Alluvial Geoarchaeology of a Middle Archaic Mound Complex in the Lower Mississippi Valley, U.S.A.

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The Nolan site (16MA201), ^{14}C dated 5200–4800 cal yr B.P. and located in the Tensas Basin of northeastern Louisiana, is the only recorded Middle Archaic mound site in the alluvial valley of the Mississippi River. Alluvial deposition has buried the Nolan site under 3–4 m of Holocene sediment, prohibiting traditional excavation of the site. Because data are unattainable by other means, soil coring and subsequent stratigraphic and sedimentological analyses permit reconstruction of the natural and cultural depositional history of the Nolan site. The sedimentary characteristics of basal deposits within cores suggest the presence of an Arkansas River paleochannel immediately adjacent to the site. Chronostratigraphic data show this channel was no longer active by ca. 5200 cal yr B.P. Contrary to existing models, the Arkansas River Meander Belt 4 and the Mississippi River Meander Belt 4 are not the same age. Microartifact and loss-on-ignition analyses of sediment identify natural versus cultural strata and permit the identification of artificial constructions—including four earthen mounds and one earthen ridge—at the Nolan site. Overbank sediments attributed to a mapped Mississippi River Stage 4 meander belt are dated ca. 4800–3800 cal yr B.P. This age is considerably younger than previous estimates and demonstrates the existing chronological models for Mississippi River meander belts must be carefully assessed. Core analyses also reveal flood-related crevasse splays deposited throughout the Tensas Basin after the occupation of the Nolan site. These deposits serve as relative chronological indicators and aid in stratigraphic assessments of the Nolan site. Reconstruction of the earthworks and their stratigraphic context reveals one of the largest and earliest Middle Archaic mound sites in North America. © 2006 Wiley Periodicals, Inc.

INTRODUCTION

The Nolan site (16MA201) is located in the Tensas Basin region of the Lower Mississippi Valley (Figure 1). The geologic setting of this site has been formed by thousands of years of natural levee construction, sedimentation through overbank flooding, and crevasse splay deposition. As a result, cultural deposits lie 3–4 m

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below the modern floodplain surface. Previous work at the Nolan site has been limited by this substantial deposition. Rising 3.5 m above the surrounding floodplain, Mound A had been identified (Figure 2); however, the existence and number of additional artificial constructions at the site had not been conclusively determined. Archaeological investigations were also impeded by the fact that few artifacts had been recovered from the site, with collection limited to the surface of Mound A (Saunders et al., 1994).

In addition to the financial and logistical deterrents to excavation of deeply buried sites, traditional archeological methods are prohibited at the Nolan site because the water table sits above the deepest cultural deposits. The buried context of the Nolan site and the modern hydrology of the Tensas Basin necessitate core extraction to investigate the cultural and natural landscape, as well as any subsequent site-formation processes that have occurred.

The stratigraphy of the Nolan site provides an archive of the fluvial and cultural events that have occurred in the Tensas Basin over the past 5,000 years, allowing for the elucidation of both the hydrological and occupational history of the area, in addition to supplying a geologic context for the Nolan mounds themselves. This study utilizes minimally intrusive, sedimentological and geoarchaeological methods to examine the Nolan site stratigraphy. These data, in turn, allow for the reconstruction of the architectural layout of one of the earliest and largest mound complexes in North America.

GEOMORPHIC SETTING AND ALLUVIAL CHRONOLOGY

The Nolan site is situated in the Tensas Basin, which is bordered by the Pleistocene-age Macon Ridge to the west and the present (Stage 1) Mississippi meander belt to the east (Figure 1). Varying in width between 40.2 and 72.4 km, the Tensas Basin is solely comprised of Holocene meander belt and backswamp deposits (Saucier, 1994, p. 27). The surface soil at the Nolan site is Sharkey clay, commonly found on poorly drained, low portions of natural levees, abandoned channels, and backswamps in this region (Weems et al., 1982, p. 16). Sharkey soils are characterized as clay-rich vertisols with common mottling and slickensides. The preservation of organic material and grayish colors with extant dark brown mottling and iron oxide and manganese concretions provide evidence of seasonal drying episodes in this poorly drained environment (Aslan and Autin, 1998).

The basic geology and geomorphology of the Lower Mississippi Valley is well known, and the archaeology has been relatively well studied (Fisk, 1944; Phillips et al., 1951; Saucier, 1967, 1974, 1994, 1996; Saucier and Kolb, 1967; Phillips, 1970; Williams and Brain, 1983; Neuman, 1984; Haag, 1996; Kidder, 2002, 2004). The geoarchaeology of this region is complex, owing to the presence of numerous superimposed Arkansas and Mississippi River channels, distributaries, meander belts, and their associated sedimentary facies. The Mississippi River meander belts have been mapped as a series of stages, with Stage 6 being the relatively oldest and the Stage 1 channel representing the modern configuration of the Mississippi River (Figure 1) (Saucier, 1994). The upper part of the Tensas Basin near the Nolan site is dominated today by

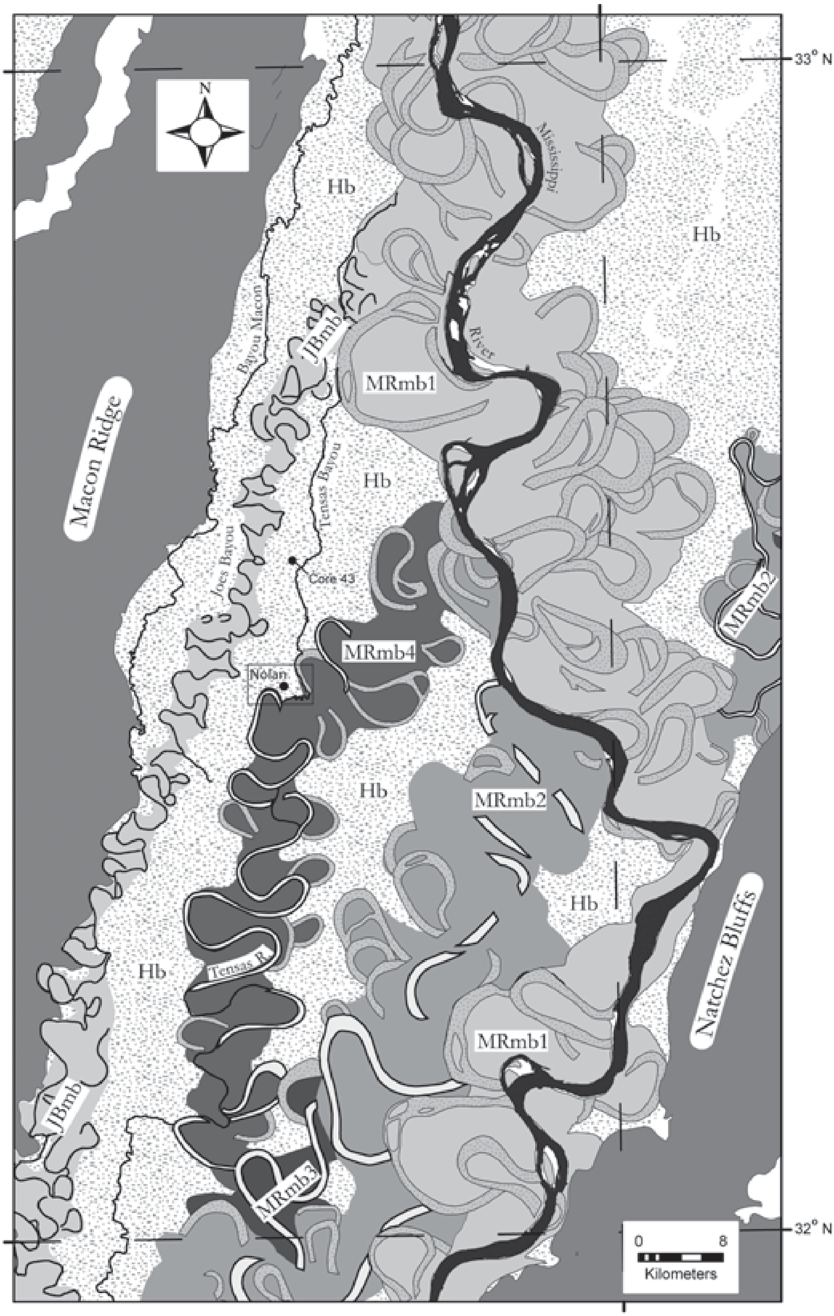

Figure 1. Tensas Basin showing associated drainages, the location of the Nolan site, and areas designated as Holocene backswamps (Hb). Numbered Mississippi River meander belts (MRmb) correspond with the stages mentioned in the text (modified from Saucier, 1994). Area shown in Figure 4 is outlined.

