Illinois Preliminary Geologic Map
IPGM Monks Mound-SG

Surficial Geology of Monks Mound Quadrangle

Madison and St. Clair Counties, Illinois

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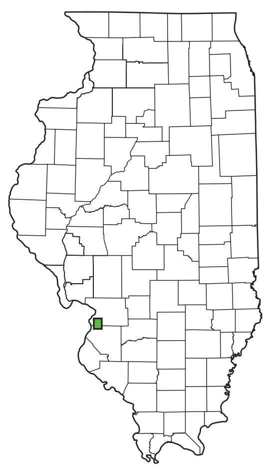
2007



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Introduction

The Monks Mound Quadrangle is located in southwestern Illinois about 5 to 10 miles east of St. Louis. A large area of the quadrangle is contained within the American Bottoms, a large alluvial valley of the Mississippi River (fig. 1), containing up to 125 feet of waterlain clay, silt, sand, and gravel above bedrock. The eastern 0.5 to 2.0 miles of the quadrangle contain glaciated uplands blanketed by thick loess. The relatively steep bluff edge separating the uplands and the American Bottoms has up to 150 feet of relief. Alluvial fans, composed of reworked deposits of the highly erodible loess, occur where large creeks emanate from the bluff line. Only a few exposures of bedrock (Pennsylvanian-age shale and coal) occur, primarily in upland ravines near the bluffs in the southeastern portion of the quadrangle (F.B. Denny and J.A. Devera, personal communication, 2001).

Methods

Map

This surficial geologic map is based in part upon soil series parent materials compiled from the Madison County and St. Clair County soil surveys (Goddard and Sabata 1982, Wallace 1978), but was modified based upon data obtained from field observations, drill cores obtained for this project, Illinois Department of Transportation (IDOT) borings, other engineering borings, and water well logs.

Cross Sections

The cross sections portray the near-surface deposits as would be seen in a slice through the earth down to bedrock. The locations of the cross section lines are shown as thick black lines on the surficial map. Data used for subsurface unit contacts (in approximate order of quality) are from studied outcrops, field descriptions of previous geologists (e.g., McKay 1977, 1979) and archeologists (Ollendorf 1993), stratigraphic test holes, engineering boring records (primarily IDOT), water well records, and coal test hole borings. A detailed 0.75 mile seismic reflection profile (fig. 2) was run in Horseshoe Lake State Park and correlated to subsurface interpretations. Although the lines of cross section intersect most borehole records, selected records were projected from up to 1000 feet to the cross section line. The projected data, indicated as dashed vertical lines on the cross sections, were transferred to points of similar elevation and similar geomorphology. Geologic unit contacts are dashed where the quality of sediment descriptions was less reliable or less detailed, particularly for some water well and coal test records. All subsurface data shown in the cross sections are on file at the ISGS Geologic Record Unit.

Upland Surficial Deposits

The following deposits occur in the 0.5 to 2-mile wide hilly upland area east of the bluff line. Illinois Episode glaciers are known to have crossed this area, just barely entering Missouri about 5 miles west of this quadrangle (Goodfield 1965, Willman and Frye 1970, Grimley et al. 2001). Rare exposures of Pennsylvanian shale and limestone occur at sites 29143 (Sec. 8, T3N, R8W) and 30651 (Sec. 8, T2N, R8W).

Pre-Illinois Episode Deposits

Pre-Illinois episode deposits have not yet been observed in the Monks Mound Quadrangle, but may occur in the subsurface in deep bedrock valleys. Previous studies indicate that the pre-Illinois episode deposits occur in many bedrock lows (typically <450 feet elevation) to the east (McKay 1979, Phillips 2004). One stratigraphic test hole was drilled just 1,000 feet east of the south portion of this quadrangle in a buried bedrock valley (Robbins Core #29889: NW, Sec.9, T2N, R8W) that encountered 64 feet of pre-Illinois episode deposits (12 feet of silty clay loam accretion gley over 28 feet of silt loam to silty clay loam diamicton over 24 feet of fossiliferous silts). This core, by extrapolation, is the basis for pre-Illinois episode deposits (Banner Formation) in the eastern part of cross section D–D′. The following members within the Banner Formation (not described on legend) may be present: upper accretionary deposits containing strong weathering of the Yarmouth Geosol (Lierle Clay Member; Willman and Frye 1970), diamicton interpreted as till deposited by glacial ice originating from the east or northeast (Omphghent member; McKay 1979), and underlying silt interpreted as proglacial slackwater lake sediment in an ancestral Canteen Creek valley (Harkness Silt Member; Willman and Frye 1970).

