Geology of the Chipola 7.5-Minute Quadrangle, LA

Louisiana Geological Survey

Introduction, Location, and Geologic Setting

The Chipola 7.5-minute quadrangle lies within the Plio–Pleistocene uplands east of the lower Mississippi River valley, in the drainage basin of the Amite River in the southeastern Louisiana coastal plain (Figures 1, 2). The axis of the subsurface lower Cretaceous shelf edge (Toledo Bend flexure), which trends west-northwest to east-southeast, lies 30 km (~19 mi) south of the southern edge of the study area. The surface comprises strata of (1) the Pliocene Citronelle Formation, Upland allogroup, characterized by the highest elevations and deeply dissected ridge-and-ravine topography lacking any original constructional landforms; (2) the Pleistocene Montpelier alloformation, Intermediate allogroup, underlying dissected but recognizable terrace surfaces along the the Amite River valley at elevations lower than the Citronelle; and (3) the Pleistocene Prairie Allogroup, at yet lower elevations, comprising an older and higher subunit (Irene alloformation) and the extensive, younger and lower Hammond alloformation, each characterized by a preserved depositional surface with indistinct constructional topography. These Plio–Pleistocene strata are covered by late Pleistocene Peoria Loess that is thinner than 1 m, with the 1-m thickness contour lying immediately west of Chipola quadrangle, and are incised by Holocene undifferentiated alluvium of the Amite River and its tributaries.

The units recognized and mapped in this investigation are summarized in Figures 3 and 4.

Previous Work

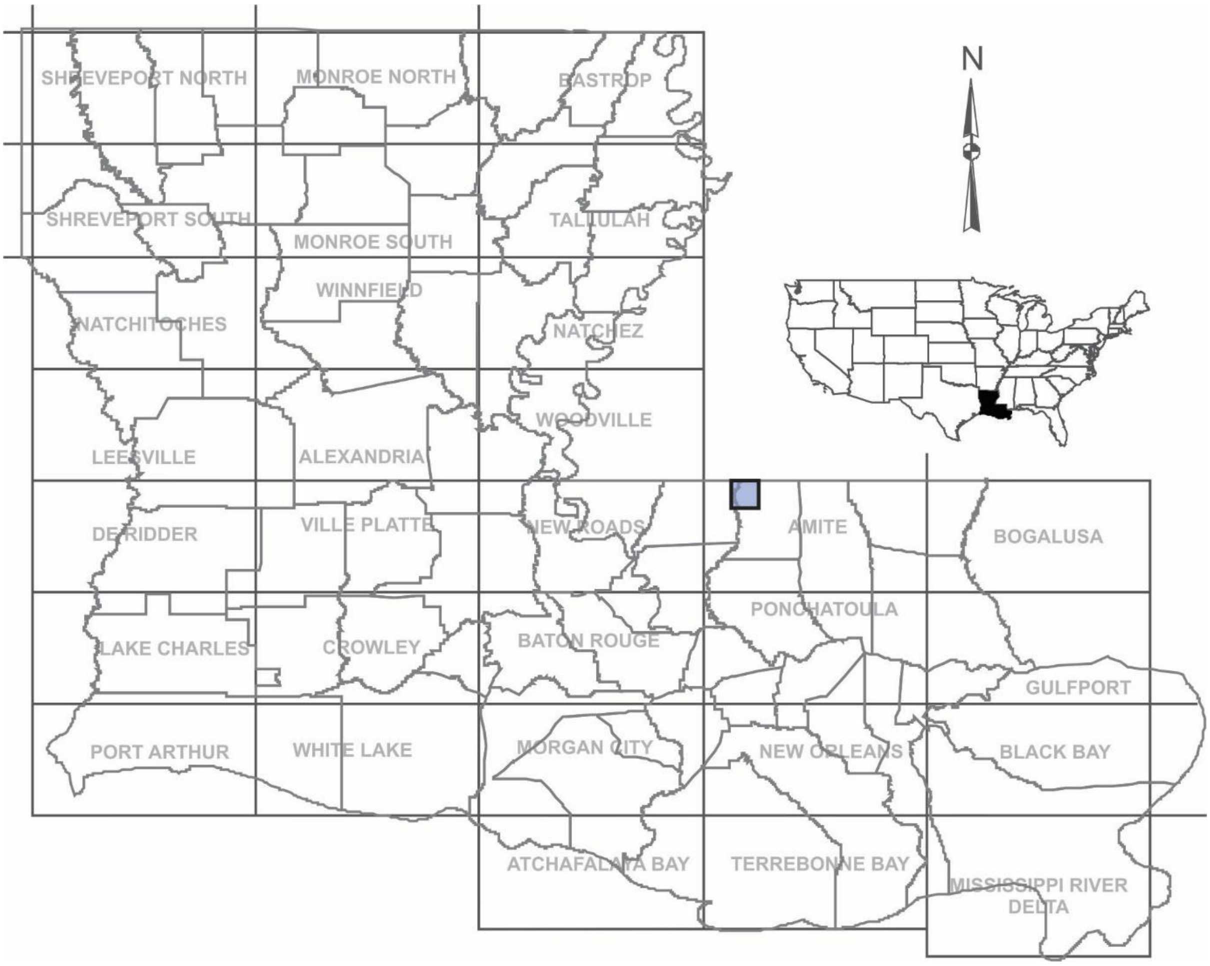
The Chipola quadrangle lies in the northwestern portion of the Amite 30 × 60 minute quadrangle, the surface geology of which was compiled at 1:100,000 scale by McCulloh et al. (1997) and digitally recompiled by McCulloh and Heinrich (2008), both with STATEMAP support, and later prepared as a Louisiana Geological Survey (LGS) lithograph (McCulloh et al., 2009). The original 1996–1997 investigation benefited from a drilling component by which the most problematic map-unit assignments were tested with a total of 15 holes drilled with a Giddings hydraulic probe.

