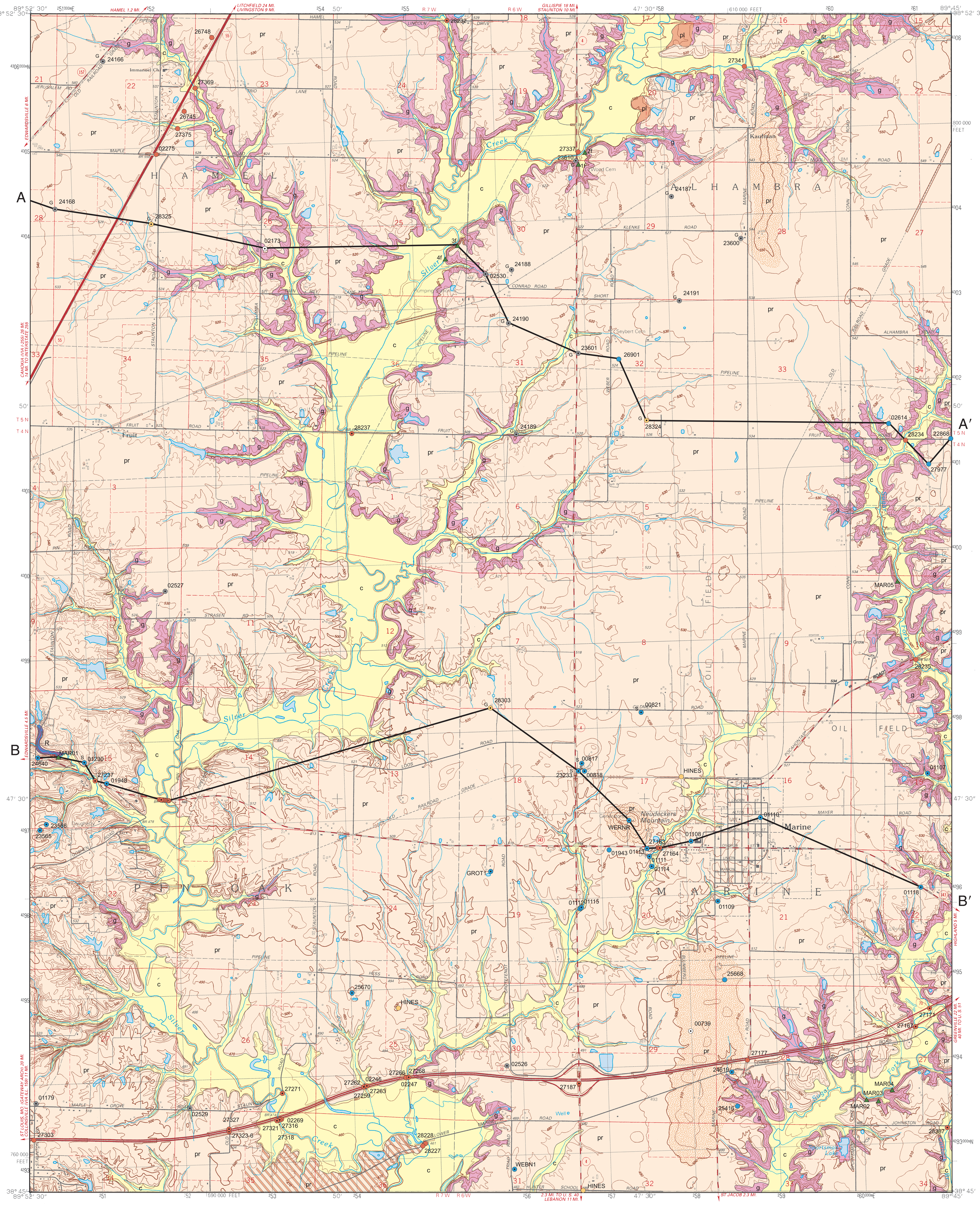
Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
William W. Shilts, Chief