Illinois Episode Deposits

Deposits of the next to last glaciation (Illinois Episode) include mainly proglacial lake sediments, till, and thin loess. They can be delineated from pre-Illinois episode sediments primarily on the basis of Yarmouth Geosol alteration in older deposits. At the base of the Illinois Episode succession, calcareous silty lake deposits (Petersburg Silt), as much as 20 feet thick, is found underlying till, particularly in ancestral valleys. Such proglacial silt is faintly bedded and may contain numerous fossil spruce wood fragments and a rich fossil assemblage of small aquatic (e.g., *Fossaria*), terrestrial (e.g., *Vertigo, Stenotrema*), and amphibious (e.g., *Pomatiopsis*) gastropods, about 1 to 7 mm in size, as well as small pill clams. *Pomatiopsis scalaris*, found in outcrops of Petersburg Silt (sites 30646 and 30647), is a genus common to moist areas near streams or in shallow water with freshwater plants and is common in the Petersburg Silt in this region (Grimley and McKay 2004). This amphibious gastropod is helpful with relative age determinations because this species does not occur in Wisconsin Episode or younger deposits in Illinois (Baker 1931). The Petersburg Silt is commonly found in bedrock lows or valleys which were backflooded as the Mississippi River aggraded to a maximum elevation of about 475 feet during the Illinois Episode. However, the lake deposits consist mainly of silt and wood fragments that were likely washed into lowlands from surrounding loess-covered uplands.

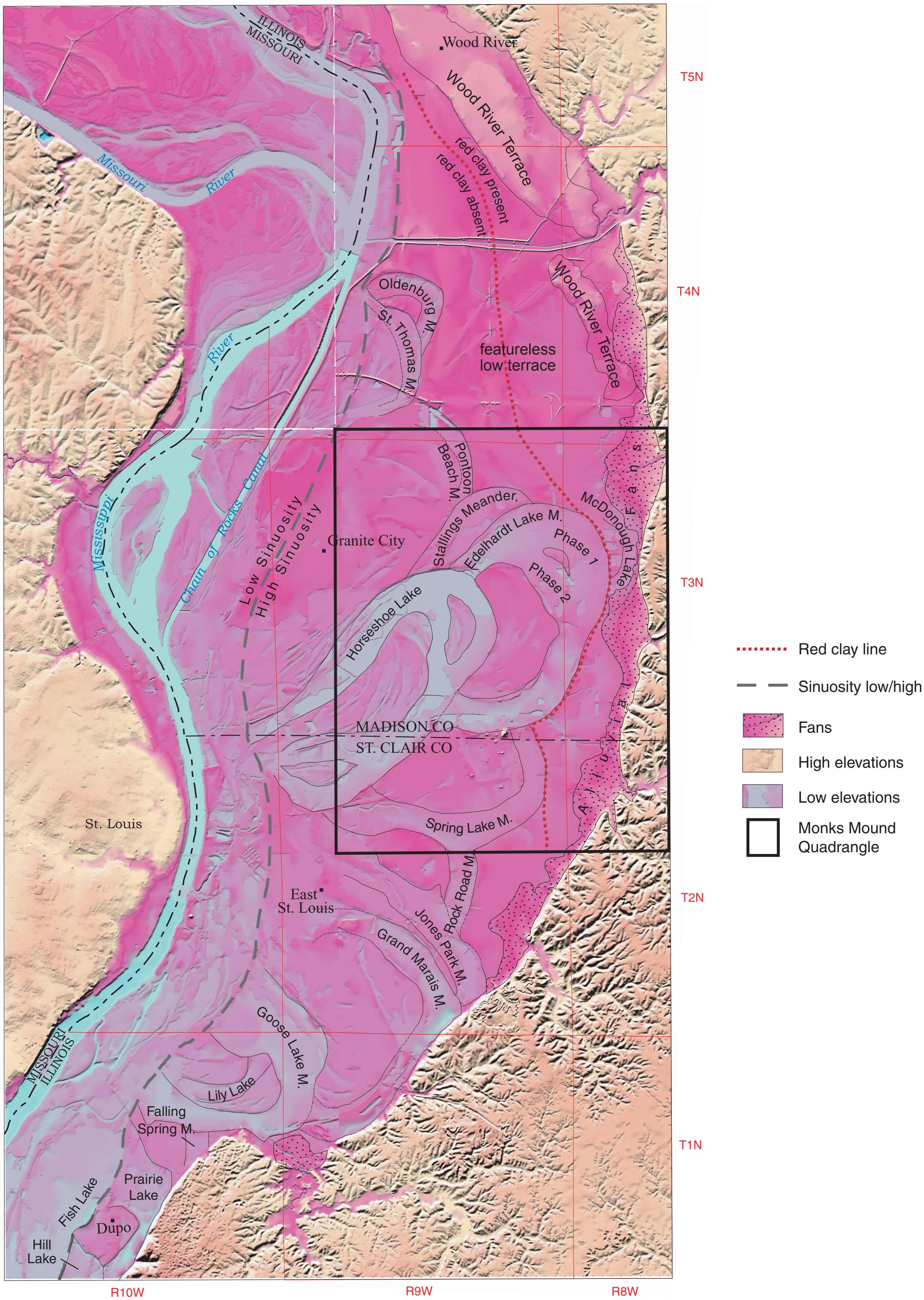

Figure 1 Physiographic map in shaded relief of the American Bottoms in Madison and St. Clair Counties, Illinois. Approximate age of labeled features described in table 1.