Tensas Bayou and Joes Bayou, which serve as local drainage streams (Saucier, 1994, p. 27). The site itself is situated near a cutbank of the modern Tensas River, which was an active Mississippi River channel in Stage 4 times (Saucier, 1994).

The relevant geological history of the region begins before 5200 cal yr B.P. At this time, the primary Mississippi River channel was located east of the modern channel, and the Arkansas River occupied a now deeply buried meander belt (Arkansas River Meander Belt 4) running roughly down the middle of the study area. By 4800 cal yr B.P., there was an upstream avulsion that formed the Stage 4 Mississippi River meander belt (Saucier, 1994). The Arkansas River was diverted into a new meander belt and was no longer active in the study area. The relative age of this Mississippi River meander belt is demonstrated by the presence of sediments overlying the Nolan site from a relict Stage 4 channel segment. The Mississippi River later moved eastward to occupy its Stage 3 and Stage 2 meander belts, although the specific chronologies of these two meander belts are very uncertain. Joes Bayou developed its own meander belt as a distributary of the Mississippi River after the development of the Stage 4 meander belt and its channels. Following the development of Joes Bayou, a significant basin formed in the region between it and the Mississippi River meander belts, particularly between the levee systems associated with Mississippi meander belts assigned to Stages 4 and 2 (Figure 1). A local drainage system, now known as Tensas Bayou, evolved in this basin sometime after Stage 4 time; the initial trend of this local drainage was northeast to southwest parallel to the Stage 4 meander belt.

The period from 3800 to 3000 cal yr B.P. was a time of relative geological stability in the study region. This period of stability was evidently short-lived, however. During the processes associated with the formation of the Stage 1 Mississippi River meander belt, Joes Bayou was captured by the Mississippi and temporarily reactivated as a major distributary in the period 3000–2600 cal yr B.P. This event is evinced by fan-shaped crevasse splay deposits, indicating significant flood episodes in the Tensas Basin (Figures 3 and 4) (Adelsberger, 2005; Kidder, 2006).

The modern expression of the Tensas Basin developed through a long history of channel formation, reoccupation, and burial, making the identification of features present before 3000 cal yr B.P. a challenging task (Saucier, 1994). We have intensively cored the Nolan site and excavated a single backhoe trench. This work was executed to determine the nature of cultural and fluvial deposits associated with this mound site. Identification of the sedimentary characteristics of deposits found at the Nolan site allows for the recognition of cultural and mound-building stages as well as natural floodplain deposits, which, in turn, provides a chronology of the cultural and natural events that occurred in this region of the Lower Mississippi Valley.

METHODS

Sixty-seven 5.08-cm diameter cores were obtained from the Tensas Basin using a trailer-mounted Giddings hydraulic soil probe in the summers of 2002 and 2004. Cores were extracted from off-site locations, mound surfaces, nonmound contexts, and along transects connecting mounds (Figure 2). Cores were described and interpreted

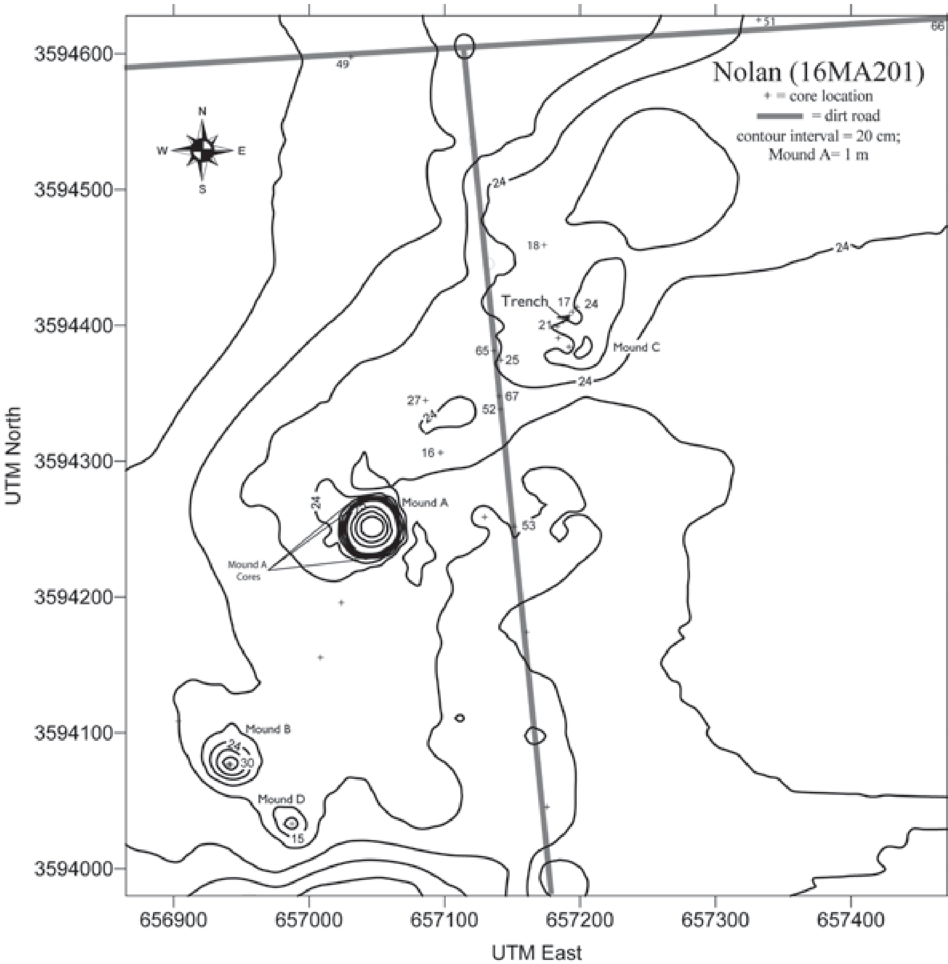

Figure 2. Topographic map of the Nolan site showing the location of soil cores (only those discussed in the text are labeled) and the site of trench excavation. Elevations of road surfaces are not accurately portrayed.

in the field and under laboratory conditions. Descriptions included Munsell color, field texture, soil horizonation, and the presence of artifacts or organics. Descriptions of soil horizons and sediments follow guidelines employed by the Natural Resource Conservation Service and the United States Geological Survey and summarized by various authors (Holliday, 1992; Schoeneberger, 1998; Birkeland, 1999; Soil Survey Staff, 1999; Vogel, 2002). Texture classes employed by the U.S. Department of Agriculture were assigned to core sediments based on tactile assessments in the field and are, therefore, qualitative designations (Thien, 1979; Soil Survey Staff, 1999; Vogel, 2002).