The quadrangle covers portions of East Feliciana and St. Helena Parishes (Figures 1, 2). Self (1980, 1986) mapped the surface geology of the uplands of all of Louisiana's "Florida" parishes in southeastern Louisiana, though at 1:250,000 scale. Delcourt (1974) mapped the surface geology of East Feliciana Parish at 1:62,000 scale, and Campbell (1972) mapped that of St. Helena Parish at 1:62,500 scale. Autin and McCulloh (1991) mapped the surface geology of East Baton Rouge Parish at 1:24,000 scale.

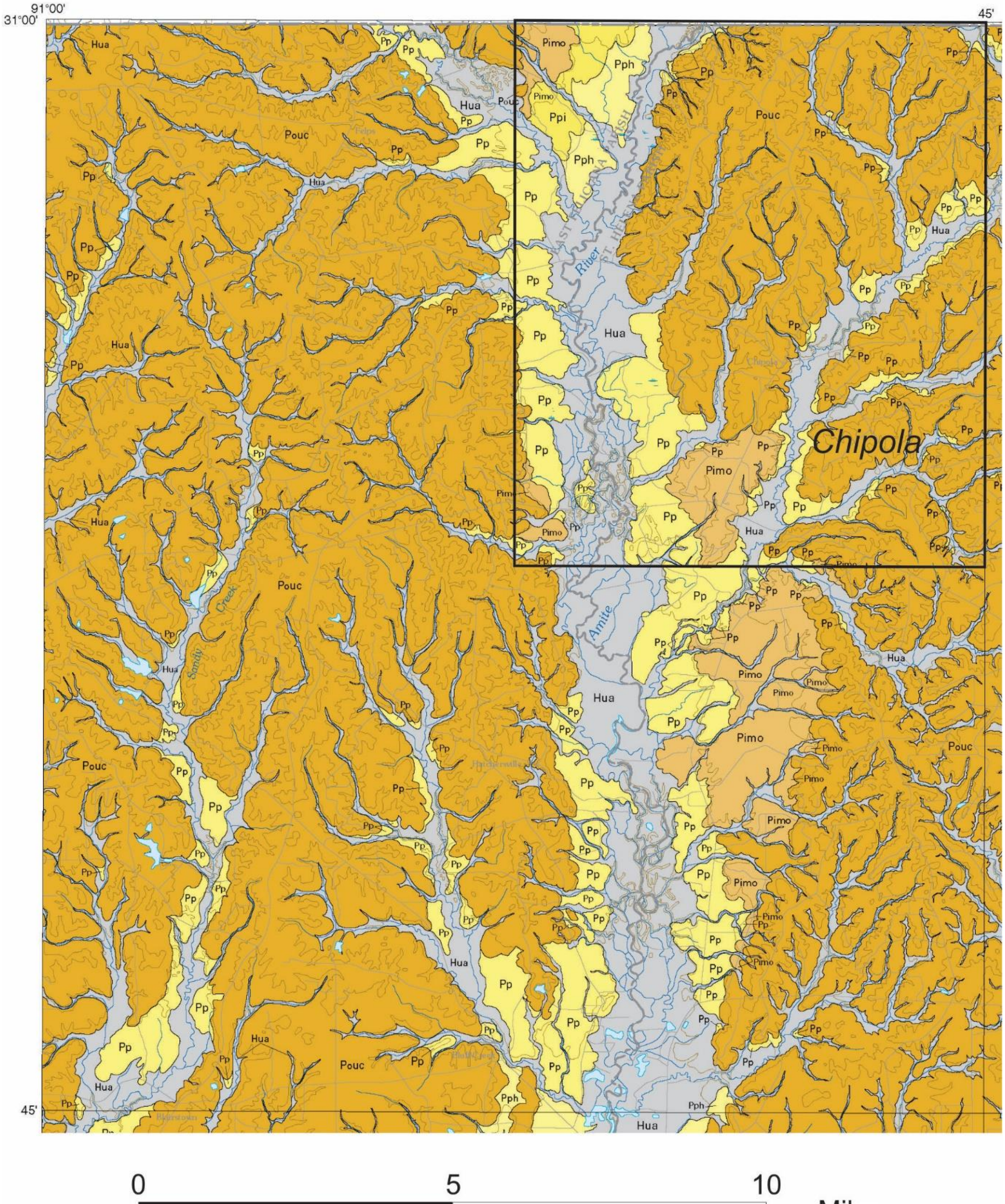
Tomaszewski et al. (2002) detailed groundwater conditions pertinent to the Southern Hills aquifer system, and Van Biersel and Milner (2010) summarized its distribution, recharge area, proportions of water-use categories, and pumpage rates.

Methods

The investigators reviewed legacy information and made new interpretations consulting remotely sensed imagery (comprising aerial photography, lidar DEMs, and other sources) and soils databases published by the Natural Resources Conservation Service (NRCS) to develop a draft surface geology layer for the study area. Field work was conducted to access the subsoil in road- and drainage-associated excavations, to examine and sample the texture and composition of the surface-geologic map units. Field observations were then synthesized with the draft surface geology to prepare an updated integrated surface geology layer for the 7.5-minute quadrangle.



1. Location of Chipola 7.5-minute quadrangle, southeastern Louisiana.



2. Surface geology of Chipola 7.5-minute quadrangle and vicinity (adapted from McCulloh et al., 2009). (**$P_o$uc**, Citronelle Formation, Upland allogroup (Pliocene); **Pimo**, Montpelier alloformation, Intermediate allogroup (Pleistocene); **Ppi**, Irene alloformation, Prairie Allogroup (Pleistocene); **Pph**, Hammond alloformation, Prairie Allogroup (Pleistocene); **Pp**, Prairie Allogroup, undifferentiated (Pleistocene); **Hua**, Holocene undifferentiated alluvium.)