Table 1 Approximate age of geomorphic features in figure 1.

Landform		Date of formation or abandonment (radiocarbon years before present)	Surface Environment	Reference
Wood River Terrace		12,000–10,000	outwash, dunes	Hajic 1993; Flock 1983
“Featureless” low terrace		9,800–2400	erosional terrace, overbank	Hajic 1993
High sinuosity meander belt	McDonough Lake	10,600–9,800	abandoned channel	Rissing 1991
	Prairie Lake	5500	abandoned channel	White et al. 1984
	Edelhart Lake	Phase I: 5,500–4,500 Phase II: 4,500–3,600	abandoned channel	Rissing 1991
	Grand Marais	3280–3090	abandoned channel	Phillips and Gladfelter 1983
	Goose Lake	3180–3150 2500–2300	active channel abandoned channel	Gladfelter 1979 White et al. 1984
	Hill Lake	3500–3100	abandoned channel	White et al.1984
	Horseshoe Lake	2400 (abandoned)	lake, point bar	Gladfelter 1981; Hajic 1993, 1998; Booth and Koldehoff 1999
Low sinuosity meander belt		2,400–present	channel, levee, crevasse splay	Gladfelter, 1981; Hajic 1998; Booth and Koldehoff 1999

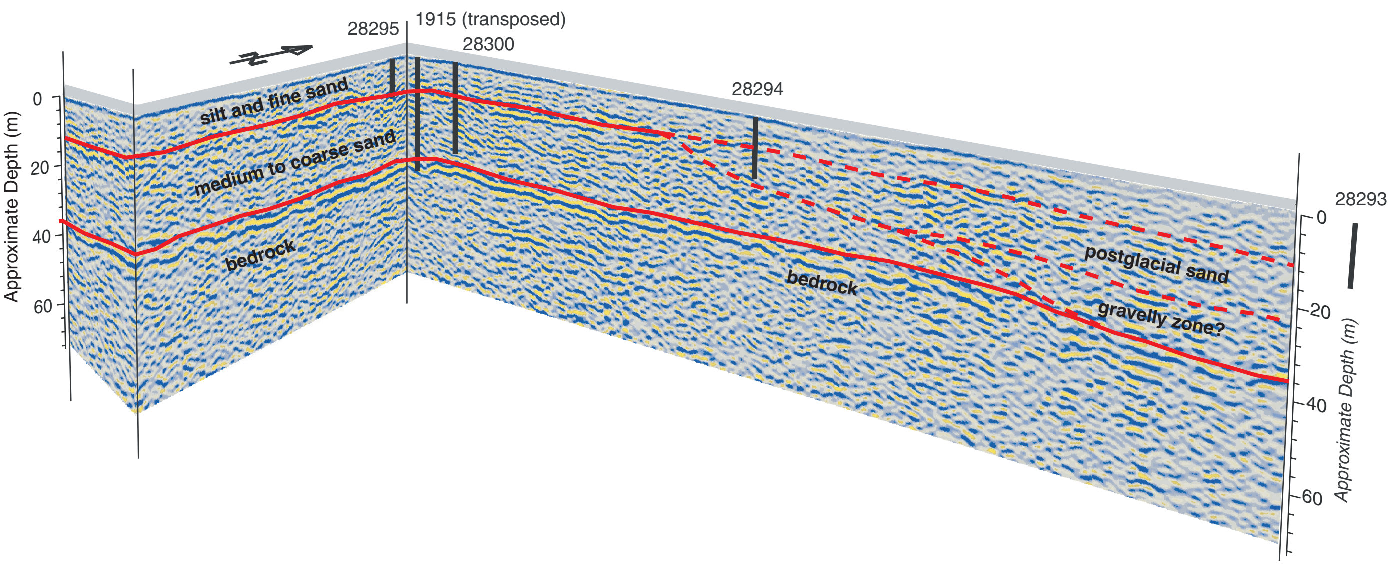

Figure 2 This is a perspective view of shear wave profiles collected by landstreamer along Horseshoe Lake Road (Sec. 28, T3N, R9W). The section is partly penetrated by 3 boreholes and completely penetrated by water-well boring 1915. The bedrock surface is generally level, but deepens to the east. Deeper sand and gravel overlying bedrock is likely Wisconsin Episode outwash. The lower gravelly zone fills a bedrock swale and is correlated to boulder trains described by Bergstrom and Walker (1956). The upper finer deposits show cross-cutting relationships and probably represent migrating channels in the mid- to late Holocene. These units fine upwards from coarse sand to fine sand to silt.