In addition to coring, a 4.0-m-deep backhoe trench was excavated at the Nolan site in the summer of 2004. Data collection from the trench was limited, owing to

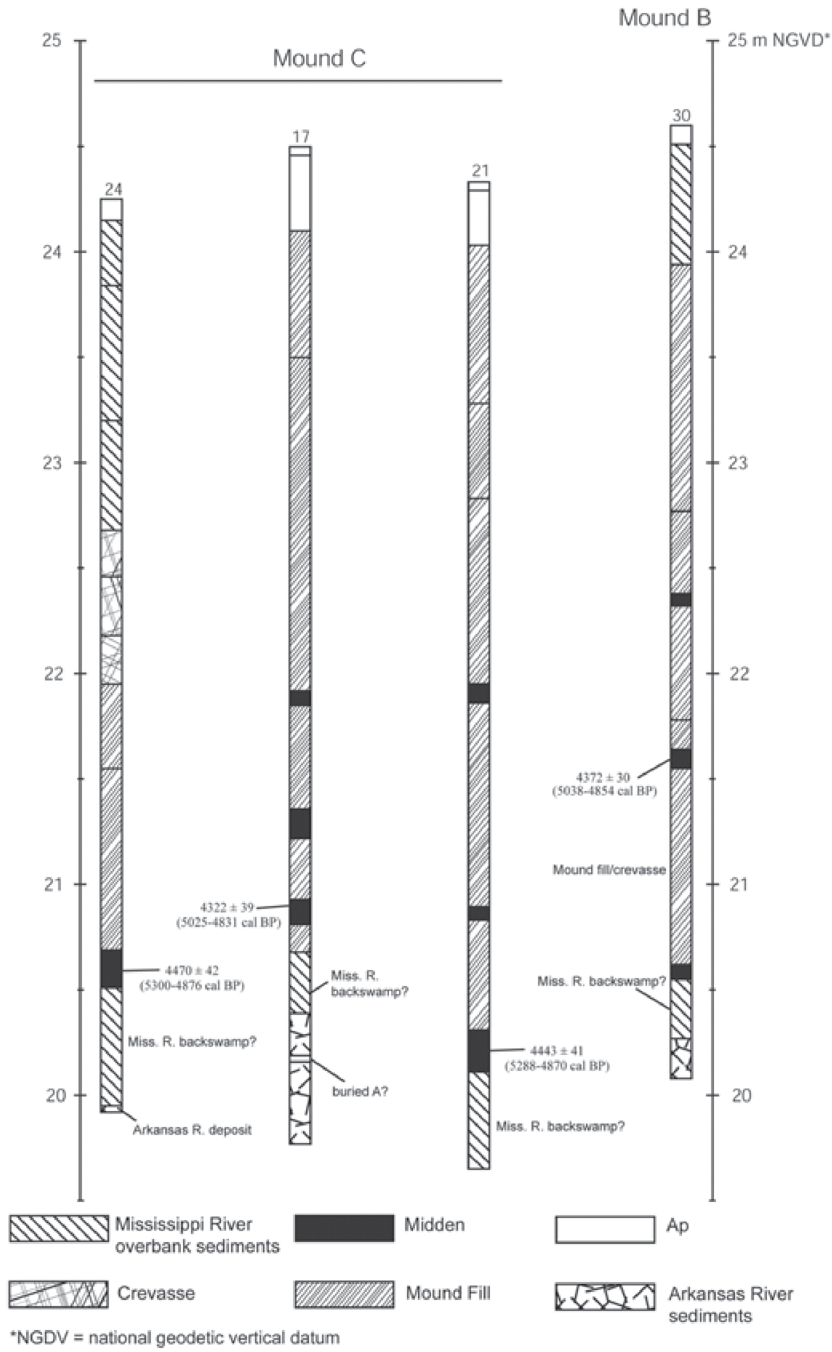

Figure 3. Stratigraphy and uncalibrated radiocarbon dates from cores 24, 17, 21, and 30. Horizontal scale is not representative of actual distances between cores.

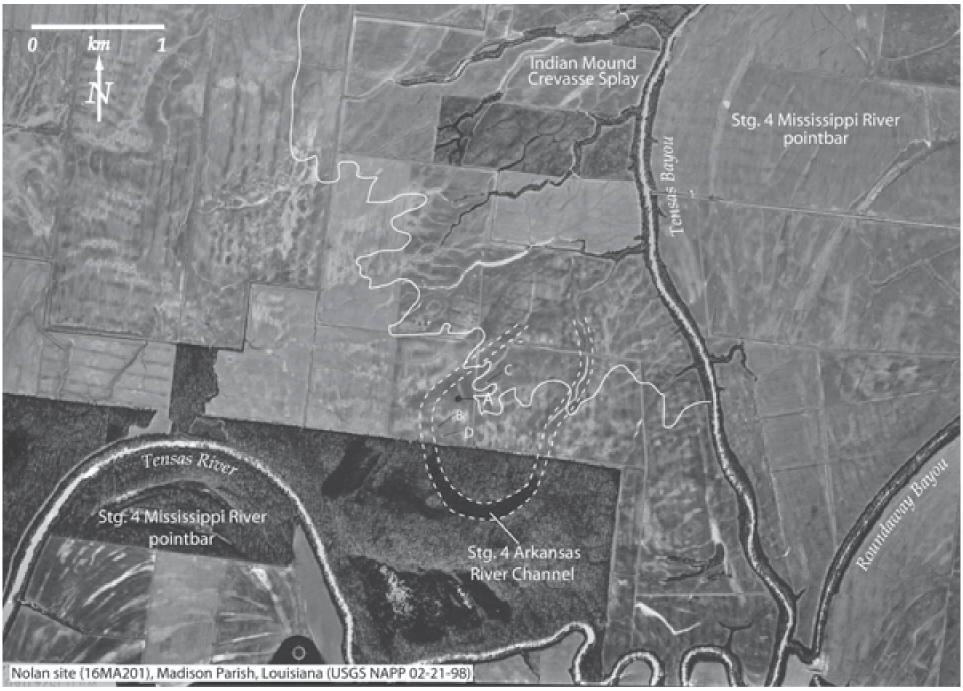

Figure 4. Aerial photo of the Nolan site showing the Mississippi River abandoned Meander Belt 4, Indian Mound Crevasse, and location of the abandoned Stage 4 Arkansas River channel in relation to the Nolan mounds.

wall collapse and the position of the water table above cultural deposits toward its base. Nevertheless, the east trench wall was described, and samples were collected for grain-size analysis using the hydrometer method (Figure 5) (American Society for Testing and Materials, 2003). Chronostratigraphic data were provided by AMS radiocarbon determinations conducted on charcoal and organic material extracted from core and trench strata (Table I). Radiocarbon assays were performed at the NSF University of Arizona AMS Facility (Tuscon, AZ) and Beta Analytic, Inc. (Miami, FL). All dates are reported in this study are given in calibrated years before present (cal yr B.P.); in cases where actual dates are not available for calibration we report ages as uncalibrated radiocarbon years before present (^{14}C yr B.P.)

Cores 52 and 53, obtained from a topographic rise between Mounds A and C, were processed at Washington University for both organic carbon content and microartifacts. These analyses were conducted to reveal information regarding the cultural or natural origin of sediment packages at the Nolan site. Loss-on-ignition assays were carried out at 5-cm intervals using methods employed by the Department of Earth Science Hovedlaboratoriet at the University of Bergen, Norway (Schrader and Monsen, 2000), as derived from Heiri et al. (2001).