QUATERNARY SYSTEM

HOLOCENE

Hua Holocene undifferentiated alluvium

QUATERNARY UNDIFFERENTIATED
Qaf Quaternary alluvial-fan deposits

PLEISTOCENE

LOESS
[pattern] Peoria Loess

PRAIRIE ALLOGROUP
Pph Hammond alloformation
Ppi Irene alloformation

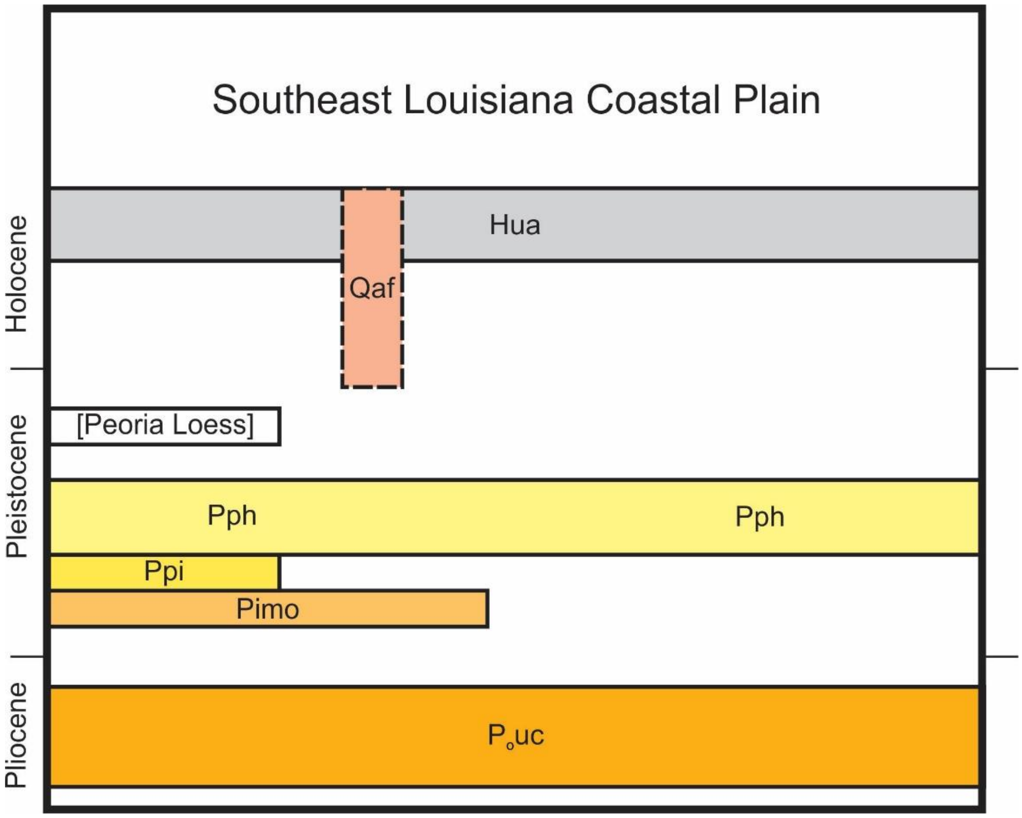
INTERMEDIATE ALLOGROUP
Pimo Montpelier alloformation

TERTIARY SYSTEM

PLIOCENE

UPLAND ALLOGROUP
$P_o$uc Citronelle Formation

3. Units mapped in the Chipola 7.5-minute quadrangle.



4. Correlation of strata mapped in the Chipola 7.5-minute quadrangle.

Allostratigraphic Approach to Pleistocene Unit Definitions

In the late 1980s the LGS had begun exploring the application of allostratigraphic concepts and nomenclature to the mapping of surface Plio–Pleistocene units (e.g., Autin, 1988). In Louisiana these units show a series of geomorphic attributes and preservation states correlative with their relative ages, which eventually led LGS to conclude that allostratigraphy offers an effective if not essential approach to their delineation and classification (McCulloh et al., 2003). The Plio–Pleistocene strata for which allostratigraphic nomenclature presently has value to LGS all are situated updip of the hinge zone of northern Gulf basin subsidence, and show a clear spectrum of preservation from pristine younger strata to trace relicts and remnants of older strata persisting in the coastal outcrop belt and on high ridgetops in places updip of it. Allounit nomenclature has figured heavily in the STATEMAP-funded geologic mapping projects of the past two decades because Quaternary strata occupy approximately three-fourths of the surface of Louisiana. The surface of the Chipola quadrangle consists exclusively of Quaternary and Pliocene strata, which dictated a continuation of this practice for this investigation.

Citronelle Formation, Upland allogroup (Pliocene)

The Citronelle Formation was first recognized and mapped by Hilgard (1860) as the “Orange Sand Formation” that consisted of a widespread, surficial mantle of weathered sands and gravels that cover much of the state of Mississippi. As originally defined and mapped it consisted of a mixture of Pliocene sands and gravels and weathered “bedrock.” In order to conform to the policies of the U.S. Geological Survey, which forbade the use of descriptive names for formations, Hilgard (1891) renamed his "Orange Sand Formation" as the “Lafayette Formation” for railroad cuts at Oxford in Lafayette County, Mississippi. Also, it replaced another name, the Appomattox Formation, used for these sands and gravels. It was under the name Lafayette Formation that McGee (1891) published a treatise on this stratigraphic unit (Dockery and Thompson, 2016).