A calcareous silt loam to loam diamicton (Glasford Formation), up to about 45 feet thick, commonly overlies Petersburg Silt or older deposits. This diamicton, interpreted as till, includes sand bodies deposited by glacial meltwater. Local Pennsylvanian shale and sandstone pebbles, as well as spruce wood fragments are common in unweathered, unoxidized till. The Glasford Formation is commonly overlain by 5 to 10 feet of weathered silt loam to silty clay loam deposit classified as the Teneriffe Silt. This is a windblown silt (loess) or reworked loess that was deposited following the retreat of glacial ice to the northeast. The upper few feet of the Teneriffe Silt contains the soil weathering profile of the Sangamon Geosol.

Wisconsin Episode Deposits

Windblown silt (loess), up to 90 feet thick, blankets older deposits in upland areas. These loess deposits, perhaps the thickest in Illinois, have been the focus of much research (e.g., Keller Farm (29153) and Pleasant Grove School Sections (29154)) because they reveal a fairly continuous record of paleoclimate and geologic history (Willman and Frye 1970, McKay 1977, Wang et al. 2000). The loess was derived from windswept outwash in the Mississippi Valley and to a lesser degree the Missouri Valley. Prevailing winds from the west to northwest deposited the thickest loess on uplands at the east side of the widest portion of the American Bottoms. Loess deposits consist of the Peoria and Roxana Silts. Typically, the older Roxana Silt is distinctively pinkish-brown, in comparison to the yellow-brown Peoria Silt, but it does contain a tan middle zone, having a similar appearance to Peoria Silt. The Roxana Silt is generally thinner and has slightly more sand, coarse silt, and clay than the Peoria Silt (McKay 1977). The Roxana Silt was deposited between about 55,000 and 28,000 radiocarbon years before present (RCYBP) and the Peoria Silt between about 25,000 and 12,000 RCYBP (McKay 1977, Grimley et al. 1998, Wang et al. 2000). Dark organic bands within the Peoria Silt represent warmer interstadial periods of soil formation (Wang et al. 2000). Both loess units contain large terrestrial gastropods.

Fine-grained lake deposits of the last glaciation (Equality Formation) occur in lower reaches of the larger tributaries to the Mississippi Valley, such as in the Canteen Creek Valley. Analogous to the Petersburg Silt, the Equality Formation was deposited in a slackwater lake environment when high water levels existed in the Mississippi Valley. This unit tends to occur in terraces at 475 to 480 feet elevation. The Equality Formation is mapped at the surface in one terrace (Sec. 5, T2N, R8W) in the southeast portion of the quadrangle. Deposits of Equality in this terrace in stratigraphic test hole #29938 are up to 105 feet thick and range in age from 45,000 to 17,000 RCYBP (Curry and Grimley 2006). The deposits are typically tan to gray, stratified, very fine sand and silt in upper portions, and reddish-brown to gray silty clay loam to silty loam with occasional gastropods in lower portions. The reddish-brown lower unit is similar in age and mineralogy to the Roxana Silt, from which it was likely derived (Curry and Grimley 2006). Subsurface borings indicate that the Equality Formation also occurs beneath postglacial alluvium (Cahokia Formation) in the larger creek valleys such as Canteen and Little Canteen Creeks, Schoolhouse Branch and Judy's Branch, as was mapped by Phillips (2004) immediately to the east.

Postglacial Deposits

In most of the tributary stream valleys east of the Mississippi Valley, postglacial river sediment (Cahokia Formation, upland facies) consists of up to 30 feet of silty sediment with some silty clay and some sand and gravel lenses. The Cahokia Formation tends to be thicker near the mouths of some of the larger creeks such as Canteen Creek and Judy's Branch. Because of the high erodibility of loess deposits, the Cahokia Formation in upland tributaries has a large component of redeposited Peoria and Roxana Silt. Sandy or gravelly layers occur as lenses or layers near the unit base in larger valleys.

On upland areas, the modern soil, typically a native forest soil (Alfisol), has developed into the Peoria Silt in the upper 3 to 5 feet. In addition, loess deposits have been leached of carbonates to depths of about 5 to 15 feet. Often these carbonates reprecipitate at lower depths into irregularly shaped nodules or concretions.

American Bottoms (Mississippi Valley)

Filling and excavation of the Mississippi River valley likely occurred several times during the Quaternary Period. River sediment associated with pre-Wisconsin glaciations presumably filled the valley at one time but has since been eroded. During glaciation of the Upper Midwest in the Wisconsin Episode, the valley was filled with outwash deposited from braided streams to an elevation of about 480 feet above sea level based on tributary terrace elevations (Grimley and Lepley 2005). Following the retreat of sediment-rich continental glaciers from the Midwest, the Mississippi River evolved from a braided to a meandering system between about 10,000 and 8500 RCYBP (Hajic 1993, Blum et al. 2000). The meandering Mississippi River migrated across the central and western portions of the valley to its present location, depositing river sand, silt, and clay unconformably on top of glacial sediments. High-sinuosity meandering between about 8500 and 2400 RCYBP left prominent meander scars and related point bar, levee and backswamp features over a large portion of the bottoms (fig. 1, table 1). At about 2400 RCYBP, the system evolved further from a high to a low-sinuosity meandering regime (Hajic 1993, Booth and Koldehoff 1999) and has since occupied the western portion of the American Bottoms (dashed line in fig. 1). However, flood waters periodically deposited fine sediment across much of the American Bottoms prior to construction of large levees in the past century.

