from the bluffs. However, since the loess becomes quite thin and discontinuous some 15 to 20 miles from the bluffs, the mapped distribution of loess in Figure 1 is significantly less than the total distribution. No loess deposits less than 4 feet thick have been mapped in western Tennessee and Kentucky (Hardeman 1966), while in Mississippi, no loess deposits less than 10 feet thick have been mapped (Bicker 1969).

A well-developed weathered or soil horizon within the loess of the Lower Mississippi Valley indicates that at least two distinct periods of deposition are represented. The upper loess sheet is by far the best developed or preserved of the two. Discussions of the probable ages of the two loess sheets are presented in the section on geologic history and chronology. In addition to the soil horizon, there is subtle bedding or stratification in the essentially homogeneous material that suggests slight variations in the rate of deposition such as could occur from shifts in the position of the source area.

Deweyville terrace

The major occurrences of the Deweyville terrace in the Lower Mississippi Valley are along the Ouachita and Arkansas Rivers. The fluvial terrace is also believed to be present along certain smaller streams, including the Amite and Calcasieu Rivers in Louisiana and the Big Black River in Mississippi; however, they have not been mapped in detail and/or their extent is too limited to show on a 1:1,000,000-scale map. Similarly, the terrace is present along the Pearl and Sabine Rivers of Louisiana, but it has not been shown in Figure 1, since, in each case, it lies just beyond the limits of the study area.

In all cases, the Dewyville terrace lies topographically lower than the adjacent Prairie terrace and higher than the adjacent Holocene alluvial deposits. Although the terrace surface is typically flat to slightly undulating with local relief being 10 to 15 feet or less, it nevertheless exhibits well preserved and diagnostic meander belt features. The more striking features are large abandoned channels which, in the case of the Ouachita River, are three times wider and have two times greater meander radii and wavelengths than does the present river (Saucier and Fleetwood 1970). These size differences have been interpreted as indicating that the Ouachita River (and presumably the Arkansas River as well) had a mean annual discharge possibly five times greater than present when these relict channels were active. Such a large discharge could have been brought about only by pluvial conditions; that is, increased precipitation and decreased temperatures.

Very few subsurface data are available on the Ouachita River Deweyville terrace and almost none on the Arkansas River equivalent. Nevertheless, indications are that relatively coarse-grained materials predominate except in the abandoned channels. Silty and sandy clays should prevail in the upper few feet; however, clean sands should be present below a depth of 15 to 20 feet, and sands with gravels should occur below a depth of 40 feet. Total terrace formation thickness should average 60 to 70 feet along the Ouachita River and 80 to 100 feet along the Arkansas River. The abandoned channels probably contain the only appreciable amounts of soft clayey and silty deposits.

Braided-stream terraces

Glacial outwash or valley train deposits laid down by swiftly flowing, sediment-choked braided streams are the principal Quaternary deposits north of the latitude of Memphis. They also extend well to the south and have been mapped at the surface to the vicinity of the mouth of the Red River (Figure 1). Several different streams have been involved in the formation of these deposits. In the Western Lowlands area west of Crowley's Ridge, the sediments were derived from glacial outwash from the Mississippi and Missouri River drainage basins and deposited by those streams, while the deposits in the St. Francis Basin east of Crowley's Ridge and in the Yazoo Basin of Mississippi were contributed by both those streams plus the Ohio River. The deposits which comprise Macon Ridge in northeastern Louisiana and southeastern Arkansas plus the deposits located west of the Grand Prairie region were contributed by the Arkansas River.

Regardless of this difference in source, the deposits and the resultant landforms are strikingly similar and can be more logically divided on the basis of age. The older deposits, designated as terrace level 1 in Figure 1, exhibit greater relief and dissection and tend to be sandier at the surface than the younger deposits which comprise terrace level 2.

In both the Western Lowlands and on Macon Ridge, the areas of oldest braided-stream deposition are on the eastern sides. Since cyclic downcutting resulting from greater stream-load transport competence progressed with time, the older deposits are now topographically higher and give rise to several terrace sublevels that are separated by 5 to 20 feet. These sublevels are delineated in Figure 1 but are not separately designated. Each sublevel is characterized by broad flat to gently rolling stream interfluves and narrower, sinuous, flat-bottomed relict braided-stream channels. The difference in elevation between the two is typically 10 to 20 feet where not accentuated further by subsequent erosion and drainage development. Fine-grained silty and clayey sediments 15 or more feet thick overlying coarser materials occur in the relict channels, much of this having been deposited within Holocene times by the local drainage that now occupies these topographic lows. In fact, the later braided channels in the Western Lowlands area appear to have influenced if not controlled the location of the Holocene meander belts of the larger rivers such as the White, Black, and Current Rivers. In contrast to the channels, the interfluve areas have quite sandy surface soils which grade into clean sands and gravels within 20 to 25 feet of the surface. These coarse-grained deposits extend to depths of 100 to 180 feet below both the channels and the interfluves and constitute a significant part of the huge Quaternary alluvial aquifer.

The sandy nature of the interfluve areas in the Western Lowlands is locally accentuated by the presence of sand dunes or hummocky sand sheets (Smith and Saucier 1971). These deposits, apparently representing material blown from active or semiactive braided channels onto adjacent bars and interfluves, are present principally between the Black and Cache Rivers. Relief within the dunes or dune field occasionally reaches 20 to 25 feet and contiguous dunes or dune fields occasionally cover 100 square miles. Within the Western Lowlands area, over 300 square miles are characterized by this type of deposit; smaller areas of dunes also occur east of Crowley's Ridge on Sikeston Ridge and adjacent younger braided-stream terraces. Although it is logical to associate the formation of sand dunes with loess accumulation, a positive relationship, either causal or temporal, has not been established.

By far the most well-preserved relict braided channels occur on the younger braided-stream terrace 2 in the St. Francis Basin area. The flat-bottomed, clay-filled, anastomosing channels of at least 2 separate river systems can be traced on one sublevel continuously for a distance of up to 60 miles. In the area and on this sublevel (the first sublevel east of Crowley's Ridge), the interfluves are flat to slightly undulating and exhibit silty and sandy surface soils. The lower sublevels in the St. Francis Basin and essentially all other braided-stream terrace 2 levels in the Mississippi Valley lack discernible relict channels. Blanketing by a thin veneer of clayey backswamp deposits derived from Holocene meander belts of the Mississippi River is the apparent explanation for this lack of mappable channels and is the reason for the more clayey soils and lower relief on all of these surfaces.

Whereas most of the braided-stream terrace 2 is a true physiographic terrace, there are certain areas such as in the center of the Yazoo Basin where the terrace is now topographically one of the lowest areas in the Mississippi Alluvial Valley. This has been brought about by continuing aggradation by the Mississippi River while it has maintained a meandering regime, and it is the reason why certain of the braided-stream terrace 2 areas have been veneered with backswamp deposits. It is also the reason why certain smaller streams such as the Arkansas River have been able to develop Holocene meander belts across some of these braided-stream terraces.

Undifferentiated alluvium

On streams smaller than those such as the Red River, a 1:1,000,000-scale map precludes the delineation of specific floodplain features. Consequently, the Holocene deposits along such streams are designated simply as undifferentiated alluvium. Nevertheless, certain features are present on nearly all these streams and the sequence of deposits varies little from one stream to another.