Later, Matson (1916) named the Citronelle Formation for highly weathered, nonmarine, Pliocene sediments that occupy the seaward margin of the Gulf Coastal Plain that extends from western Florida to Texas and consist of yellow and red sands and clays and include significant amounts of gravel near their landward margins. The type locality is a 3- to 4-mile stretch of the Mobile and Ohio Railroad north of the town of Citronelle in Mobile County, Alabama. South of its type locality, it contains a fossiliferous clay bed with a well-preserved flora that was regarded by Berry (1916) as Pliocene in age (Dockery and Thompson, 2016).

The regional distribution of the Citronelle Formation has been mapped and illustrated by numerous studies. They include Matson (1916); Doering (1935, 1956); and the “High Terraces” of Mossa and Autin (1989) and of Snead and McCulloh (1984). A georeferenced comparison using ArcGIS of Fisk’s (1938a) Williana, Bentley, and Montgomery Formations as illustrated by Bernard and Leblanc (1965, their figure 2) with published LGS 30 × 60 degree geologic quadrangle maps (Heinrich and Autin, 2000; Heinrich and McCulloh, 2007; and McCulloh et al., 2009) indicates they are all subdivisions of the Citronelle Formation. Only the southern edge of Fisk’s “Montgomery Formation” overlaps with the northern edges of the Montpelier and Irene alloformations.

Within the region of the Chipola 7.5-minute quadrangle, the Citronelle Formation consists largely of reddish brown sands, interbedded sands and gravels, and gravels. Paralleling the course of the modern Amite River is a well-defined gravelly trend composed largely of gravelly sands, sandy gravel and muddy sands. The gravel content of these sediments decreases and their clay content increases gulfward. The coarse-grained nature of the Citronelle contrasts greatly with the finer-grained overlying and underlying units. The gravels of the Citronelle Formation consist largely of highly weathered, honey-colored chert pebbles. Very well-rounded quartz granules are also typically present within the Citronelle Formation along with typically deep red to purplish silt and claystone intraclasts (Self, 1986, Otvos, 2004).

The upper and lower contacts of the Citronelle Formation are unconformities. The Citronelle lies unconformably above the Miocene Pascagoula Formation (Bicker, 1969). Either Peoria Loess or Pleistocene alloformations overlie the deeply eroded upper surface of the Citronelle Formation, which is characterized by a thick, reddish, well-developed paleosol (Autin, 1984). This deeply weathered surface is characterized by well-developed clay skins, plinthite, and ironstone nodules, and a vermicular fabric of highly oxidized and more reduced zones is present. The reduced zones appear to be associated with both root casts and burrows (Mossa and Autin, 1989). The Citronelle Formation is deeply dissected to the point that its original surface has been completely destroyed by the formation of ridge-and-ravine topography.

Regionally, the Citronelle Formation is largely unfossiliferous. It does contain reworked, silicified Paleozoic fossils within its chert gravels. These cherts formed by the silicification of Paleozoic carbonate rocks in the source areas such as the Nashville Dome. Later, these chert nodules were eroded from their parent carbonate strata and transported gulfward as gravels by fluvial systems (Smith and Meylan, 1983). The Citronelle Formation also contains large ironstone “cylinders” that are interpreted as root casts (Mossa and Autin, 1989).