Deposits in the Mississippi River valley, outlined below, consist of mixed waterlain clay, silt, sand, and gravel. Deposits are texturally variable in the upper 50 feet because of the variety of sedimentary environments associated with former Mississippi River channels. Sediments tend to coarsen at depth (see cross sections, fig. 2), with sand and gravel outwash typically comprising the lower one-third to one-half of the sediment volume.

Glacial Outwash
A medium to coarse sand with some fine sand and gravel (Henry Formation) is the oldest known outwash still preserved in the Mississippi Valley in the Monks Mound Quadrangle and lies unconformably on bedrock. As much as 100 feet thick, the Henry Formation may contain some large erratic pebbles, cobbles, and boulders, particularly in the lower 15 feet. Its deposition is related to glacial advances in the upper Midwest that did not reach the study area but caused aggradation in the Mississippi and Missouri Valleys. The upper, near-surface portion of the Henry Formation is fine sand, such as in the ridge mapped west of McDonough Lake. The sand here is suspected to be Henry Formation because postglacial red clay (see below) is found immediately west of the ridge but not within the ridge (Higgins 1990). The Henry Formation begins to thin within about 0.5 miles of the bluff edge as the bedrock surface rises. In a few places, a reddish colored sand or gravel, noted in water well records and engineering boring logs at depths of ~90 to 100 feet, may represent the middle Wisconsin Episode outwash associated with Roxana Silt and lower Equality Formation deposition.

Red Clay Layer (Glacial/Postglacial Boundary)
In the easternmost mile or so of the American Bottoms in this quadrangle (east of the red dashed line on map and fig. 1), it is envisioned that the postglacial Mississippi River has never meandered because of the presence of thin red silty clay beds present below gray overbank silty clay. The red clay, usually 1–2 feet thick, is interpreted to be sourced from the Lake Superior region, perhaps from a glacial lake outburst, and was deposited between about 9900 to 9500 RCYBP in the region (Flock 1983, Hajic 1993). Wood in organic-rich gray clay immediately above red clay has an age of 9259±200 (ISGS-1559) at about the 23-foot depth immediately northwest of the Henry "bar" mapped west of McDonough Lake (SE, Sec.7, T3N, R8W) (Higgins 1990). Radiocarbon ages of 7890±120 (ISGS-4893, 21.5-foot depth) and 7850±140 (ISGS-4895, 19.5-foot depth) were determined on wood fragments in the lower portion of a silty clay in Sec. 6, T3N, R8W, immediately overlying a red clay layer. The red clay essentially separates postglacial clayey sediments (Cahokia Formation) from underlying glacial outwash (Henry Formation). Based on fifteen observations of the red clay in the subsurface in the Monks Mound and Wood River Quadrangle (immediately to the north), the top of the clay typically occurs between 395 and 403 feet elevation above sea level.

Postglacial Deposits
Postglacial deposits mapped in the American Bottoms consist of fine to medium sand (Cahokia Formation, sandy Mississippi Valley facies), silt to silty clay (Cahokia Formation, clayey Mississippi Valley facies), silty to loamy alluvial fan deposits, and disturbed ground. Sandy and clayey deposits near the surface generally coincide with subtle changes in topography (compare surficial map to fig. 1) associated with meander scars and are often reflective of material to a depth of 10 to 60 feet (see cross sections). Topographic expression has become subdued because of vertical accretion of flood sediments in low areas on the meander scars. In the subsurface, sandy valley deposits commonly interfinger with and are overlain by silty clay to silty clay loam, in swale fills and abandoned channels of the Mississippi River (cross section B–B′). During floods fine to medium sand was generally deposited adjacent to channels to form ridges, and silt and clay was deposited farther from the channel in backswamp environments. Multiple depositional environments have occurred at any given location as the Mississippi River meander belt shifted through time with the river eroding on the outside of meander bends and depositing sediment on the inside. Post-depositional erosion or slumping of sandy ridges into former channels and/or reoccupation of channels by the river may also have caused sediment interspersal.

Previous studies of the valley sediments (Bergstrom and Walker 1956, Willman and Frye 1970) and our study have concluded that sand-rich sediments (Cahokia Formation, sandy valley facies) are mainly postglacial channel and point bar sediments. These sands are predominantly fine to medium and are typically 50 to 65 feet thick. Fining-upwards sequences, observed in detailed core descriptions from a Horseshoe Lake State Park point bar, record the migration of environments from channel sands through overbank fines. In the cross sections, the boundary between Cahokia and Henry sand was estimated where the sand coarsens or at the base of clay-filled, abandoned meander channels. In some water well logs and sample sets, clay layers were found to occur near the base of the Cahokia Formation. In other cases, the textural distinction between postglacial and glacial sand was not obvious from water well or engineering logs.