Floodplains of nearly all such streams are low, flat, and typically densely forested. They normally experience seasonal flooding, and extensive tracts frequently remain swampy throughout the year. As a consequence, the near-surface soils are usually organic clays and silts. These deposits are characteristically 10 to 20 feet thick and overlie several tens of feet of sands and gravels.

The forested tracts are occasionally interrupted by small lakes or streams that mark the locations of abandoned channels (oxbow lakes or cutoffs) or abandoned courses. Since the small streams have minor suspended sediment loads, the abandoned channels and courses remain unfilled for long periods (possibly thousands of years) and natural levees, either along abandoned or active channels, are poorly developed. Compared with streams like the Red and Arkansas Rivers, the rates of meandering of small streams are quite low. In numerous instances, for example, no changes in channel position during historic times are discernible.

Low fluvial terraces of Holocene or late Pleistocene age are also occasionally included in the undifferentiated alluvium mapping unit. As previously mentioned, these may include the Deweyville terrace, but they may also include younger terraces or "high-level floodplains" originating from changes in river regime. Climatic changes of a minor nature and changes in sediment load due to land clearing or vegetation modification are two factors that could bring about a change in river regime.

Mississippi Valley alluvium

In view of the large areal extent of the Holocene alluvial deposits of the Mississippi River and its major tributaries and considering the variety of landforms and sediment types present, the following fourfold division is employed.

Meander belts

Meander belts include all of the area of and landforms resulting from lateral migration or meandering of a stream while occupying a single course. In the case of freely meandering streams like the Mississippi or Arkansas Rivers, accretion topography consisting of parallel arcuate ridges and swales comprises most of the meander belt area. However, abandoned channels in various stages of filling from mostly open water (oxbow lakes) to completely filled (referred to as "clay plugs") are the more conspicuous meander belt features. Depending in part on the length of time a particular meander belt was active, the number of abandoned channels varies from a dozen or more to well over a hundred in the case of the Mississippi River meander belts.

As the term clay plug implies, abandoned channels fill with thick deposits of clays and silts. Mississippi River abandoned channel filling may reach thicknesses of 100 feet or more, while thicknesses of 70 to 80 feet occur in Red and Arkansas River channels. These deposits typically support a dense swamp or forest vegetation. This stands in sharp contrast to the large expanses of cleared agricultural land that is the overwhelming meander belt landscape. Widespread cultivation and habitation is possible along the meander belts because of the well-developed natural levees that occur as low ridges along all abandoned channels and courses and as a thin veneer over most of the accretion topography. In contrast to the abandoned channel filling, natural levee deposits are predominantly well-drained silty and sandy clays. Where natural levee deposits overlie accretion topography, the silty and sandy clays grade downward through several tens of feet into silty sands and sands and eventually sands and gravels. The relatively coarse-grained deposits that result from river migration and which form accretion topography are referred to as point bar deposits.

Natural levees are typically smooth to slightly undulating surfaces that slope away from their parent streams at rates not often exceeding 5 feet per mile. Greatest meander belt relief, often 20 to 25 feet, occurs where natural levee crests abruptly join the topographically lower abandoned channels or active small streams. Accretion topography, where not well veneered with natural levee deposits, typically exhibits 10 to 15 feet of local relief of an undulating nature.

Where local Mississippi Valley drainage and upland streams like the St. Francis, Ouachita, and Tallahatchie Rivers intersect abandoned meander belts of the Mississippi, Arkansas, or Red Rivers, they frequently occupy the relict abandoned courses as underfit streams or they may sporadically occupy portions of several abandoned channels. In some instances the smaller streams have completely conformed to the general linear trend of the larger streams, while in other instances, they have created their own small meander belts generally or totally within the confines of the larger relict channel. In both cases, the smaller streams have usually built their own natural levees which are distinguishable on the basis of size from the relict channel levees.

In Figure 1, the limits of the Mississippi River meander belts have been mapped as extending to include the outermost abandoned channels thought to be related to the particular meander belts. Natural levees associated with the meander belts do extend 2 or 3 miles beyond these limits, but, since the outer edges of the natural levees are irregular and gradational with other areas, they are not readily definable for mapping purposes. The meander belts of the Red and Arkansas Rivers are typically only 2 to 3 miles wide and quite intricate; consequently, they have been portrayed in Figure 1 by dimensionless lines. Since the actual scale width of the lines is less than a mile, this has resulted in an exaggeration of the extent of backswamp areas between meander belts.

An inspection of Figure 1 quickly reveals that there is appreciable variation in the width of the Mississippi River meander belts. Several factors are involved in this variation. Perhaps the most important factor is the duration of the active period of flow in the meander belt; the longer the activity, the wider the meander belt. This factor has been largely responsible for the variation in the width of the present meander belt (designated as No. 5 in Figure 1) between Cairo, Illinois, and Natchez, Mississippi. A second factor is that meander belts naturally become narrower downstream, particularly in the transition zone between the alluvial valley and the deltaic plain. This is brought about by the significant increase in a downstream direction of both the thickness and areal extent of clayey backswamp deposits that are quite difficult to erode. Intricately involved in this change in partly a cause-effect relationship is the downstream decrease in the amount of sand in the bed and banks of the meandering stream and changes in hydrologic regime such as decreases in stage variations. A third factor is that certain meander belts, such as segments of meander belts No. 2 and No. 4, never carried the entire discharge of the Mississippi River. This situation is discussed more fully in the geologic history section of this paper.

Difficulties and uncertainties in mapping meander belts increase markedly with increasing age of meander belts and in the areas where meander belts intersect. Because of veneering by younger natural levee and backswamp deposits, some abandoned channels may have escaped detection or have been incorrectly assigned. In the Mississippi Valley proper, the amount of subsurface data available has precluded the possibility of the omission of an entire buried or obscured meander belt. However, this possibility definitely exists in the case of the Red River and possibly in the case of the Arkansas River.

Backswamp areas

The backswamp or floodbasin areas mapped in Figure 1 are areas that have remained predominantly marginal to meander belts throughout most if not all of the Holocene. They have received only clays and silts carried into the area by floodwaters, and they represent areas of continuous or nearly continuous slow aggradation. Specific depositional environments range from infrequently flooded forested bottomlands to deep, lake-filled swamps that rarely dry up (Krinitzsky and Smith 1969). Both types are characteristically quite flat and occupy the lowest parts of the floodplains. Included as backswamp areas are the rim swamps that have developed between meander belts and valley walls or higher terraces and the ponded or alluvially drowned lower reaches of upland streams whose gradients were appreciably shallowed at the edge of the alluvial valley as a result of meander belt development or other causes.

The distribution of backswamp areas and deposits in the Lower Mississippi Valley reflects dramatically the downstream changes in the hydrologic regimen and sediment load of the Mississippi River, the frequency and distribution of meander belt development, and the effects of eustatic sea level variation on river gradient. From the vicinity of Memphis southward to near Natchez, the thickness of backswamp deposits varies little and increases in thickness from 40 to 50 feet to 60 to 70 feet. South of Natchez, however, the thickness increases abruptly, reaching 100 feet above Baton Rouge, and consistently being 100 to 120 feet thick throughout the lower part of the Atchafalaya Basin. Local variation in thickness also increases below Baton Rouge.