SURFICIAL GEOLOGY OF MARINE QUADRANGLE
MADISON COUNTY, ILLINOIS

Andrew C. Phillips and David A. Grimley
2004

Illinois Preliminary Geologic Map
IPGM Marine-SG



QUATERNARY DEPOSITS

Description	Unit	Interpretation/Occurrence
HUDSON EPISODE (~12,000 years before present (B. P.) to today)		
Mixed: Silty clay, silt loam, sandy loam, fine sand; local sand and gravel lenses; massive to well stratified; gray to brown; leached; very soft to moderately stiff; moist to very moist; up to 30 feet thick	Cahokia Formation: c	**Stream sediment** in stream valley floodplains; mainly redeposited loess; may be coarser grained in lower portion where sediment derived from till and buried glacial stream sediment
WISCONSIN EPISODE (~75,000 years - 12,000 B.P.)		
Silt loam; massive to blocky structure, friable, locally thin bedded immediately east of Silver Creek; yellowish brown to gray to brown (pink hue); mainly leached but may be dolomitic; contains modern soil solum in upper 2 to 5 feet (commonly weathered to silty clay loam); soft to stiff; up to 15 feet thick	Peoria and Roxana Silts: pr; (underlain by Hagarstown Member, Pearl Formation): pr; (underlain by Pearl Formation, undifferentiated): pr	**Loess**, but includes some slope deposits; upper and thicker portion is Peoria Silt (yellow brown to gray); lower portion is Roxana Silt (brown with pink hue to gray); thickest on uneroded uplands in west-southwest
ILLINOIS EPISODE (~200,000 years - 130,000 B.P.)		
Mixed: sand, gravel, and diamicton; interbedded; brown to gray; leached to calcareous; loose to very stiff; up to 70 ft thick	Hagarstown Member Pearl Formation (cross sections only): pl-h	**Ice marginal sediment** including debris flow, outwash, and till; characteristically variable; forms ridges and mounds on uplands but includes associated buried units; covered by up to 15 ft of loess, overlies or intertongues with Pearl (unclassified) or Glasford Formations; contains Sangamon Geosol in upper portions
Sand, fine to coarse moderately sorted sand to sandy loam; massive to well stratified, gravel and silt lenses; may be clay-rich in upper few feet where a buried soil occurs; reddish brown, brown, gray; leached to calcareous; loose to very stiff; up to 15 feet thick	Pearl Formation undifferentiated: pl	**Meltwater stream sediment**; forms terraces along Sugar Fork and Silver Creek where it is buried by loess, buried by Cahokia Formation in Silver Creek; contains Sangamon Geosol in upper portions except where eroded; covered by up to 5 ft of loess on surficial map units
Pebbly loam diamicton; massive, includes lenses of silt, sand and gravel (predominantly in upper part) up to 10 feet thick and hundreds of feet wide; olive brown to dark gray to dark grayish brown; upper few feet is more clay rich, brown, weathered, softer, and relatively moist; lower portion is commonly more uniform, grayer, calcareous, stiff to hard, with low moisture; lowest 5 to 10 feet also commonly more clay rich; up to 70 feet thick	Glasford Formation: g	**Till and ice marginal sediment**; weaker and more moist upper portion is supraglacial till, lower dense portion is basal till; pervasive below Peoria and Roxana Silts; underlies stream sediment (Cahokia Formation) in tributary valleys; crops out along stream valley slopes; Sangamon Geosol developed in upper few feet; covered by up to 5 ft of loess on surficial map units
PRE-ILLINOIS EPISODES (~700,000 - 400,000 years B.P.)		
Silty clay loam and silty clay, few pebbles; crudely to well stratified; greenish gray to dark grayish brown; medium strength; leached; up to 8 feet thick	Lierle Clay Member Banner Formation (cross sections only): b-l	**Accretionary Sediment**, deposited in shallow depressions, with some stream and slope sediment; Yarmouth Geosol developed throughout the unit though partially truncated; local extent
Clay loam to loam diamicton, few thin silt and sand lenses, although basal sands are up to 20 feet thick and extend laterally thousands of feet; massive to crudely bedded, more variable at base; upper part is olive brown to dark grayish brown (sometimes with pinkish hue), lower part is dark gray; leached to calcareous; very stiff; low to moderate moisture; up to 60 feet thick	Omphghent member Banner Formation (cross sections only): b-o	**Till and ice marginal sediment**; mainly basal till, but may include proglacial debris flow, lake or stream sediment in basal portions; Yarmouth Geosol may be developed in upper 10 feet but commonly truncated
Mixed: loam, silt loam, silty clay loam, and clay, with fine sand to gravel near base of unit; weakly stratified to well stratified, fines upwards but variable; olive gray to olive brown; leached; stiff to hard; moderately to very moist; up to 25 feet thick	Canteen member Banner Formation (cross sections only): b-c	**Stream and lake sediment**, nonglacial; contains one or more paleosols, may include residuum; overlies bedrock