Clay and silt-rich sediments (Cahokia Formation, clayey Mississippi Valley facies) are interpreted as floodplain, backswamp, or abandoned channel deposits. Many oxbow lakes and abandoned meanders are clearly visible as present-day lakes or as patterns of surficial clay on the surficial geology map and on the shaded relief map (fig. 1). Abandoned channels in the high-sinuosity meander belt, most prominently Spring Lake, Edelhardt, and Horseshoe Lake meanders (fig. 1), contain some of the thickest and most fine-textured Cahokia clay, as much as 55 feet thick. These abandoned meanders formed by a classic neck cutoff in which the river meandered so strongly that it completely curved back upon itself. During flood stages, a new shorter route was found and the former path was abandoned, left behind a crescent-shaped lake (known as an "oxbow lake"). Since abandonment, these deep lakes were filled with thick deposits of silt and clay. Only Horseshoe Lake still remains today as a lake, whereas former oxbow lakes in the Edelhardt, Spring Lake and other meanders have been completed filled with fine-grained sediment, known as a clay plug.

Radiocarbon ages and superposition relationships among the former channels indicate they were abandoned between about 6000 and 2400 RCYBP (fig. 1, table 1). The Horseshoe Lake meander, the youngest on this quadrangle, was active from before about 4400 to about 2400 RCYBP (Gladfelter 1981, Hajic 1998). The basis for these estimates was a radiocarbon age of 3270±80 (ISGS-563) from Horseshoe Lake clay plug sediments (30 foot depth) and from archeological constraints of Middle Woodland settlements on point bar complexes. A radiocarbon age of 8340±250 (W-317) was noted by Willman and Frye (1970) on wood at the 60 to 65-foot depth west of Horseshoe Lake. It is probable that the sample was from well # 01900 (NW, Sec. 20, T3N, R9W; cross section B–B′) or a nearby well.

Alluvial fans, containing silty redeposited loess up to 40 feet thick (cross section A–A′), occur on the edge of the valley where large creeks emerge from the bluffs onto the Mississippi floodplain. Silty sediment was deposited here where the gradient of the creeks was drastically reduced and the creeks once split into many distributaries prior to channelization for flood control during the past century. The largest fans occur at the mouths of Judy's Branch, Schoenberger, and Canteen Creeks. The upper few feet of sediment in the fans may have been deposited post-European settlement (Booth and Koldehoff 1999).

Soil profiles in the American Bottoms are much less developed than those in the uplands because much less time has been available for soil formation to occur. Additionally, the drainage classes are generally much poorer, so there is less capability for B horizon soil development by translocation.

Extensive areas of the American Bottoms have been significantly altered by human activity, from Cahokian civilization to the present. A few disturbed areas include Monks Mound (a large platform mound in Sec. 35, T3N, R9W) and other mounds in nearby Cahokia Mounds State Park constructed from basket transportation of local soil about 1000 years ago. The majority of areas mapped as disturbed ground are from the past century and include several highway interchanges and various urban landscapes that contain more than about 5 feet of fill. The texture of such fill is variable, ranging from silt and sand to rubble, with most being derived from local sources.

Economic Resources and Environmental Hazards

Sand and Gravel

Sand deposits, containing some gravel and as much as 90 feet thick (cross section A–A′), lie predominantly below the water table in the Mississippi Valley and are a potential source of construction aggregate. Dredging for sand (from Henry Formation) is currently in operation in the eastern portion of the Bottoms near McDonough Lake (Sec. 17, T3N, R8W) where sand is encountered below 12 to 22 feet of clayey alluvium. The upper sand is relatively fine-grained and is primarily used for fill and for golf courses. The sand coarsens with depth, and below 50 feet depth, the cleaner sand is more usable by the construction industry (Goldman 1994). Some lignite in the gravel can be a problem for use of the aggregate in some construction materials.

Groundwater

Underlying the floodplain of the American Bottoms, thick, extensive sand and gravel of the Henry Formation are capable of yielding large quantities of groundwater (see cross sections and Bergstrom and Walker 1956). The Cahokia Formation, overlying the Henry, has lesser groundwater potential because of finer textures and discontinuous sand bodies, yet, small supplies are readily available (Bergstrom and Walker 1956). Additionally, sand in the Cahokia Formation is often hydrologically connected with underlying coarse sand and gravel in the Henry Formation. Extensive sand and gravel deposits suitable for groundwater use are generally absent beneath the uplands, where only minor bedrock aquifers are utilized. Wells drilled into near-surface sandstone and limestone generally yield limited groundwater supply locally. Bored wells, finished in the loess and thin till deposits, are also common on the uplands for low-yield household wells. The potential for groundwater contamination is generally high in the floodplain because of the inter-connectivity of the sand and gravel bodies and the discontinuous covering of silt and clay. Beneath uplands, the contamination potential is low, where loess and till deposits are thickest, to moderate, where surficial deposits are thin or bedrock crops out (Berg et al. 1984).