The extensive backswamp development in the Atchafalaya Basin is an extraordinary situation brought about by a peculiar set of circumstances. Perhaps most important has been the development and persistence of a Mississippi River meander belt along the western edge of the alluvial valley for a period of at least 7,000 years. During this entire time, a deep swamp to lake environment prevailed eastward across the valley, partly influenced by a rising sea level (Krinitzsky and Smith 1969). The meander belt also served to block any marine influence from the south. When the river adopted a course along the eastern side of the valley, the Atchafalaya Basin continued to be marginal to active sedimentation. Only during the last 100 years has there been an introduction of significant quantities of silt and sand into the central and upper part of the basin as part of an incipient (but now controlled) diversion of the river (Fisk, Kolb, and Wilbert 1952). Previous abortive attempts during the last few thousand years are evidenced by the minor distributaries or crevasse channels mapped in the basin area (Figure 1).

Backswamp deposits of the Red and Arkansas Rivers tend to be thinner, siltier, and more discontinuous than those of Mississippi River origin because of the nature of the streams and the smaller sizes of the valleys. Deposits generally do not exceed 40 feet in thickness. As pointed out earlier, their extent has been exaggerated in Figure 1 because of the meander belt symbology used.

Deltaic plain

A line drawn between Donaldsonville and Franklin, Louisiana, has traditionally been the best approximation of the indefinite boundary between the alluvial valley and the deltaic plain of the Mississippi River (Fisk 1944). Although some deltaic plain criteria such as river distributaries occur north of the line in the Atchafalaya Basin, this area lacks most other criteria, particularly evidence of effects of the marine environment. Recent studies, in fact, have shown a need for an even further seaward shift of this indefinite line to the approximate location shown in Figure 1 (Krinitzsky and Smith 1969; Saucier 1969).

The Mississippi River deltaic plain is composed of at least five discernible subdeltas or delta complexes, each of which has several recognizable delta lobes or distributary networks (Frazier 1967). Each lobe and in a more complex way, each subdelta represents a predictable cycle of sedimentation and landscape development. Each cycle involves essentially the same changing pattern of response to controlling processes (i.e., fluvial and marine) and results in essentially the same sequence of deposits. The geographic and topographic separation of delta lobes and complexes and the resultant formation of overlapping lenses of deltaic sediments is attributable to the omnipresent subsidence (including sea level rise) under which deltaic plain formation has taken place.

From the physiographic or landscape development standpoint, each cycle of delta lobe and subdelta development involves the following sequence. As the river diverts to a new course and begins discharging into a shallow body of water or develops a major crevasse into a bay or lagoon, flow is soon restricted by natural levee growth to one or more distributaries. The natural levees form as subaqueous features ahead of the rapidly advancing distributary mouth and gradually build and emerge as subaerial ridges. Development of subaqeous bars at the distributary mouths where the stream's load of silt and sand is dropped causes frequent bifurcation or branching of the distributaries. Most branches remain active for only a short period of time before being abandoned as a single branch eventually becomes dominant. While distributaries advance seaward as long fingers of land, part of the river's suspended load of clay and silt is deposited ahead of and between the distributaries. As the material accumulates, water bodies shallow and intertidal mudflats develop. These soon become colonized with grasses, sedges, and rushes, and extensive tracts of deltaic marsh result. Numerous small marsh lakes and ponds typically characterize the marsh. Although marine influences are sufficiently strong at the seaward edge of the lobe or subdelta to cause brackish to saline marshes, more inland areas between distributaries frequently become sheltered and sufficiently fresh to allow cypress and gum swamps to develop.

This pattern of coastline advance, dominance of fluvial sedimentation over marine processes, and prevalence of aggradation over subsidence continues until the river diverts upstream to a new course or begins developing a new distributary system in another part of the deltaic plain. As this happens, the amount of discharge and sediment introduced to the existing lobe or subdelta begins to decline. Mudflats and marsh areas along the irregular delta margin begin to erode under increasingly dominant marine influences. Coarse sediments winnowed from the eroded deposits accumulate in beaches, and the delta margin becomes more regular in plan. With complete abandonment of the lobe or subdelta, subsidence rapidly becomes a dominant process. Marsh growth, heretofore able to keep pace with subsidence through vertical accumulation of organic debris, begins to decline rapidly. Interdistributary areas experience rapid expansion of lakes and bays, and the influence of saline water extends further inland. Mainland beaches eventually get transformed into barrier island chains as more and more marsh deteriorates. Distributary natural levees, no longer nourished by sediment-laden floodwater, become narrower and their distal portions retreat inland as subsidence becomes prevalent. Inland swamp areas die out and become "ghost forests" of standing dead timber as water salinities become excessive for swamp growth. Distributary channels, deprived of through flow, tend to fill in near their heads while they tend to open up and become tidal channels in their lower reaches. The barrier island chains retreat inland across widening and deepening water bodies and eventually disappear themselves as less and less sediment becomes available.

Looking at the deltaic plain, the Plaquemines-Modern subdelta (No. 5) is the only area in which active delta growth is taking place. A delta lobe will eventually begin to form in the Atchafalaya Bay area due to increased discharge through the Atchafalaya Basin; however, a conspicuous subaerial delta is a decade or more away. All other subdeltas are in various stages of decay depending on their relative age. Only the oldest recognized subdelta, the Maringouin subdelta (No. 1) is now virtually completely destroyed and/or buried beneath younger deltaic deposits.

In certain respects, the modern or "birdfoot" delta of the Mississippi River departs from the pattern discussed above (Kolb and Van Lopik 1958; Kolb 1962). The principal visible difference is in the small number of major distributaries, while other differences include the unusual permanency of the distributaries, the slow rate of seaward build-out or progradation, the unusually large rate of subsidence, and the abnormally great effect of marine processes. These all can be explained by the fact that the present subdelta is the only one that has formed in relatively deep water at the edge of the continental shelf.

Whereas an individual delta lobe may go completely through a cycle of growth and decay in a few hundred years, a subdelta or complex of delta lobes may well last several thousand years. This is due to the fact that a subdelta may experience several periods of growth in different portions or the same portions provided there is no diversion in the upstream trunk channel. As will be discussed later, the subdeltas that have formed since sea level has attained its approximate present level (about 5,000 years ago) and remained relatively constant have tended to remain active longer than those that formed earlier during a time of rather rapid sea level rise.

The present topographic expression of the deltaic plain also reflects the duration of occupancy and age of the various subdeltas. Natural levees along Bayou Lafourche, one of the younger major distributaries, are as much as several miles wide, reach maximum elevations of 20 to 25 feet above sea level near Donaldsonville, and are continuous as ridges for nearly 100 miles. Although all distributary natural levees narrow and decline in elevation downstream, the effects of subsidence near the seaward margin of the deltaic plain are still evident. Bayou La Loutre in southeastern Louisiana, once equally as large as Bayou Lafourche but considerably older, graphically illustrates the effects of age and subsidence. Its natural levees are less than half as wide and nowhere attain elevations of over 7 or 8 feet above sea level. Elevations of marsh and swamp areas are not indicators of age, however, since they are basically controlled by tidal variations and are nowhere over 2 to 3 feet above sea level.

Excluding a few minor features like modern or relict beach ridges and artificial features like spoil banks, distributary natural levees provide the only land high enough to support tree growth near the outer parts of the deltaic plain. Farther inland, the natural levees are sufficiently wide for agriculture; consequently, all but the narrowest levees have been cleared of timber and are cultivated. The distribution of natural levees is also the overwhelmingly dominant control over the pattern of permanent habitation and land transport network in the deltaic plain.