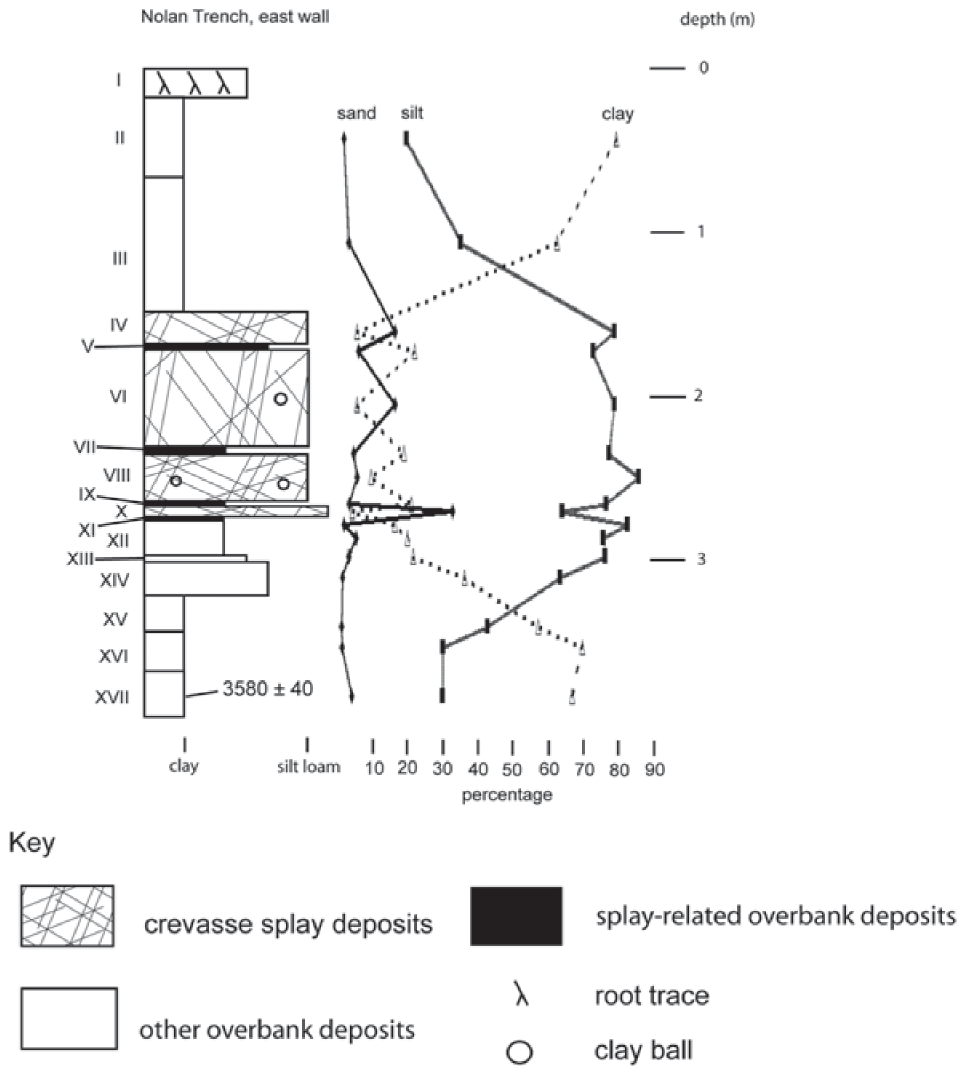

Figure 5. Stratigraphy, granulometric data, and uncalibrated radiocarbon date from the east wall of the Nolan site trench.

Microartifact assays were performed on samples taken at 5-cm intervals from each core. Each sample was weighed and manually homogenized before 50 g were extracted and dried at 50°C for 24 hours. Forty grams of sediment were extracted for wet sieving, dispersed in a 200-mL sodium hexametaphosphate (40 g/L) solution, and washed through 4.0-mm, 2.0-mm, 1.0-mm, and 0.5-mm screens (U.S.A. standardized testing sieves numbers: 5, 10, 18, and 35, respectively). All material larger than 0.5 mm was recovered and analyzed (Sherwood, 2001).

Table I. Radiocarbon dates from Nolan and contemporary geological contexts. Dates are calibrated with Calib (Version 5.0.2) (Stuiver and Reimer, 1993) using the INTCAL04 Terrestrial Radiocarbon Age data set (Reimer et al., 2004)

Provenience	Depth below surface	Sample no.	Dated material	$\delta\ ^{13}C/^{12}C$	Conventional RC age	2σ age BP	2σ age BC	Relative area under probability distribution
Backhoe trench, Str. 17	380–390 cm	Beta-197513	Charcoal	–26.7	3580 ± 40	3983-3818	2034-1869	0.897
						3795-3758	1846-1809	0.060
						3754-3724	1805-1775	0.043
Core 17, Str. I, Horizon 5Ab	357–369 cm	AA-55457	Charcoal	–26.82	4322 ± 39	5028-5020	3079-3071	0.014
						4973-4834	3024-2885	0.986
Core 21, Str. J, Horizon 7Ab	402–422 cm	AA-57681	Charcoal	–27.2	4443 ± 41	5284-5160	3335-3211	0.363
						5141-5101	3192-3152	0.080
						5086-4950	3137-3001	0.455
						4943-4877	2994-2928	0.102
Core 24, Str. J, Horizon 9Ab	356–374 cm	AA-55459	Charcoal	–26.1	4470 ± 42	5298-4967	3349-3018	1.000
Core 30, Str. J, Horizon 7Ab	296–305 cm	AA-55460	Charcoal	–25.24	4372 ± 30	5030-5005	3089-3056	0.108
						4980-4857	3031-2908	0.892
Core 43, Str. F, Horizon 5C[a]								
Sample 43A	334 cm	AA-55455	Uncarbonized leaf		3877 ± 55	4435-4147	2846-2198	0.993
						4111-4101	2162-2152	0.007
Sample 43B	336–338 cm	AA-55456	Uncarbonized wood		3254 ± 39	3567-3389	1618-1440	1.000

[a] 3605980N, 657560E, UTM Zone 15N.

RESULTS

Nolan Site Stratigraphy

Arkansas River Deposits

The deeply buried earthworks at the Nolan site are directly superimposed on deposits of the Arkansas River, which are easily identifiable in the field by their reddish (5YR 4/4 reddish-brown) coloration. Previously, Saucier (1994), following Fisk (1944), identified Joes Bayou, located 5 km west of Nolan, as the former axis of the Arkansas River Stage 4 meander belt. However, the characteristics of the Arkansas deposits within some of the Nolan cores indicate the site was constructed on an Arkansas River natural levee with a relict channel immediately adjacent. Relatively coarse Arkansas River sediment packages that include silt loam and very fine sandy loam suggest proximity to channel activity. Core 67, which was excavated to 9.5 m below ground surface, revealed the Arkansas River deposits are substantial and indicates the presence of a relatively stable point bar platform in this location (Figure 2). These data suggest the Stage 4 Arkansas River meander belt underlies modern Tensas Bayou. In fact, cores excavated near Joes Bayou to the north and west of Nolan indicate Joes Bayou sediments unconformably overlie Arkansas River overbank clays, indicating Joes Bayou is younger than the Arkansas River meander belt in this locality.

We suspect the primary axis of the Arkansas paleochannel is east of modern Joes Bayou (Adelsberger, 2005). An Arkansas River meander belt in the center of the Tensas Basin is not improbable because an avulsion event ~7500 ^{14}C yr B.P. is thought to have activated the Stage 4 Arkansas meander belt near the headwaters of modern Tensas Bayou (Saucier, 1994, p. 272). To account for the coarse sediment packages found beneath the Nolan site the Arkansas River must have followed this more eastern course. The duration of occupation of this meander belt would have been adequate to produce small meander features, such as the abandoned channel segment visible just south of the Nolan site (Figure 4), before abandoning the area prior to mound construction 5200–4800 cal yr B.P.

The location of the Arkansas channel in relation to the site is inferred from the thickness, textures, and depths of the Arkansas River sediments, as well as their absence from various Nolan site cores. Cores extracted northwest of Mounds A and C reveal lower elevations of Arkansas River sediments than those below the earthworks and other areas of the site. Southwest of Mounds A and C, Arkansas River sediments were detected between 4.2 and 4.8 m below the natural ground surface. In contrast, cores 18, 27, and 65 reached depths of up to 6.1 m but did not contain Arkansas River sediments (Figure 2). Cores 49 and 51 contained dark gray (5YR4/1 and 2.5Y4/1) clay deposits, which may represent infilling of the abandoned channel or an oxbow lake. These core data indicate the Nolan site is located on a natural levee created by the Arkansas River Stage 4 meander belt. Although our data are insufficient to determine its position fully, the location of this paleochannel appears to have been just northwest of the site. The absence of Arkansas River overbank deposits interleaved with, or overlying, the Nolan site demonstrates that channels occupied by the Arkansas River were abandoned before human occupation at the site.