Montpelier alloformation, Intermediate allogroup (Pleistocene)

The Intermediate allogroup, also mapped as either the “Intermediate Terraces” or “Intermediate Complex,” is an unconformity-bounded collection of depositional sequences of alloformation rank that unconformably overlies the Citronelle Formation and is onlapped gulfward by the Prairie Allogroup. It is a coast-parallel unit with comparatively minor surface exposure and is described as consisting of “light gray to orange-brown clay, sandy clay and silt, with much sand and gravel locally” (Mossa and Autin, 1989). Near the Mississippi Valley, the Peoria and Sicily Island loesses blanket the surface of the Intermediate allogroup. Unlike southwest Louisiana, the Intermediate allogroup does not form an extensive and a well-developed coast-parallel terrace. In striking contrast, it only occurs as rare terrace fragments that lie between the outcrop of the Citronelle Formation to the north and terrace surfaces of the Prairie Allogroup to the south. In addition, in the Florida Parishes, the Intermediate allogroup consists of only one stratigraphic unit, the Montpelier alloformation. Overall, the Montpelier alloformation lacks a diagnostic or consistent texture and lithologic character. The sediments composing it exhibit highly variable lithology and may contain locally abundant sand and gravel.

The surface of the Montpelier alloformation exhibits more dissection and is topographically higher than the surfaces of the Prairie Allogroup. Within the Chipola 7.5-minute quadrangle, it consists of small terrace remnants that range in elevation from about 53 to 69 m (~174 to 226 ft) in elevation. These terrace fragments generally lie about 5 to 10 m (~16 to 33 ft) below the edge of the deeply eroded Citronelle Formation, but may lie as little as 1 m (~3 ft) or as much as 20 m (~66 ft) below it. The surface of the Montpelier alloformation is too fragmented for its slope to be calculated within the study area.

Prairie Allogroup, undifferentiated (Pleistocene)

The Prairie Allogroup is a collection of late Pleistocene depositional sequences of alloformation rank (Autin et al., 1991; Heinrich, 2006). The sediments of the Prairie Allogroup accumulated within a diverse suite of coastal-plain settings, i.e., fluvial (meander-belt and backswamp), colluvial, possibly eolian, estuarine, deltaic, and shallow-marine environments. These largely fine-grained sediments accumulated over a considerable part of the late Pleistocene (Sangamon to Wisconsin) (Autin et al., 1991; Otvos, 2005; McCulloh et al., 2003; Heinrich, 2006).

The surface of the Prairie Allogroup forms a coastal terrace along the northwest coast of the Gulf of Mexico from a point about 110 km (~70 mi) south of the Rio Grande within Mexico over to at least Mobile Bay, Alabama. This surface is the lowest continuous terrace lying above Holocene coastal and flood plains. This relatively undissected terrace exhibits constructional topography that is more poorly preserved than exhibited by terraces of the Deweyville Allogroup and lacking on older Pleistocene surfaces. It comprises multiple stratigraphic units of alloformation rank (Saucier and Snead, 1989; Autin et al., 1991; Dubar et al., 1991; Winker 1990).

Irene alloformation, Prairie Allogroup (Pleistocene)

The Irene alloformation is an unconformity-bounded stratigraphic unit separated from the underlying Montpelier alloformation and older units by a regional unconformity. The first use of the name “Irene” was by Durham et al. (1967) for the surface identified by Fisk (1938b) as the “second terrace” (the second terrace surface above present alluvial bottoms) in the western Florida Parishes of southeastern Louisiana. Fisk viewed this surface as the next elevated relict floodplain surface up from the “Port Hickey” or Prairie (upper surface of the Hammond alloformation of this report). Snead et al. (1998) used the name again in the same context, but in an allostratigraphic sense, to refer to the depositional sequence underlying the surface identified by Fisk. These authors kept the name “Prairie” as a formation-rank unit (alloformation) and referred to its subdivisions as allomembers; subsequent usage by the Louisiana Geological Survey elevated the Prairie to group rank and its subdivisions to formation rank.

According to Fisk (1938b):

> The coastwise Port Hickey Terrace is separated from the next higher one by an irregular slope, representing the eroded edge of the second coastwise surface. The base of this slope may be traced as an irregular line from Port Hudson eastward beyond Zachary . . . Isolated remnants of the higher surface commonly protrude as islands above the lower surface close to the separating slope. These remnants point to a former greater extent of the slope, and to its frayed character previous to Port Hickey alluviation. (p. 8, 10)

This embayed and irregular character is exemplified by the dissected surface of the Irene alloformation in the Chipola 7.5-minute quadrangle, especially in the quadrangle’s southwestern portion. This surface lacks any discernible relict constructional topography except for some alluvial fans along the valley wall, relatively flat, sloping interfluves (ridge crests), and accordant summits. Within the region of the Chipola 7.5-minute quadrangle, its fluvial terrace is too fragmented for the slope to be measured. At this time, little is known about the lithology of the Irene alloformation, except that it is distinctly finer-grained than the underlying Citronelle Formation. Close to the Mississippi Valley, the Peoria and Sicily Island loesses blanket the surface of the Irene alloformation (Miller et al., 1985).