From the standpoint of subsurface lithology and stratigraphy, each delta lobe ideally creates the following generalized vertical sequences of sediments. As a delta lobe advances seaward to a given point, the first deposits to be laid down are fine-grained prodelta clays. These settle out in a fan ahead of the lobe and their eventual thickness is governed by the depth of water into which the lobe is building. The deposits become much coarser (silts and fine sands) and rates of accumulation increase as the distributary mouths advance to the given point. Distributary mouth bar sands are naturally thickest along the axis of the distributary and decrease in thickness laterally away from the distributary, but they extend appreciable distances through the effects of reworking by waves and currents and frequent bifurcations of the distributary. Once the distributary has advanced beyond the given point, natural levee and channel deposits (silty clays and silts) accumulate along the distributary axis, while organic clays and silts and frequent peat deposits accumulate for long distances laterally. These deposits result from the interdistributary marsh and swamp environments. Once the process of deltaic deterioration begins and the delta lobe front retreats landward of the given point, the sediments that accumulate are mostly silts and sands winnowed and reworked from eroding deltaic deposits. Some finer grained sediments, often quite shelly or fossiliferous, accumulate in enlarging lakes and bays and mark the final stage of the delta lobe sediment sequence.

Because of prevailing subsidence, it is not at all uncommon for an entire sediment sequence to be preserved as part of the mass of deltaic sediments. However, if an area remains inactive for too long a period and water depths offshore from a retreating coastline become too deep, the upper parts of the sediment sequence may be destroyed. This has apparently happened in parts of the Maringouin subdelta area and possibly the St. Bernard subdelta area (Figure 1).

Chenier plain

The chenier plain of southwestern Louisiana is a 15- to 20-mile-wide strip of Holocene deposits that extends from just west of Vermillion Bay to Sabine Pass and Lake. In cross section, it is an extremely thin wedge of sediment that onlaps the gently seaward-dipping Prairie terrace formation (Byrne, LeRoy, and Riley 1959). Deposit thicknesses increase from zero along the contact to an average maximum of 25 to 30 feet along the present coast.

Only two types of landforms and landscapes characterize the chenier plain. The areally dominant landscape consists of relatively featureless marsh interspersed with streams, rivers, ponds, and lakes, sometimes of appreciable size. Marsh topography is extraordinarily flat with elevations rarely exceeding 2 to 3 feet above sea level. The second and highly conspicuous landscape involves long, narrow, coast-parallel ridges that attain elevations of 5 to 10 feet, vary in width from a few tens of feet to 1,500 feet, and extend for miles. These are the characteristically live oak tree-covered relict beaches to which the Louisiana French people aptly applied the term "chenier."

The pattern of relict beaches or cheniers attests the fact that cyclic shoreline advance and retreat has been the dominant process with a resultant net advance or progradation of the coast. It has long been apparent that the shoreline fluctuations are closely related to Mississippi River subdelta and delta lobe development and decay and the resultant changes in volume of fine-grained Mississippi River sediments being carried westward by longshore currents. When the Mississippi River was building a subdelta or major lobe toward the western side of its deltaic plain, a relatively large amount of fine sediment was carried westward along the coast and mudflat development and coastal progradation dominated. The mudflats would soon become colonized with marsh vegetation and take on all of the characteristics of the mainland. When the locus of subdelta or delta lobe development shifted to the eastern side of the deltaic plain, less sediments were carried westward. Mudflats would cease growing and begin to erode under coastal wave attack. As the shoreline retreated inland, coarse sediments were winnowed from the eroding mudflats and marsh and combined with shells and shell debris from the coastal environment to form beaches. The beaches would retreat inland with continued coastal erosion and would grow in size as more material was added. With the next westward shift in the Mississippi River, longshore sediment volumes increased, erosion ceased, mudflats formed, and the beaches were left stranded in the marsh. Because of their higher elevations, the cheniers were soon colonized with woody vegetation.

All of the cheniers in southwestern Louisiana were formed after sea level reached its present stand and none are known to be over 2,800 years old (Gould and McFarlan 1959). Cheniers that might have formed earlier during the time of rising sea level would be situated south of the present shoreline provided they were not destroyed by erosion or subaqueous planation. It is more likely, however, that a rising sea level did not permit the periodic coastal progradation that is essential to chenier formation; hence, they did not occur.

Deposits of the chenier plain are predominantly the soft organic clays and silts and frequently peats of the marsh environment. In contrast to these, the deposits of the cheniers are characteristically mixtures of silt, sand, and shell fragments. It is not uncommon, in fact, for the shell to be the predominant material by volume in the cheniers.

GEOLOGIC HISTORY AND CHRONOLOGY

The portion of the geology of the Lower Mississippi Valley with which we are concerned began with the widespread deposition of sands and gravels on an erosional landscape of Tertiary age, regardless of whether this occurred in the late Tertiary or the early Pleistocene. Evidence appears to favor a preglacial, southern Appalachian origin for the materials, in spite of an absence of evidence for an impetus.

The first major period of erosion and dissection of this graveliferous blanket probably took place during the Nebraskan Glacial Stage (Figure 2). It is assumed that this initial continental glaciation was responsible for the derangement of preglacial drainage and the creation of a southward-trending ancestral Mississippi River and valley. A combination of climate, sea level fall, and braided-river regimen probably led to sufficient lateral and vertical corrasion to result in a distinctive topographic valley at least several miles wide. At least an incipient network of valley tributaries would have developed as well.

With waning of the Nebraskan glaciation and attainment of the succeeding Aftonian Interglacial Stage, valley alluviation or filling was the dominant process. However, because of long-term eustatic trends or extraregional geotectonics, the maximum level of aggradation attained was topographically appreciably below the average level of the graveliferous blanket discussed above. Tributary valley filling correspondingly did not proceed to former levels.

Waxing continental glaciation occurred again several hundred thousand years later during the Kansan Glacial Stage and resulted in renewed valley degradation and stream entrenchment. It is believed that the ancestral Mississippi Valley widened appreciably during this stage and most if not all of the alluvial valley fill deposited during the preceding Aftonian Interglacial Stage was removed. This would mean that no relict floodplain survived to form a depositional terrace formation of the type envisioned by Fisk (1939) as representing each interglacial stage. But this does not mean that physiographic terrace levels are absent. It appears logical that the surviving remnants of the preglacial graveliferous blanket would have generally accordant crest elevations and would physiographically represent a terrace surface, while a similar lower terrace surface would survive to mark the base level of erosion in the upland corresponding with and caused by the level of valley fill achieved during the Aftonian Interglacial Stage. These physiographic rather than depositional terraces, developed on a single formation, may well be the Williana and Bentley terraces of Fisk (1939).

Evidence for coastwise terrace development including deltaic plain or marine features is totally lacking for the Aftonian Stage and earlier. If features developed, they are either incorporated in the thick mass of subsurface Pleistocene sediments of south Louisiana or they have been destroyed by erosion.

The Montgomery terrace formation is considered as representing remnants of the alluvial valley fill and coastal plain that developed during the Yarmouth Interglacial Stage, although there appears to be an inconsistency between the extent and degree of preservation of the terrace (with age taken into consideration) and the long duration of the interglacial stage as indicated in Figure 2. It is possible, however, that the interglacial stage includes a number of substages and the terrace represents only one of the later substages. Because of the same regional base level control exerted previously, the Montgomery terrace is topographically lower than older terraces. Although a large part of the terrace is a coastwise terrace, there is no evidence of marine features or other expression of the mode of origin.