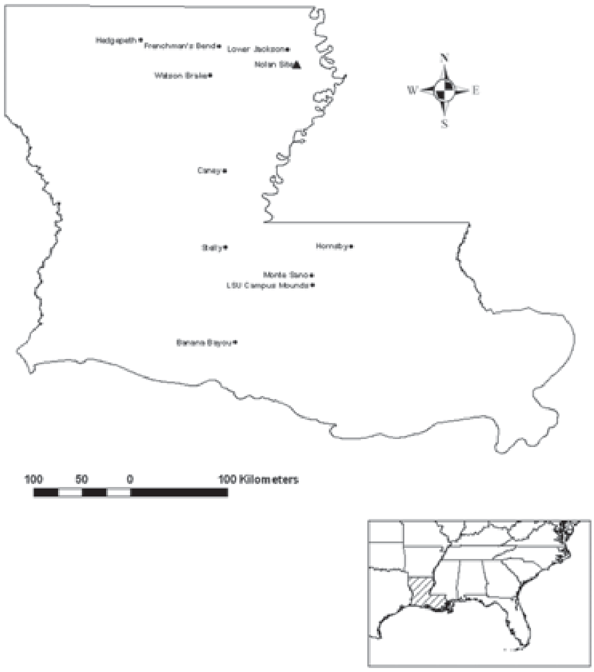

Figure 6. Middle Archaic mound sites in Louisiana.

Abandoned channels provide swamp and small stream habitats with diverse food resources and are amenable to human occupation (Saunders et al., 1997), which may explain the common association of Middle Archaic mound complexes with relict Arkansas River channels in northeast Louisiana (Figure 6). Three successive Stage 4 Arkansas meander belts can be found east of the Caney site (16CT5) (Saucier, 1994; Saunders et al., 2000). Frenchman's Bend (16OU259) and Watson Brake (16OU175) also lie near a relict channel of the Arkansas River (Saunders et al., 1994, 1997, 2005; Saunders, 2004). The paleohydrography of alluvial sediments and landforms may, therefore, aid in predicting the location of and subsequently identifying buried archaeological sites in this region, as well as assessing the likelihood of their preservation (Saucier, 1981; Guccione et al., 1998; Stafford, 2004). Additional coring directed toward refining our current knowledge of this Arkansas River paleochannel may aid in the identification of additional Middle Archaic mound sites in the Tensas Basin.

Crevasse Splay and Overbank Deposits

The archaeological remains at Nolan are immediately overlain by fine-grained sediments attributed to Mississippi River sources. The proximate sources of these Mississippi River sediments are abandoned channels associated with a mapped Mississippi River Stage 4 meander belt immediately east and south of the site. After abandonment, the Nolan area was blanketed by massive, fine-grained overbank deposits of varying thickness relative to the underlying landform. These sediments postdate the site occupation and thus are more recent than 4800 cal yr B.P.; however, they stratigraphically underlie the crevasse deposits (discussed below), which are radiocarbon dated after 3900 cal yr B.P.

These chronostratigraphic data are perplexing in light of existing age estimates for Mississippi River meander belts. What is mapped as the Mississippi River stage 4 meander belt in the Nolan site area is apparently considerably younger than its estimated age (~7500–4800 ^{14}C yr B.P). and may be equivalent to the age assigned to Mississippi River meander belt 2 (Saucier, 1994, pp. 257–260 and Figure 50). Saucier (1994, p. 257) notes the paleogeography of this meander belt is "especially confusing and uncertain." The total discharge of the Stage 4 river south of modern Helena, Arkansas, was evidently divided, and the Tensas Meander Belt segment shows characteristics of a major distributary rather than a full-flow channel (Saucier, 1994, p. 258). Because of the complex geology of the region, it is possible the deposits overlying Nolan relate to a relatively late reoccupation of a relict Stage 4 channel, which would account for an age estimate considerably younger than the date of the avulsion that formed this meander belt. We cannot judge the reason for the age estimate discrepancies, but we believe some of Saucier's mapped meander belt segments may be incorrectly identified; it is certain that the ages of these meander belts need to be carefully scrutinized.

A crevasse splay (known as the Indian Mound Crevasse) emanating from the nearby relict Stage 4 Mississippi River channel is mapped in the Nolan site area (Figure 4). Deposits associated with this crevasse are present in 14 of the Nolan site cores and overlie Mississippi River backswamp deposits, as well as cultural features. The thickest crevasse deposit found in the study area contained approximately 1.5 m of sediment, present in core 18 just northwest of Mound C. These deposits are characteristic of crevasse splay sediments, composed of fine sand and silt-sized particles forming coarsening-upward sediment packages that thin to the west and south (Smith et al., 1989; Farrell, 2001). The thickest of these deposits are found in the northeast corner of the site, indicating the relative proximity of this part of the site to the source of the crevasse (Coleman, 1969, p. 159). This interpretation is supported by aerial photography and digital elevation models of the site, in which the crevasse deposits and associated incised channel features, as well as their source at the Tensas Bayou channel, are visible (Figure 4).

Examination of local topography, channel features, and core lithology provides a tentative estimate of the minimum surface area of the deposits associated with the Indian Mound Crevasse, as well as a provisional definition of the crevasse edge near the Nolan site. This crevasse was at least 3 km in N–S diameter and extended approximately 2 km west from the modern Tensas Bayou channel along its midpoint. These estimates are based upon modern topographic and sedimentologic data, however, and the actual crevasse may have been significantly larger when it was initially deposited. Crevasse channels preserved on the modern land surface vary between 20 and 40 m in width. The presence of these channel networks suggests a significant period of crevasse activation (Smith et al., 1989; Farrell, 2001).

In addition to these surface features, granulometric data from the Nolan site trench strata indicate prolonged activation of the Indian Mound Crevasse. These data reveal different stages and variable composition of crevasse splay deposition in strata 4, 6, 8, and 10, representing distinct episodes of crevasse sedimentation with different depositional velocities near the Nolan site (Figure 5). Stratum 10 contains the highest percentage of sand and is likely associated with the initial activation of the crevasse. The multiple crevasse splay deposits, separated by overbank sediments in the trench and Nolan site cores, indicate repeated crevasse activation.

Examination of these crevasse deposits in relation to the Nolan site reveals the site is overlain by the southern edge of the Indian Mound Crevasse; therefore, the cores obtained from the Nolan site itself are unlikely to provide detailed information about the nature of the crevasse or the timing of its major depositional events. The edge of a crevasse deposit is not the locus of maximum deposition, as flow direction may vary across the lobe of sediment and material may be deposited in different areas at various times in its development. Crevasse deposits also generally thin as they prograde (Farrell, 2001). Differences in core stratigraphy may be attributed to the variable nature of crevasse deposits and their associated channels. Local, small drainage patterns in backswamps are often erratic and result in lateral variability of sediments, especially in the location and presence of coarser sediment horizons (Smith, 1996). These dynamic, low-gradient streams that feed into backswamps result in the extremely localized deposition of coarser particles from higher-energy flood events. As a result, horizons of silts and sands can be regionally discontinuous and often cannot be correlated between cores even when they are extracted within 30 m of each other (Krinitzsky and Smith, 1969; Saucier, 1994, pp. 102–105).