Within the Chipola 7.5-minute quadrangle, information concerning the age of the Irene alloformation is lacking. An optical luminescence date of 206 ± 14 ka (Baker I-1) from this alloformation near Baker, Louisiana indicates that it dates to Marine Isotope Stage 7; that it correlates with the Bastrop alloformation in northern Louisiana; and that the Hammond alloformation postdates Marine Isotope Stage 7 (Shen et al., 2012, 2016).

Hammond alloformation, Prairie Allogroup (Pleistocene)

Within the Florida Parishes, the youngest and most extensive surficial unit is the Hammond alloformation of the Prairie Allogroup (Heinrich, 2006; McCulloh et al., 2009). Its name is derived from Hammond, Louisiana and the Hammond terrace of Matson (1916). It is an allostratigraphic unit that forms part of the Prairie Allogroup. The surface of the Hammond alloformation is a coast-parallel terrace that is 16–40 km (10–25 mi) wide and extends from the eastern valley wall of the Mississippi River alluvial valley eastward across the Florida Parishes and the Pearl River into Mississippi. It is the lowest and best preserved of the Pleistocene terraces found between the Mississippi and Pearl rivers. In the Florida Parishes it exhibits moderately to poorly preserved relict constructional landforms. These landforms include relict river courses, meander loops, ridge-and-swale topography, coastal ridges, and beach ridges. In some areas, they include valley walls and flood plains of entrenched valleys. Overall, the surface of the Hammond alloformation consists of a series merged alluvial cones that abruptly flatten out into a broad coastal plain. In areas to the south of the Chipola quadrangle, faulting has displaced the surface of the Hammond alloformation, creating numerous fault-line scarps.

Within the Chipola 7.5-minute quadrangle, the surface of the Hammond alloformation is only moderately well preserved. Although this surface is undissected, it noticeably lacks obvious relict fluvial landforms. It lies just above the level of the modern Amite River floodplain. In this area, the surface of the Hammond alloformation consists of the proximal apex of the alluvial cone of the Amite River. Multiple, well-preserved paleochannels and channel belts can be observed in lidar DEMs. The slope of its fluvial terrace within the study area is 0.8 m/km (4.2 ft/mi) within this quadrangle.

Information concerning the age of the Hammond alloformation in the Chipola 7.5-minute quadrangle is lacking. However, optical luminescence dates from the Baton Rouge and Denham Springs areas indicate that the Hammond alloformation is a mixture of sediments that accumulated during Marine Isotope Stages 5 and 3 and postdates Marine Isotope Stage 7 (Shen et al., 2012, 2016).

Peoria Loess (Pleistocene)

Within the Chipola 7.5-minute quadrangle, a blanket of relatively homogeneous, seemingly nonstratified, unconsolidated, well-sorted silt blankets the formations of Pleistocene and Tertiary age. This surficial layer of well-sorted silt, which is called “loess,” is distinctive because of its unusually massive nature, uniformly tan to brown color, and extraordinary ability to form and maintain vertical slopes or cliffs (Miller et al., 1985; Pye and Johnson, 1988; McCraw and Autin, 1989; and Saucier, 1994).

Loess is eolian sediment that accumulated during times of near-maximum to early-waning glaciation. During such periods, seasonally prevailing, strong, north and northwest winds deflated large amounts of silt from recently deposited and unvegetated glacial outwash that accumulated within glacial valley trains. These seasonal winds then transported the material for tens to hundreds of kilometers (tens to hundreds of miles) to the east and south. Eventually, this deflated silt fell out of suspension and incrementally accumulated within adjacent uplands as a drape over either preexisting terraces or dissected, hilly landscape. The greatest amount and relatively coarsest of the silt accumulated closest to the source areas (Miller et al., 1985; Pye and Johnson, 1988; McCraw and Autin, 1989; and Saucier, 1994).