After deposition of the Montgomery terrace, the alluvial valley area was again subjected to lowered base levels with the usual pattern of erosion, entrenchment, and valley degradation. Although the Illinoian glaciation which was responsible for this is believed to have been of relatively brief duration, there was nevertheless sufficient time for virtually all of the Montgomery fluvial terrace deposits north of the coastal area to be destroyed by erosion. Evidence suggests that valley widening proceeded with the most active lateral corrasion again on the eastern side of the valley. This eastward migration or trend, apparently prevalent throughout much of the Quaternary, undoubtedly has resulted from the fact that most of the larger sediment-transporting tributaries enter the western side of the Mississippi alluvial valley and deposit part of their load in that area as fans or cones.

The Sangamon Interglacial Stage, succeeding the Illinoian glaciation, was the third major episode of valley aggradation as evidenced by the Prairie terrace formation. This formation exhibits indications of a relatively long period of slow valley aggradation and coastal progradation that is believed to have lasted from about 80,000 to at least 100,000 years ago (Figure 3). The earliest depositional history of the formation is preserved in its subsurface and involves an initial phase of glacial outwash (sand and gravel) deposition followed by meander belt and backswamp formation and deposition of mostly fine-grained sediments. In the coastal area, an early relatively high, and relatively stationary sea level led to the development of the barrier islands and lagoons. Somewhat later, possibly after a slight regression of sea level or a fall followed by a rise of not quite equal magnitude, the Red River constructed a delta seaward of the barrier islands in southwestern Louisiana. The position of the Mississippi River delta at this time is unknown; however, somewhat later it is known to have formed even farther seaward and slightly to the east of the Red River delta. This development marks the last phase of depositional history of the formation in the coastal area for which there is either physiographic or stratigraphic evidence. In the alluvial valley area, the final phase includes the development of a cone or fan by the Arkansas River. This consists of numerous meander belts that radiate from the vicinity of Little Rock, eastward and southward, overlying older Mississippi River meander belt deposits in the Grand Prairie region of Arkansas.

According to generally accepted glacial stratigraphy and chronology, the Sangamon Interglacial Stage was followed by the Early Wisconsin glaciation which began about 75,000 to 80,000 years ago. Stratigraphic evidence from the Lower Mississippi Valley suggests that this was a major glaciation accompanied by a major drop in sea level. Base levels in the lower part of the valley must have responded directly to this sea level drop; while in the upper part of the valley, an analogous change in base level is assumed to have accompanied the initiation of a new wave of braided-stream deposition of glacial outwash. Although there is evidence of widespread valley deepening and widening and the consequent destruction of large areas of Prairie terrace, there is no definitive evidence of depositional features dating from this period. However, if assumed relationships between loess formation and valley train deposition are correct, there must have been a period of loess formation that occurred during the late waxing stage and/or early waning stage of the Early Wisconsin glaciation, In Mississippi, it is known that scattered remnants of a loess sheet too old to date by the radiocarbon method overlie the upland graveliferous deposits and underlie the well-developed upper loess sheet. Krinitzsky and Turnbull (1967) tentatively considered this older loess (i.e., the pre-Vicksburg loess) to be pre-Sangamon (hence, pre-Prairie terrace formation) in age whereas Snowden and Priddy (1968), working with the same evidence, considered it to be post-Sangamon in age and attributable to the Early Wisconsin glaciation (Altonian Substage). In view of alluvial valley stratigraphy, the latter interpretation appears to be logical and more tenable. It is not likely, for instance, that easily erodable material like loess would survive the long period of erosion and weathering that appears to have characterized the Sangamon Interglacial Stage.

The latter waning stages of Early Wisconsin

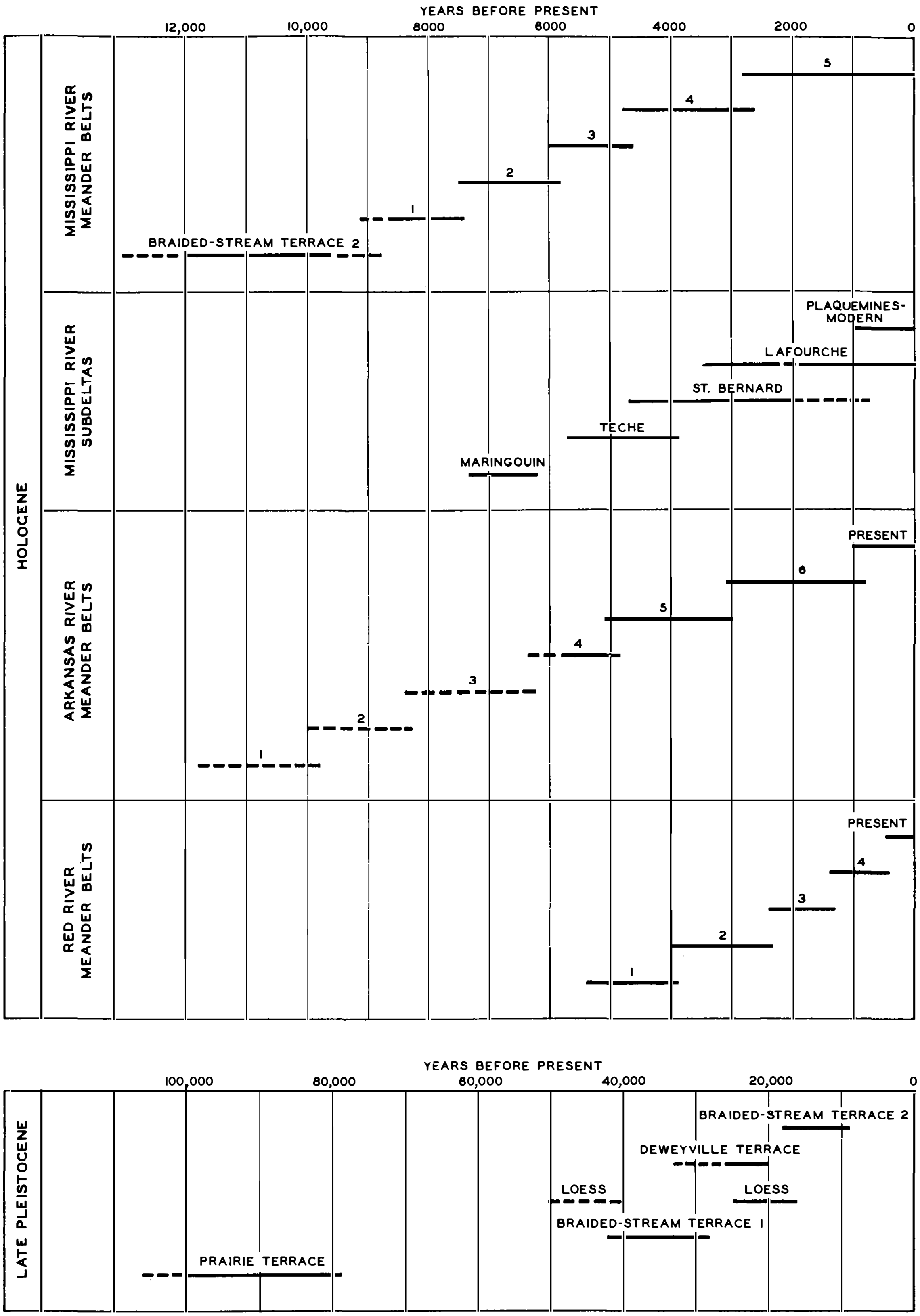

Figure 3. Chronology of late Pleistocene and Holocene landforms and deposits.

glaciation, occurring perhaps 35,000 to 40,000 years ago, resulted in the introduction of large volumes of glacial outwash into the Lower Mississippi Valley. Although the material was widely distributed throughout most of the alluvial valley, it now survives at the surface principally only in the Western Lowlands and as Macon Ridge. There can be no doubt that most of the St. Francis and Yazoo Basins were once a continuation of the sheet of braided-stream-deposited glacial outwash; however, subsequent valley erosion and degradation has destroyed the uppermost parts.