Mass Wasting

Erosion, undercutting and slumping of thick loess deposits at bluff edges are a potential hazard to property and stream environments (Krumm 1984, Killey et al. 1985). Slumps, rotational failures in sediment along a curved slip surface, commonly occur in this area where groundwater saturates loess above the clayey and relatively impervious Sangamon Geosol or Glasford Formation (Krumm 1984). These slumps predominantly occur within loess deposits and were observed during this mapping along many creek cutbanks and steep bluffs. Slope failure and slumping, in large part due to site excavations and heavy precipitation, was studied in detail at a site along Bunkum Road, immediately to the south in the French Village Quadrangle (SW, Sec. 18, T2N, R8W, Krumm 1984).

Soil Erosion and Siltation

Steep slopes along ravines and along the bluffs are subject to severe soil erosion by running water due to the friable nature of loessal soils which have a low shear resistance. Runoff during rain storms can quickly erode into and enlarge rills and gullies. Erosion is accelerated as water is channeled into the growing drainage system. Eroded sediment is transported from steep upland creeks through channelized ditches to the American Bottoms floodplain, and thus causes rapid siltation in bottomland wetlands, lakes, and swamps. Due to the channelization of creeks for flood control, sediment can no longer be deposited in alluvial fans as occurred during the past several thousand years. Furthermore, the erosion of silt from uplands and siltation in bottomlands has been accelerated in historical times because of the onset of farming, construction, and deforestation in upland areas. In some areas, the upper portion of the Cahokia Formation (upland facies), contains 5 to 10 feet of recent (post-European settlement) silt deposits, containing buried glass bottle, can, or brick fragments, suggesting rapid deposition during the last century.

Mined-Out-Area Subsidence

Large areas of the uplands in the eastern part of this quadrangle have been undermined for extraction of the Herrin (#6) coal in the past century (Jacobs 1971, Elrick and Barrett 2001). Land subsidence in these mined out areas is a serious potential problem for developers and construction projects (Treworgy and Hindman 1991).

Acknowledgments

Individuals at the Illinois Department of Transportation and Madison County Highway Department helped provide engineering boring locations and descriptions. We also greatly appreciate the cooperation of landowners who allowed us access to their properties and of consultants who provided important data for this project.

This research was supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program under USGS award number 00HQAG0151. Some seismic work was supported by USGS-NEHRP award number 06HQGR0192. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

References

Baker, F.C., 1931, Ecological relationship of the genus *Pomatiopsis* with special reference to *Pomatiopsis lapidaria*: Ecology, v. 12, no.3, p. 489–496.

Berg, R.C., J.P. Kempton, and K. Cartwright, 1984, Potential for contamination of shallow aquifers in Illinois: Illinois State Geological Survey, Circular 532, 30 p.

Bergstrom, R.E. and T.R. Walker, 1956, Groundwater geology of the East St. Louis areas, Illinois: Illinois State Geological Survey, Report of Investigation 191, 44 p.

Blum, M.D., M.J. Guccione, D.A. Wysocki, P.C. Robnett, and E.M. Rutledge, 2000, Late Pleistocene evolution of the lower Mississippi valley, southern Missouri to Arkansas: GSA Bulletin, v. 112, no. 2, p. 221–235.

Booth, D.L. and B. Koldehoff, 1999, The emergency watershed project, archeological investigations for the 1998 Metro East ditch cleanout project in Madison and St. Clair Counties, Illinois, T.E. Emerson, ed.: Illinois Transportation Archeological Research Program, Research Reports, no. 62.

Curry, B.B. and D.A. Grimley, 2006, Provenance, age, and environment of mid-Wisconsin Episode slackwater lake sediment in the St. Louis Metro East area, U.S.A.: Quaternary Research, v. 65, p. 108–122.

Elrick, S. and M.E. Barrett, 2001, Coal mines in Illinois–Monks Mound Quadrangle, Madison and St. Clair Counties, Illinois: Illinois State Geological Survey Map, 1:24,000.

Flock, M.A., 1983, The late Wisconsinan savanna terrace in tributaries to the upper Mississippi River: Quaternary Research, v. 20, p. 165–176.

Gladfelter, B.G., 1979, Geomorphic change in the Mississippi floodplain near St. Louis: Proceedings of the 75th Annual Meeting of the Association of American Geographers, Philadelphia, April 23, 1979.

Gladfelter, B.G., 1981, Investigations at the Labras Lake site: in geomorphological observations in the vicinity of the site, v. III, Illinois Department of Transportation, Springfield.

Goldman, H.B., 1994, Sand and gravel, *in* D.D. Carr, ed., Industrial minerals and rocks, 6th edition: Littleton, Colorado, Society for Mining, Metallurgy, and Exploration, Inc.

Goddard, T.M. and L.R. Sabata, 1982, Soil survey: Madison County, Illinois: University of Illinois Agricultural Experiment Station and United States Dept. of Agriculture, 254 p.