Nevertheless, the stratigraphy and chronology of the Indian Mound Crevasse and contemporaneous splays occurring on Joes Bayou aid our analyses of the Nolan site. A massive fine-grained clay deposit found in the Nolan site trench may represent a filled borrow area used for mound construction. Charcoal recovered from this deposit ~70 cm beneath splay deposits dates to 3870 cal yr B.P. (Figure 5; Table I). Radiocarbon dates from organic remains in backswamp clay immediately below one of the splays off Joes Bayou in core 43 indicate the crevasse deposits must be younger than 3469 cal yr B.P. (Figure 1; Table I). The oldest archaeological sites found on these splays date to the Early Woodland, supporting the interpretation that these splays formed in the intervening period. Radiocarbon dates from the Raffman (16MA20), St. Mary (16MA62), and Borrow Pit (16MA57) sites, located on the eastern edge of one of the splays, place the Early Woodland occupation at 2500–2200 cal yr B.P. Although we lack desired temporal precision, we conclude the splays must have formed in the period 3000–2600 cal yr B.P., at a time when the Nolan site was no longer occupied.

The origin of these splays is hypothesized to be the result of a brief but very intense period of basinwide flooding associated with large-scale global climate change ~3000–2600 cal yr B.P. (Adelsberger, 2005; Kidder, 2006). At this time, Joes Bayou was reactivated as a Mississippi River distributary and both this bayou and Tensas Bayou received massive amount of water and sediment leading to rapid crevasse formation. Unlike the crevasses that formed on Joes Bayou, the Indian Mound

Crevasse was periodically reactivated after the initial episode of sedimentation. The position of the crevasse sediments in relation to the mounds and other cultural strata provides a relative chronology for depositional events in the Tensas Basin. The stratigraphic relationship between the crevasse deposits and other natural as well as cultural horizons provides a distinctive marker for the identification of postoccupational sediments at the Nolan site. The subsequent burial and obfuscation of the Nolan site is primarily the result of the vertical accretion of backswamp sediments in the region, which occurred after the Indian Mound Crevasse splay was active. Dates for archaeological sites on the surface of crevasse sediments indicate deposition ended by 2600 cal yr B.P. at the latest (Figures 3 and 5).

Cultural Landscape Features

The largest and earliest-recognized cultural feature at Nolan is Mound A, which stands 3.5 m above the modern ground surface and had been the location of prior archaeological surface collections. However, none of the recovered artifacts are associated with the Middle Archaic period. Before the radiocarbon assays of this study, the presumed antiquity of the site was based solely on geomorphological and pedological investigations of Mound A (Saunders et al., 1994). The three additional earthen mounds at the Nolan site have very little modern topographic expression. The summit of Mound B is 80 cm above the floodplain, and the exposed portions of Mounds C and D stand 40 cm above the surrounding terrain. However, Nolan site core stratigraphy and sediment analyses permit the identification and assessment of the original vertical and spatial extent of the four earthen mounds and one earthen ridge that comprise the site (Figure 7).

Cultural deposits at Nolan consist of midden as well as of mound and ridge fill stages. These cultural sediments are primarily identified by the variable texture (from clay clumps to small packages of fine sand) and color (from very dark gray (10YR 3/1) to brown (7.5YR 5/4), often with strong brown (7.5YR 5/6) mottling of the sediment. The heterogeneity of the culturally modified sediments suggests they are composed of a mixture of sediments from various sources, collected in one place through human activity. Cultural horizons are composed primarily of silty clay and commonly contain carbonized organic material, particularly in the instance of midden deposits.

Recognition of cultural sediments aided the identification of buried earthworks in this alluvial setting. At the surface, Mound A is the largest of the four mounds found at Nolan; however, its base lies an additional 3 m below the modern surface of the floodplain. Its total height of 6.5 m makes this the second-tallest Middle Archaic mound currently known. Its dimensions are superseded only by the 7.5-m-high Mound A at Watson Brake (Saunders et al., 1997, 2005). Mound C is the second-largest construction at the Nolan site, with a total height of 3.9 m. The loaded horizons within core 30 and core 15 indicate the heights of Mounds B and D are approximately 3.3 and 3.1 m, respectively.

In addition to the expected identification of cultural layers at Mounds A, B, C, and D, loading episodes were detected between Mound A and Mound C. In contrast,

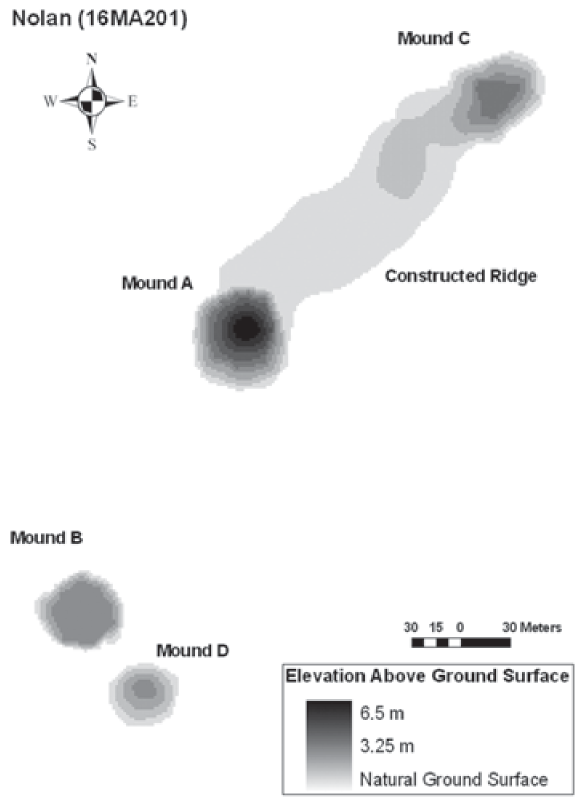

Figure 7. Reconstruction of the Nolan site earthworks before burial.

cores did not reveal artificial constructions between Mounds A and B or B and D. The culturally constructed ridge is not visible on the surface and was identified in the field within cores 16, 25, 52, and 67. Core 67 contained up to 2.11 m of fill, which may demarcate the crest of the ridge. Field descriptions of core 53 noted possible loaded horizons; however, the cultural or natural origin of the deposits could not be readily determined. Stratigraphic comparisons and microartifact and loss-on-ignition analyses were, therefore, required to reveal the spatial extent of this completely buried architectural component.

Stratigraphy of Cores 52 and 53

Core 53 lies approximately 87 m south of core 52 and is farther away from the ridge's hypothetical crest (Figure 2). Analyses of soil horizons within cores 52 and 53 reveal a number of differences in their depositional sequences (Figure 8). The strata identified as loaded or possibly loaded deposits of the artificial ridge lie between the deepest buried A horizons and the Indian Mound Crevasse deposits within each