If the assumption is correct that Cordilleran glaciation in the Rocky Mountain region waned earlier than continental glaciation in the upper Midwest, the glacial outwash of the Arkansas River that formed Macon Ridge would be somewhat older than the glacial outwash of the Mississippi drainage system in the Western Lowlands. Evidence including radiocarbon dates has already been presented (Saucier 1968) indicating that the maximum level of aggradation of glacial outwash deposition by the braided Arkansas River was achieved well prior to approximately 30,000 years ago. It is likely that slow downcutting or degradation brought about by increased braided-stream load-carrying competency was well progressed if not even terminated by this time.

No absolute age determinations of any type are available to indicate the chronology of glacial outwash deposition in the Western Lowlands. It appears reasonable, however, to assume that the maximum level of aggradation also occurred prior to 30,000 years ago and that valley downcutting began shortly thereafter. As indicated previously, the relatively older areas of glacial outwash in both cases are the more eastern higher levels.

The stage of maximum withdrawal of the Early Wisconsin glaciation about 28,000 to 30,000 years ago is referred to as either the Mid Wisconsin Interglacial Stage (Figure 2) or the Farmdalian Substage of the Wisconsin Stage. The distribution of glacial outwash in the Western Lowlands area indicates that the ancestral Mississippi River never did change from a braided to a meandering regime in this latitudinal zone before the onset of the next or Late Wisconsin glaciation. If the river developed meander belts farther south, they are either now destroyed, buried and unrecognized in the subsurface, or they may include the meander belt features on the Prairie terrace in southwestern Louisiana in the Marksville and Lafayette-Abbeville areas. In view of present evidence, however, a Sangamon Interglacial Stage origin for the latter features is still preferable.

When the episode of glacial outwash deposition reached its maximum extent during the Mid Wisconsin Stage, several perennial lakes developed on minor Mississippi Valley tributaries as a result of damming of the valley mouths by the outwash. These lakes were first recognized on and apparently were best developed on the Ouachita River in Louisiana and Arkansas (Saucier and Fleetwood 1970). Relict lake bottom areas or lacustrine plains now form low terraces on the tributaries that experienced the flooding or ponding. In the case of the Ouachita River, part of the Deweyville terrace sequence as mapped in Figure 1 includes some of these relict lake bottom areas and deposits.

Whether or not sea level rose to an elevation close to that of present sea level during the Mid-Wisconsin Interglacial Stage (Farmdalian Substage) is a much debated topic in glacial geology. The writer has recently assessed evidence from the Gulf Coast area relative to this question (Saucier 1971), and has concluded there is reason to believe sea level attained an elevation equal to if not slightly higher than present sea level during this time. Regardless of the precise level, however, visible coastal features attributable to this stage are restricted to nothing more than small beach ridges along or near the present Prairie terrace — Holocene deltaic and chenier plain contact in Louisiana. If a deltaic plain formed, it is in the subsurface below the Holocene deltaic plain seaward of the Prairie formation and marked by a weathered erosional surface.

By 25,000 years ago, the Mid-Wisconsin Interglacial Stage had terminated and the entire Mississippi Valley area was beginning to respond to waxing Late Wisconsin glaciation. The braided Mississippi River was still slightly downcutting but had adopted a relatively stationary position west of Crowley's Ridge more or less along the present lower courses of the Black and White Rivers. The Ohio River was flowing near the eastern side of the valley, while the Arkansas River was confined to the area west of the Grand Prairie region and west of Macon Ridge.

Even during a time of waxing glaciation, there was almost certainly enough glacial debris and a sufficient seasonal discharge variation for the Mississippi River to maintain a braided regime throughout much if not all of the alluvial valley; however, increased discharges on certain tributaries because of pluvial conditions apparently led not to a braided regime but rather to the distinctive type of meandering evidenced by the Deweyville terrace. Studies of the Deweyville terrace sequence on the Ouachita River (Fleetwood 1969) and observations of its expression on other streams like the Arkansas and Big Black Rivers in the study area (Saucier 1967) and the Red, Sabine, and Pearl Rivers outside the study area (Gagliano and Thom 1967) indicate cyclic downcutting and valley degradation occurred through a period of possibly several thousand years. Radiocarbon dates from the Gulf Coast area indicate that the period of Deweyville terrace formation lasted until at least 20,000 years ago on certain streams. On the Arkansas and the lower Red Rivers, the lower and relatively younger Deweyville terrace levels are now buried beneath Holocene meander belt deposits or have been destroyed by lateral stream migration.

While the Lower Mississippi Valley area was experiencing the cool and wet pluvial conditions 20,000 to 25,000 years ago during waxing glaciation, there is strong evidence to indicate that this was also the time when the last major sheet of loess was being deposited (Snowden and Priddy 1968). This seemingly paradoxical situation can be largely resolved with the assumptions that the climate at this time was characterized by heavy warm-season precipitation with dry, windy, cool seasons. Radiocarbon dates on the Vicksburg loess indicate that deposition persisted for several thousand years after the end of Deweyville terrace formation and up until and possibly beyond the maximum extent of Late Wisconsin glaciation (Figure 3).

Although evidence is quite meager, the writer feels that valley stratigraphy supports the concept that this last period of loess formation involves two source areas and a major change in stream positions. During the initial phase of loess deposition about 20,000 to 25,000 years ago, the source areas were the Mississippi valley train on the west side of the Western Lowlands and the Ohio valley train in the St. Francis and Yazoo Basins. Rates of silt deflation and deposition were relatively low, and this was the time of the formation of the extensive sand dunes and dune fields in the Western Lowlands. It was probably also the time of the principal accumulation of the thin loess deposits on the older braided-stream terraces in the Western Lowlands and areas such as the Grand Prairie region. About 18,000 to 20,000 years ago, when the volume of glacial outwash carried by the Mississippi River started to increase substantially, the river abandoned the Western Lowlands area entirely in favor of a course through a gap in Crowley's Ridge (the Bell City-Oran Gap according to Fisk) into the St. Francis Basin. Thus, with both the Mississippi and Ohio valley trains along the eastern side of the valley and with the beginning of a major episode of glacial outwash introduction due to waning glaciation, a major increase in loess deposition rates occurred east of the valley. If this concept is correct, the inference is that the bulk of the loess on Crowley's Ridge is equivalent to the pre-Vicksburg loess of Mississippi rather than to the Vicksburg loess. This possible age difference has not been investigated, much less established.