Goodfield, A.G., 1965, Pleistocene and surficial geology of the city of St. Louis and the adjacent St. Louis County: University of Illinois at Urbana-Champaign, Ph.D. thesis, 214 p.

Grimley, D.A. and S.W. Lepley, 2005, Surficial geology of Wood River Quadrangle, Madison County, Illinois: Illinois State Geological Survey, Illinois Preliminary Geologic Map, IPGM Wood River-SG, 1:24,000.

Grimley, D.A., and E.D. McKay III, 2004, Surficial geology of French Village Quadrangle, St. Clair County, IL: Illinois State Geological Survey, Illinois Geologic

Quadrangle Map, IGQ French Village-SG, 1:24,000.

Grimley, D.A., A.P. Phillips, L.R. Follmer, H. Wang, and R.S. Nelson, 2001, Quaternary and environmental geology of the St. Louis Metro East area, *in* D. Malone, ed., Guidebook for field trip for the 35th annual meeting of the North-Central Section of the Geological Society of America: Illinois State Geological Survey, Guidebook 33, p. 21–73.

Grimley, D.A., L.R. Follmer, and E.D. McKay III, 1998, Magnetic susceptibility and mineral zonations controlled by provenance in loess along the Illinois and Central Mississippi Valleys: Quaternary Research, v. 49, no. 1, p. 24–36.

Higgins, M.J., 1990, The Notcha Site: the early, middle, and late archaic occupations (11-Ms-128), *in* C.J. Bareis and and J.A. Walthall, eds., American Bottom archeology FAI-270 Site Reports: Illinois Department of Transportation, University of Illinois Press.

Hajic, E.R., 1993, Geomorphology of the Northern American Bottom as context for archeology: Illinois Archeology, v.5, no.1–2, p. 54–65.

Hajic, E.R., 1998, Appendix E: Geological investigations, *in* T.R. Pauketat, M.A. Rees, and S.L. Pauketat, An archeological survey of the Horseshoe Lake State Park, Madison County, Illinois: Illinois State Museum, Report of Investigation, no. 55., p.137–147.

Jacobs, A.M., ed., 1971, Geology for planning in St. Clair County, Illinois: Illinois State Geological Survey, Circular 465, 35 p.

Killey, M.M., J.K. Hines, and P.B. DuMontelle, 1985, Landslide inventory of Illinois: Illinois State Geological Survey, Circular 534, 27 p.

Krumm, R.J., 1984, A slope stability problem: analysis of a slump-type landslide, M.S. thesis: Southern Illinois University at Edwardsville, 137 p.

McKay, E.D., III, 1977, Stratigraphy and zonation of Wisconsinan loesses in Southwestern Illinois, Ph.D. thesis: University of Illinois at Urbana-Champaign, 242 p.

McKay, E.D., III, 1979, Stratigraphy of Wisconsinan and older loesses in southwestern Illinois, *in* Geology of Western Illinois, 43rd annual Tri-State Geological Field Conference: Illinois State Geological Survey, Guidebook 14, p. 37–67.

Ollendorf, A.L., 1993, Changing landscapes in the American Bottoms (USA): an interdisciplinary investigation with an emphasis on the late-prehistoric and early-historic periods, Ph.D. thesis: University of Minnesota.

Phillips, A.C., 2004, Surficial geology of Collinsville Quadrangle, Madison and St. Clair Counties, IL: Illinois State Geological Survey, Illinois Preliminary Geologic Map, IPGM Collinsville-SG, 1:24,000.

Phillips, J.L. and B.G. Gladfelter, 1983, The Labras Lake site and the paleogeographic setting of the Later Archaic in the American Bottom, *in* J.L. Phillips and J.A. Brown, eds., Archaic hunters and gatherers in the American Midwest: New York , Academic Press, p. 197–218.

Rissing, J., 1991, Report on the geomorphology along the 5.8-mile extension of FAI-270 (255): FAI-270 Illinois Transportation Archeology Project, Archeological Mitigation Project, Geomorphology Report 11.

Treworgy, C.C. and C.A. Hindman, 1991, The proximity of underground mines to residential and other built-up areas in Illinois: Illinois State Geological Survey, Environmental Geology 138, 18 p.

Wallace, D.L., 1978, Soil survey of St. Clair County, Illinois: University of Illinois Agricultural Experiment Station and United States Department of Agriculture, 114 p.

Wang, H., L.R. Follmer, and J.C. Liu, 2000, Isotopic evidence of paleo-El Nino-southern oscillation cycles in loess-paleosol record in the central United States: Geology, v. 28, no. 9, p. 771–774.

White, W.P., S. Johannessen, P.G. Cross, and L.S. Kelly, 1984, Environmental setting, *in* C.J. Bareis and J.W. Porter, eds., American Bottom archeology: A summary of the FAI-270 Project contribution to the culture history of the Mississippi Valley: University of Illinois Press, p.13–33.

Willman, H.B. and J.C. Frye, 1970, Pleistocene stratigraphy of Illinois: Illinois State Geological Survey, Bulletin 94, 204 p.