The two loess sheets that occur within the Chipola 7.5-minute quadrangle are, from youngest to oldest, the Peoria and Sicily Island loesses. Numerous radiocarbon, thermoluminescence, and optical luminescence dates and other lines of evidence have been used to determine the age of the Peoria Loess. It has been found to be unquestionably of Late Wisconsin age, between 22,000 and 12,500 years BP, and consistent with the age of known meltwater valley trains (Miller et al., 1985; Pye and Johnson, 1988; McCraw and Autin, 1989; and Saucier, 1994). The favored age of the Sicily Island Loess is an Early Wisconsin age, which is consistent with its presence overlying the surface of the Irene Alloformation and its absence beneath the Peoria Loess where it overlies the Hammond alloformation.

Quaternary alluvial-fan deposits (Quaternary undifferentiated)

Alluvial-fan deposits (**Qaf**) comprise sediment at the termini of two very small drainage courses incising strata of the Montpelier alloformation, Intermediate allogroup and the Irene alloformation, Prairie Allogroup on the east side of the Amite River valley. These two alluvial-fan deposits lie in the southwestern portion of the quadrangle, where their source drainages debouch onto the surface of the adjacent Hammond alloformation, Prairie Allogroup.

Holocene alluvium

The Holocene sediments mapped in the Chipola 7.5-minute quadrangle consist of undifferentiated deposits of small upland streams; unconsolidated alluvial deposits of minor streams and creeks filling valleys; and the meander belt of the Amite River. The deposits of small upland streams and alluvial deposits of minor streams and creeks have not been studied in detail and are poorly known. The textures of these sediments vary greatly from gravelly sand to either sandy mud or silty mud. Typically, the amount of coarse-grained sediments present directly reflects the texture of the local "bedrock."

In the case of the Amite River valley, the sediments within it reflect its formation by a coarse-grained meandering river. Within it, lateral accretion associated with the secondary development of chutes and cutoffs are the processes that govern sediment deposition. As a result, the floodplain exhibits point bar and scroll bar ridges and active and abandoned thalweg channels and chute channels. The sediments underlying the floodplain consist of two facies, a lower sandy facies and an upper silty facies, associated with these processes and landforms. The lower sandy facies consists of point bar, scroll bar, and channel lag deposits that typically are stratified. The upper silty facies consist of gray and brown silt. The gray silt occurs as lenticular to V-shaped fills of abandoned chute and thalweg channels. The brown silt comprises natural levees and the upper portion of abandoned chute and thalweg channel fills (Autin, 1985, 1989; Mossa and Autin, 1989). These sediments were differentiated by Autin (1989) into three alloformations, known as the Magnolia Bridge, Denham Springs, and Watson alloformations on the basis of unconformable boundaries, landscape morphology, and relative pedogenic development. These units were not mapped in this investigation because of lack of the detailed information needed to differentiate them.

Summary of Results

The surface of the Chipola quadrangle comprises strata of the Pliocene Citronelle Formation, and Pleistocene stratigraphic units of the Intermediate and Prairie allogroups consisting of sediment deposited by the Amite River and by coastal processes. The Montpelier alloformation, Intermediate allogroup, and the Irene and Hammond alloformations of the Prairie Allogroup, form part of a coast-parallel belt of terraced Pleistocene strata. These Plio–Pleistocene strata are covered by late Pleistocene Peoria Loess up to slightly greater than 1 m thick. Holocene strata comprise undifferentiated alluvium of the Amite River and its tributaries.

The geologic map of Chipola quadrangle provides basic geologic data of potential value to the conduct of aggregate-mining activities in the Amite River flood plain. The area hosts sizable sand and gravel resource potential in Holocene floodplain sediment, Pleistocene strata of the Prairie and Intermediate allogroups, and Pliocene sediment of the Citronelle Formation (Heinrich and McCulloh, 1999). The area has produced significant sand and gravel in the past decade (U.S. Geological Survey, 2011), and production activities have moved progressively northward in recent years. The 1:24,000-scale surface-geologic map of the study area also should serve efforts at protection of the Southern Hills aquifer system in the upper Amite River area.

Acknowledgments

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