The diversion of the Mississippi River into the St. Francis Basin area marked the beginning of the last major episode of glacial outwash deposition and braided-stream terrace formation. The Mississippi and Ohio valley trains probably combined in the lower St. Francis Basin area and flowed southwestward around the southern tip of Crowley's Ridge and thence southward through the western side of the Yazoo Basin. A braided-stream regime may have persisted as far south as the Gulf Coast, but this has not been established with certainty. During this time, the Arkansas River was depositing its load of glacial outwash west of the Grand Prairie region and north and west of Macon Ridge. Carrying no glacial outwash, the Red River did not develop a cone or fan as did these other rivers. In fact, there is no evidence that establishes beyond doubt that the Red River ever maintained a braided regime south of Alexandria during the Wisconsin Stage.

It is generally accepted that man first appeared in the southeastern United States, and presumably in the Lower Mississippi Valley area as well, about 12,000 years ago. This was also the time of some significant geological events and changes in river regimes. On the basis of radiocarbon dates, it appears that the

Mississippi River south of Baton Rouge changed rather abruptly from a braided to a meandering regimen about this time and started forming extensive backswamp areas in the Atchafalaya Basin (Krinitzsky and Smith 1969; Saucier 1968). A sharp increase in the rate of sea level rise, possibly related to a major period of glacial recession (the Two Creekan Substage?), may have been the impetus. North of Baton Rouge, the Mississippi River was still braided and probably occupied a course that carried it through the central or eastern part of the Yazoo Basin. Although there is no direct evidence, it is felt that the Arkansas River changed from a braided to a meandering regime about 12,000 years ago and began forming what is now the oldest discernible meander belt southeast of Little Rock (Figure 3).

Considering patterns of early human occupancy of the Mississippi Valley, it is important to remember that significant changes in the level of the floodplain of the Mississippi River and its tributaries have occurred during the Holocene. About 12,000 years ago, the average floodplain level south of Baton Rouge was probably 75 to 80 feet lower than it is today. The difference in level decreases rapidly upstre. m; however, the floodplain probably averaged 20 to 25 feet lower than today throughout most of the interval from Vicksburg to Memphis. Only north of Memphis was the floodplain higher than today, the next to lowest mapped braided-stream terrace (the level now occupied by the St. Francis River) being the active depositional surface at the time. Floodplains of the two major Mississippi River tributaries, the Arkansas and Red Rivers, were probably at least 10 to 15 feet lower than today and these have been slowly aggrading since.

Midwestern glacial stratigraphy indicates that there was a brief glacial advance 10,000 to 11,000 years ago (the Valderan Substage), after which time the ice sheet withdrew north of the Great Lakes. The withdrawal probably took place by at least 9,000 years ago, and this was roughly the time that the Ohio and Mississippi Rivers probably occupied the lowest level of braided-stream terrace 2 adjacent to Sikeston Ridge. It is also inferred that about this time or shortly thereafter, the Mississippi River was meandering as far north as about Memphis. If relative dating of later meander belts with archeological evidence is correct, a logical sequence of events would call for a time span of from about 7,500 to 9,000 years before present for the oldest discernible Mississippi River meander belt (No. 1, Figure 3) in the Yazoo Basin area. South of Vicksburg, the meander belt is in the subsurface and indistinguishable. Similarly, no delta or deltaic plain remnants dating from this interval have been identified offshore.

For the next few thousand years, the history of the Mississippi River is more complex and less well known and understood than one would logically expect. The basic problems appear to be mainly ones of correct temporal association of segments of meander belts, correct association of meander belts with subdeltas, and an understanding of the mechanics of river diversions and waxing and waning discharges among meander belts. Archeological investigations have provided almost all chronological evidence; meaningful or diagnostic radiocarbon dates on other than archeological remains literally number less than a dozen. With admittedly only partial knowledge of even the archeological evidence, the writer offers the following tentative chronology.

About 7,500 years ago, the Mississippi River began slowly to abandon its initial meander belt south of Memphis (No. 1, Figure 1). While the mean annual discharge slowly declined over a period of possibly several hundred years, a new meander belt formed (No. 2) and began to enlarge. This meander belt was located along the route of the present river from near Memphis to about 60 miles south of Greenville, Mississippi. From this point southward for a distance of 40 miles, a segment of meander belt survives (No. 2, Figure 1) to mark the trend of this former course. This segment is referred to as the Upper Tensas Meander Belt (Fisk 1944). South of this segment, the meander belt is either destroyed or buried, or both, but probably trended along the western side of the valley along the route of the later No. 3 meander belt.

The meander belt which was slowly being abandoned at this time trended along the eastern side of the valley and is evidenced by a short surviving segment southwest of Greenwood, Mississippi (No. 2, Figure 1). From this area southward, it must have hugged the eastern valley wall to some point near Natchez, where it recombined with the newly forming meander belt to form a full-flow stream channel.

Continuing southward, it followed the western side of the valley and eventually reached the Gulf, forming the Maringouin Subdelta.

Apparently full flow was never achieved by the newly formed meander belt between Memphis and Natchez. A roughly equal division of flow between the two meander belts persisted for several hundred years before another diversion began. This new diversion, occurring about 6,000 to 6,500 years ago, took place in the upper part of the Yazoo Basin and led to the development of the meander belt segment situated about 40 miles northeast of Greenville (No. 2, Figure 1). It is surmised that this partial-flow channel lasted only a short while before full flow was achieved and No. 3 meander belt developed. The name Sunflower Meander Belt has been applied to this system, which can be traced southward for about 100 miles through the Yazoo Basin (Fisk 1944). The southern continuation of the No. 3 meander belt can be identified just west of Natchez, where it is called the Cocodrie Meander Belt and can be traced directly into the Teche Ridge along the western side of the alluvial valley. There appears to be little doubt that the Teche Subdelta is the correlative of this meander belt system. Upstream in the vicinity of Memphis, the identification of the meander belt segment in the southern end of the St. Francis Basin (the St. Francis Meander Belt of Fisk) as being part of the No. 3 meander belt system is quite tenuous and was done by a process of elimination. Assuming such associations to be correct, the No. 3 meander belt is the oldest to have more or less continuous surface expression and an identifiable deltaic plain or subdelta.

At the northern end of the Mississippi Valley, a major event took place with the diversion of the Mississippi River from the lowest level of braided-stream terrace 2 through a gap in Crowley's Ridge (Thebes Gap) into the area east of Sikeston Ridge. This diversion also appears to mark the date of the change of the last segment of the river from a braided to a meandering regime. The date of the diversion and change in regimen is unknown; it is postulated herein that it occurred about 6,000 years ago with the beginning of the No. 3 meander belt system. From this time on, the Mississippi and Ohio Rivers joined near Cairo and maintained a meander belt along the eastern side of the valley to near Memphis.

While the westernmost No. 2 Mississippi River meander belt past Greenville was active, the Arkansas River meander belt or belts were necessarily restricted to the area west of Macon Ridge. Only after this meander belt was abandoned and the No. 3 meander belt was carrying the full flow of the Mississippi River could the Arkansas River flow farther eastward. It appears that it did this only once with development of the No. 4 Arkansas River meander belt. The principal period of activity in this meander belt was probably between 5,000 and 6,000 years ago (Figure 3).

The abandonment of the No. 3 Mississippi River meander belt and the formation of the several partial-flow No. 4 meander belts presents a major problem in alluvial valley history. Irrespective of the large volume of archeological evidence available, there are still several ways in which the sequence of meander belt development can be interpreted and still maintain compatibility with the evidence. The sequence outlined below appears compatible with all evidence and is based in part upon the intangibles or "feel" that one develops after being closely associated with a problem for a long period.