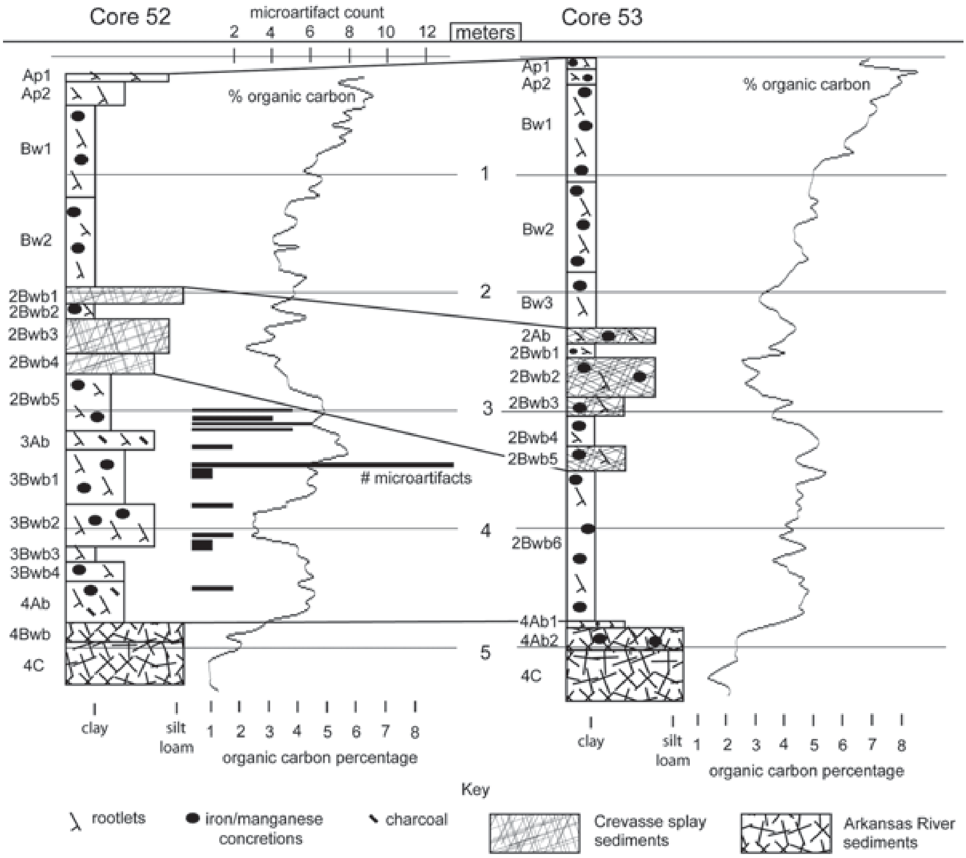

Figure 8. Stratigraphy of core 52 and core 53 showing microartifact counts and organic matter content percentages. Microartifact counts refer to the number of bone fragments present. Meters are depths below surface level of core 53. Ground surface indicated by Ap1 in each core.

core. After the abandonment of the Arkansas paleochannel, there was a period of landscape stability indicated by the weakly developed 4Ab and 4Ab1/2 horizons in cores 52 and 53, respectively. Subsequent deposition of sediment buried both horizons.

The 2Bwb1, 2Bwb3, and 2Bwb4 horizons present in core 52 and the 2Ab through 2Bwb5 horizons in core 53 are comprised of coarser particle sizes and represent Indian Mound Crevasse deposits. The position of the horizons showing evidence of higher-energy depositional events is a source of variability between cores 52 and 53. There are no Indian Mound Crevasse sediments found between the two buried A horizons in core 52. Conversely, crevasse sediments are present between the 2Ab and 4Ab1 horizons within core 53. Events of crevasse splay deposition between the buried A horizons in core 53 are followed by a period of stabilization when the 2Ab horizon formed. Within core 52, no such pedogenesis occurred after these high-energy depositional events and before soil-formation processes associated with the modern land surface.

The relative chronology established for mound construction activity and the Indian Mound Crevasse deposits provides information regarding the earthen ridge at the Nolan site. Only those deposits located stratigraphically below the Indian Mound Crevasse deposits in both cores can be associated with ridge construction activity, as occupation of the Nolan site had ended before deposition of crevasse sediments (Figure 8). Mound and ridge-loading episodes were identified in cores 16, 25, 52, and 67 (Figure 2), which were extracted between the mounds; however, identifying cultural deposits found within other cores proved more difficult in the field and necessitated laboratory analyses.

Microartifact and Loss-On-Ignition Analyses

Microartifact and loss-on-ignition analyses were conducted on cores 52 and 53 to accurately define the morphology and extent of the culturally deposited ridge between mounds A and C. These analyses provide for a more accurate determination of the boundaries of the cultural ridge by increasing the resolution of stratigraphic profiles and revealing additional, subtle differences between strata (Stein, 1984).

Microartifacts

Because of the limited volume of soil contained within a single core, screening for microartifacts provides the most comprehensive method to identify and extract potential cultural material. Moreover, microartifacts often constitute a relatively large proportion of the cultural material at archaeological sites and provide valuable information for distinguishing natural from cultural deposits, as well as identifying site-formation processes (Butzer, 1978; Fladmark, 1982; Hull, 1987; Stein and Teltser, 1989; Dunnell and Stein, 1989; Rosen, 1993; Stafford, 1995, 2004; Sherwood, 2001, p. 328). The analysis of particles larger than 0.5 mm within cores 52 and 53 corroborates the evidence provided by qualitative comparisons, which suggest the culturally constructed ridge represented in core 52 does not extend as far south as the location of core 53. Screening of the sediment from strata between the buried A horizons within core 52 produced fragments of calcined and unburned bone. Twenty-three bone fragments, 10 of which were burned, were identified in six horizons within core 52, suggesting these sediments were culturally deposited (Figure 8).

Core 53 contained charcoal fragments and natural inclusions; however, all samples from the core were void of microartifacts. Sediment collected from strata within both cores includes redoximorphic features, such as iron oxide and manganese nodules, formed through repeated episodes of soil wetting and drying (Buol et al., 2003). Additional natural features related to floodplain hydrology include calcareous accumulations formed through seasonally influenced changes of the water table (Saucier, 1994; Aslan and Autin, 1998). Owing to lateral variability of these features commonly present in backswamp environments, the stratigraphic differences between these soil features provides little relevant information (Aslan and Autin, 1996, 1998; Smith, 1996). For example, changes in the depth of soil features, such as mottling and slickensides, coincide with seasonal water-table fluctuations and cycles of soil wetting and drying, increasing in depth towards the lowest elevations (or centers of backswamps) where the seasonally low water table is depressed (Aslan and Autin, 1996; 1998, p. 440). These autogenic mineral accumulations are normal components of backswamp sediments in this region (Saucier, 1994; Aslan and Autin, 1996, 1998). Other expected natural inclusions extracted from these sediments include uncarbonized plant remains, rootlets, seeds, and seed coats.

Loss-On-Ignition and Organic Carbon Content

Loss-on-ignition analyses provide more information regarding the depositional sequences of cores 52 and 53 (Figure 8). Although high clay content of sediment can influence results (Holliday and Stein, 1989; Smith, 2003; Santisteban et al., 2004), the organic matter percentages obtained in the course of this study are typical of buried vertisol A horizons, which generally average 3.5% (Buol et al., 2003, p. 64). Thus, these analyses appear to have produced an accurate assessment of organic matter content.

Beginning with the lowermost soil horizons, the 4Ab horizons within core 53 contain less organic matter than the 4Ab horizon within core 52. Furthermore, it appears more of this organic material was translocated to lower horizons within core 53 than core 52. These differences suggest the 4Ab horizon within core 52 was more quickly covered with sediment through the construction of the artificial ridge, which lessened subsequent translocation of organic matter down the soil column.

Although interrupted by the crevasse splay deposits, the organic carbon content of core 53 resembles that of the expected natural backswamp sequence, in which organic carbon content decreases with depth (Aslan and Autin, 1998). The expected lower organic content of the crevasse deposits is displayed in both cores. However, organic carbon content within core 52 exhibits a more irregular pattern. In addition to the higher organic carbon content of buried A horizons in core 52, the carbon content of horizons lying between them is less uniform. Specifically, samples from the 3Bwb2 horizon, which is located in the middle of the sequence of loaded deposits, contain approximately 2.5% organic carbon. This variable content may represent a different source or deposit depth from which building material was being gathered. However, off-site cores must be extracted and analyzed to determine whether these patterns exist elsewhere. Additional loss-on-ignition analyses of Nolan site cores will be necessary to reveal intrasite variability of organic carbon content between different cores and their horizons. These analyses may aid in the identification of other cultural and architectural features currently hidden beneath the surface of the Mississippi River floodplain.

THE MIDDLE ARCHAIC LANDSCAPE IN LOUISIANA

The Middle Archaic mounds of Louisiana represent the earliest evidence of monumental architecture in North America (Figure 6). As a result, the structural components and locations of these mound sites are important to our understanding of landscape utilization, human social organization, and cultural integration in this period (Anderson, 2002, 2004). There is a great deal of variation in the composition of Middle Archaic mound sites, including the number and size of mounds as well as their layout and orientation. The scale of construction ranges from single conical mounds at Lower Jackson (16WC10) and Banana Bayou (16IB24) to the 11 mounds and series of connecting ridges at the largest-known Middle Archaic mound site, Watson Brake (Gagliano, 1967; Brown and Lambert-Brown, 1978; Saunders, 1994; Saunders et al., 1997, 2001, 2005). In addition to variation in monumental architecture, differences in artifact assemblages exist. For instance, the distribution and presence of lapidary technologies, stone beads, and fired-earthen objects differs from site to site (Saunders et al., 1998, 2005; Johnson, 2000; Saunders, 2004).

Despite this intersite variability, all known Middle Archaic mound sites, other than Nolan, have been constructed solely on Pleistocene-age terraces or older landforms (Figure 3) (Saunders et al., 1994, 1997; Saunders and Allen, 1995). Among the Middle Archaic mound complexes in Louisiana, the Nolan site is the only site situated on the Holocene floodplain. However, the ostensible uniqueness of the Nolan site's location may be attributed to fluvial deposition of sediment in the floodplain setting and burial of contemporaneous sites. Moreover, the known Middle Archaic mounds are typically smaller than those found at the Nolan site, which contains the second-largest mound currently identified from this period. Sites such as Monte Sano (16EBR17), Hornsby (16SH21), and Banana Bayou include mounds ranging from 1.5 to 4.0 m in height (Gagliano, 1967; Brown and Lambert-Brown, 1978; Manuel, 1983; Gibson and Shenkel, 1988; Saunders, 1994; Russo, 1996). Mounds of this size would be even more likely to be buried by the vertical accretion of sediment. Therefore, Middle Archaic sites in the alluvial valley with similar mound dimensions may now be entirely undetectable on the surface. Even the incomplete burial of earthenworks, when combined with more recent landscape alterations by humans such as modern farming practices, can significantly reduce the topographic expression of mounds and, therefore, lessen their visibility. In addition, an unknown number of Middle Archaic mound sites may have been completely destroyed through the lateral migration of Mississippi River channels.

The geometric similarity of the Middle Archaic mound complexes in Louisiana has led some to suggest mound construction across portions of the Middle Archaic landscape was a planned endeavor that operated at a regional rather than site-level scale (Sassaman, 2004; Sassaman and Heckenberger, 2004). The detection and reconstruction of the monumental architecture at Nolan has identified the site as a component of this group of sites with similar mound layouts.

The Nolan site, Watson Brake, Frenchman's Bend, Stelly Mounds (16SL1), and the Caney site share many structural characteristics (Russo and Fogleman, 1994; Sassaman and Heckenberger, 2004). All these sites include a line of earthen embankments and mounds oriented along an alluvial terrace, escarpment, or landform that overlooks a river or stream (Saunders et al., 1994, 1997, 2000, 2005; Sassaman and Heckenberger, 2004). The largest mound of each complex is typically centrally located within the linear formation of earthen mounds and ridges, resulting in an arcuate, circular, or elliptical arrangement of earthenworks (Sassaman, 2004; Sassaman and Heckenberger, 2004). The discovery of these features at the Nolan site suggests more Middle Archaic mound sites of similar architectural layout may remain undiscovered on the Mississippi floodplain, awaiting geoarchaeological methods capable of uncovering their monuments.

CONCLUSIONS

The coring of archaeological sites provides an efficient and relatively nondestructive method to investigate natural and cultural paleolandscapes, and this method is particularly useful when sites exist in deeply buried contexts (Stein, 1986). Stratigraphic interpretations, enhanced through laboratory analyses of both natural and cultural deposits within the Nolan site cores, permit the correlation of strata and afford a better understanding of the complex geomorphic and cultural history of the Tensas Basin.

The stratigraphy of the Nolan site reveals the presence of Arkansas River deposits beneath four earthen mounds and one earthen ridge constructed at approximately 5200 cal yr B.P. The texture of Arkansas River sediments and their stratigraphic positions within the Nolan site cores indicate the location of a previously unrecognized and unmapped segment of the Stage 4 Arkansas River meander belt. In addition, the stratigraphy and dating of the Nolan site have refined the geochronology of the Stage 4 Mississippi and Arkansas River meander belts. Before this study, these relict channels were thought to have been active in the same time interval (7500–6200 ^{14}C yr B.P. (Saucier, 1994). Our data suggest the Arkansas River Stage 4 channel immediately adjacent to the Nolan site became inactive ~5200 cal yr B.P, earlier than previous estimates. Stratigraphy and dates from the Nolan site suggest a considerably younger age for the Stage 4 Mississippi River meander belt as well, which was active in this area by 4800 cal yr B.P. but not before 5200 cal yr B.P. Results from geoarchaeological work at Nolan provide one of the few examples of tightly constrained chronostratigraphic data from the entire Lower Mississippi Valley and demonstrate the critical significance of integrating archaeological and geological data in this highly dynamic fluvial environment (Saucier, 1994, pp. 13–15; Kidder, 1996, pp. 306–312). Future research in the Lower Mississippi Valley will likely reveal additional problems with the extant locations and chronology of relict river channels and allow for the refinement of current knowledge on this topic.

The Nolan earthworks were later buried by overbank flooding and crevasse splay sediments originating from ancestral Mississippi River channels. In this study, differences between stratigraphic sequences in core samples, elucidated via microartifact and loss-on-ignition analyses of cores 52 and 53, allow for a more accurate determination of the nature and origin of deposits at the Nolan site. In addition to providing a more accurate reconstruction of the Nolan site, determining the location and extent of its architectural features adds to our knowledge of regional mound site similarity and variability in the Lower Mississippi Valley in the Middle Archaic.

Despite its burial and obfuscation, the Nolan site has been identified as the second-largest known Middle Archaic mound site in the Lower Mississippi Valley. Mound A is 6.5 m tall, and Mound C reaches a height of 3.9 m. Mounds B and D are both more than 3.0 m tall. The boundaries of a culturally constructed ridge (with a maximum height of 2.11 m) located between mounds A and C have been more accurately constrained. Identification and reconstruction of the monumental architecture at the Nolan site reveals similarities among the layout and environmental setting of Nolan and other Middle Archaic mound complexes in Louisiana. In addition to identifying the Nolan site as a component of this group of similar Middle Archaic mound complexes, this study provides a demonstrated method for future archaeological surveys in alluvial environments.

Aside from the Nolan site, no other Middle Archaic mound sites have been identified in the Holocene floodplain of the alluvial valley. The apparent absence of additional sites may be attributed to natural fluvial sedimentation processes, which may have buried sites and resulted in the poor representation of Archaic sites in alluvial valleys (Stafford, 2004). Geoarchaeological investigations of dynamic floodplain environments reveal the inadequacy of surficial techniques in recording Archaic sites and studying settlement patterns in this period (Wiant et al., 1983; Hajic, 1993; Bettis and Hajic, 1995; Mandel, 1995; Stafford and Creasman, 2002). In the absence of extensive subsurface investigations, such as those conducted at the Nolan site, this record may remain undetected (Stafford and Creasman, 2002).

Distinguishing between cultural signatures or modifications made to the landscape and those of natural origin permits investigation of buried archaeological landscapes. Knowledge of natural sedimentary processes and the resolution of paleolandscape reconstructions are enhanced by the relative temporal precision of dated archaeological sites (Kidder, 1996). The value of studies that combine sedimentary and cultural contexts lies in their ability to reveal specific events of landscape alteration and hydrologic dynamism (Rosen, 1993). Intensive coring and other subsurface studies advance our knowledge of the first mound builders in North America through the reconstruction of the natural landscapes in which they lived, with which they interacted, and of which they were an integral part (Kidder, 1996). These methods provide the only means to adequately investigate the buried Middle Archaic landscapes in this region and advance our knowledge of the unique mound-building groups of Louisiana.

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