Abandonment of the No. 3 Mississippi River meander belt occurred rather abruptly with the formation in quick succession of two diversions in the vicinity of Memphis. One diversion resulted in the development of a partial-flow channel (No. 4, Figure 1) down the eastern side of the Yazoo Basin past Vicksburg and thence along the base of the valley wall past Natchez and Baton Rouge. No surface evidence of this meander belt survives south of Vicksburg; however, subsurface evidence may be present in the form of a buried meander belt (Saucier 1969). Furthermore, its presence is affirmed by the initial growth of a subdelta or delta lobe on the eastern side of the deltaic plain about 4,600 or 4,700 years ago (the St. Bernard Subdelta).

Sometime prior to 4,000 years ago, a second diversion in the vicinity of Memphis led to the development of a second No. 4 meander belt. This one followed the approximate route of the present river past Greenville to a point about 15 miles northwest of Vicksburg. From this point, it trended southwestward west of the No. 3 meander belt for a distance of about 100 miles. This segment survives as the distinctive Walnut Bayou Meander Belt (Fisk 1944). Near the mouth of the Red River, this new meander belt was forced to cross the abandoned No. 3 meander belt and apparently rejoined the other No. 4 meander belt a short distance farther downstream.

The No. 4 meander belt hugging the eastern valley wall never achieved full flow, but apparently it carried a relatively constant partial flow (from 40 to 60 percent of the total Mississippi River discharge) for a period of at least 800 years. The remainder of the discharge was carried by the second No. 4 meander belt mentioned above. This diversion of flow led Fisk to develop what was one of the basic premises of his valley history reconstruction; that is, the easternmost meander belt was formed by the Ohio River while flowing in a channel separate from the Mississippi-Missouri River part of the system. Recent geologic mapping in the upper part of the valley (Saucier 1964), however, has yielded seemingly definitive evidence that the Mississippi-Missouri and Ohio Rivers could not have occupied separate meander belts at this or any other time during the last 6,000 years. For example, at one point about 10 miles south of Cairo, the width of the Holocene floodplain as measured between the valley wall and the edge of the braided-stream terrace 2 is only 4 miles. It is considered impossible for the two rivers to have maintained separate meander belts through such a narrow gap.

Abandonment of the easternmost No. 4 Mississippi River meander belt seems to have taken place relatively slowly between about 3,500 and 4,000 years ago. As a consequence of this abandonment, the westernmost No. 4 meander belt enlarged to accommodate the full discharge of the Mississippi River. This period of full flow lasted from at least 2,800 to 3,500 years ago. The river at this time was roughly along the present route from Cairo to near Vicksburg, along the Walnut Bayou Meander Belt to the vicinity of the mouth of the Red River, and thence along the present river route past Baton Rouge.

During the principal life span of the No. 4 meander belts or from about 2,800 to 4,700 years ago, it appears that both the St. Bernard and Lafourche Subdeltas developed from this trunk channel and remained active. Detailed subsurface sedimentological studies suggest that various delta lobes in both subdeltas alternately formed during this period (Frazier 1967); however, the average age of the St. Bernard Subdelta distributaries is older than that of the Lafourche Subdelta. It should be noted that the Lafourche Subdelta distributaries formed during this period comprise what is also sometimes referred to as the Early Lafourche Subdelta. In many areas, they are buried or masked by the considerably more conspicuous and better preserved Late Lafourche Subdelta distributaries that formed during the last 2,000 years. The amount of discharge into and distributary development in the St. Bernard Subdelta during the past 2,000 years has not been too significant.

The last major Mississippi River meander belt shift occurred as a result of a diversion near Vicksburg from the Walnut Bayou Meander Belt into the backswamp area at the base of the valley wall between Vicksburg and near the mouth of the Red River. At the latter point, the river reoccupied the No. 4 meander belt and continued flowing southward therein. On the basis of only meager evidence, the writer feels that this last river diversion started about 2,800 years ago and was finalized within several hundred years.

The writer would like to digress at this time to indicate a possible point of confusion in regard to the use of the No. 5 meander belt designation. Whereas the numbering of other meander belt segments is based on the relative date of their abandonment, this is obviously not possible with the currently active one. It should be kept in mind that where continuous occupation or reoccupation has occurred, only the latest occupation can be shown. For instance, the No. 5 meander belt north of Memphis lies in essentially the same location as the preceding No. 3 and 4 meander belts. Since it is impossible to determine which if any of the various surviving abandoned channels or other meander belt features are associated with a particular time span or meander belt such as No. 4, only the latest designation can be used. Consequently, it is important to remember that the No. 5 meander belt north of Memphis may contain landforms that are anywhere in age from 0 to 6,000 years. Between Vicksburg and Baton Rouge, features anywhere in age from 0 to 4,800 years may be present, since the No. 4 meander belt occurs in the same location as the latest one. This same situation also occurs elsewhere on older meander belts, but to a far less extent.

From New Orleans, Louisiana, to the Gulf, the

No. 5 meander belt developed not from a diversion but rather from the preferential occupation of a distributary or distributaries. In the vicinity of New Orleans, the present river channel was adopted about 1,200 years ago (Saucier 1963), and it becomes progressively younger downstream. A date of 1,000 years before present is thought to be a good approximation for the beginning of the Plaquemines-Modern Subdelta (Figure 3).

Turning to the Arkansas River area, the No. 4 meander belt of this stream was abandoned about 5,000 years ago as a result of a major upstream diversion near Little Rock (Figure 1). The new meander belt (No. 5) formed west of Macon Ridge and persisted for possibly as long as 2,000 years. At least two segments were later abandoned as a result of diversions, one of which developed through a gap in the Prairie terrace into the Ouachita River valley (No. 6) about 3,000 years ago (Saucier and Fleetwood 1970). Abandonment of this meander belt in favor of the present one may have occurred as recently as 1,000 years ago.

In view of the writer's unfamiliarity with both the geology and archeology of the lower Red River area, the chronology of meander belts for this stream is quite tentative. The greatest chronological guide, other than the obvious relative ages of the meander belts, has been their relationship to the No. 3 Mississippi River meander belt. Thus, whatever errors in absolute chronology are present with the Mississippi River meander belt result in compounded or exaggerated errors in the Red River sequence; but, assuming no great error in this association and assuming that no meander belt greatly exceeded the 1,000- to 1,500-year average length of occupation, a strikingly short period of meander belt activity is indicated (Figure 3). The geologic history of the Lower Mississippi Valley offers no explanation or justification for such a short period. Consequently, the writer has concluded that significantly older meander belts do exist but have not been observed because of a lack of detailed mapping or, more probably, because of burial by more recent meander belt deposits. Rapid aggradation in the lower part of the Red River valley during the Holocene should have been prevalent because of proximity to the Gulf of Mexico and its appreciable eustatic sea level rise.

In the coastal area, detailed chronologies for both deltaic distributaries and cheniers have been worked out (Frazier 1967; Gould and McFarlan 1959); however, this level of detail is inconsistent with the nature of this report and is not reported herein. It is sufficient to say that all cheniers are younger than 2,800 years and all are related to shifts in sedimentation patterns within the St. Bernard, Lafourche, and Plaquemines-Modern Subdeltas.

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