PRE-QUATERNARY DEPOSITS

Description	Unit	Interpretation/Occurrence
PALEOZOIC BEDROCK		
Predominantly shale, clay-rich, greenish-gray, noncalcareous; but may include siltstone, sandstone, limestone, or coal	Near-surface bedrock: R	Mainly buried but shale is within 5 feet of the surface of some tributary valley bottoms in southwest areas; at depth (cross sections), shale, siltstone and sandstone are equally common

Data Type

- Outcrop
- Stratigraphic boring
- Water well
- Engineering boring
- Other boring
- SG: Boring with samples (s) or geophysical log (g); dot indicates to bedrock
- Contact
- Inferred contact
- A—A′ Line of cross section
- Water

Note: Numeric labels indicate the county number, a portion of the 12-digit API number on file at the ISGS Geological Records Unit. (Outcrop labels indicate field number.)

Base map compiled by Illinois State Geological Survey from digital data provided by the United States Geological Survey. Topography compiled from imagery dated 1986. Field checked 1988. Map edited 1991.

North American Datum of 1983 (NAD 83)
Projection: Transverse Mercator
10,000-foot ticks: Illinois State Plane Coordinate system, west zone (Transverse Mercator)
1,000-meter ticks: Universal Transverse Mercator grid system, zone 16

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SCALE 1:24 000
1 MILE; 7000 FEET; 1 KILOMETER

BASE MAP CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Released by the authority of the State of Illinois: 2004

Geology based on fieldwork by A. Phillips and D. Grimley, 2003-2004.

Digital cartography by M. Barrett, Illinois State Geological Survey.

This Illinois Preliminary Geologic Map (IPGM) is a lightly edited product, subject to less scientific and cartographic review than our Illinois Geological Quadrangle (IGQ) series. It will not necessarily correspond to the format of IGQ series maps, or to those of other IPGM series maps. Whether or when this map will be upgraded depends on the resources and priorities of the ISGS.

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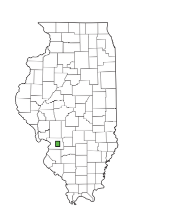

ADJOINING QUADRANGLES
1 Prairietown
2 Worden
3 New Douglas
4 Edwardsville
5 Grantfork
6 Collinsville
7 St. Jacob
8 Highland

APPROXIMATE MEAN DECLINATION, 2004

ROAD CLASSIFICATION
- Primary highway, hard surface
- Secondary highway, hard surface
- Light-duty road, hard or improved surface
- Unimproved road
- Interstate Route; U.S. Route; State Route

Introduction

This map depicts geologic materials found within 5 feet of the ground surface in the Marine 7.5-minute Quadrangle, Madison County, southwestern Illinois (fig. 1). The cross sections show the extent of surficial and buried units down to bedrock. This product can be used for preliminary geologic assessments of construction siting issues, geologic hazards, groundwater resources, environmental protection, and other activities. The work is part of the ISGS Metro-East mapping program, intended to provide critical geologic data in this rapidly developing area. Previously published maps of the area have been at 1:500,000 scale (Lineback 1979; Stiff 2000), although there has been unpublished research at larger scales. This project builds upon the earlier work, especially Fox et al. (unpublished map), by adding new observations of the surface and subsurface, incorporating them into a digital database, and interpreting them at large scale. The morphology of a major bedrock valley was refined (fig. 2), the sedimentary fills of the bedrock and modern valleys were distinguished, and areas with relatively good and relatively poor geologic control were identified. Prediction of the occurrence of buried units far from the lines of cross section should be made with care. Additional studies are necessary if greater detail is desired.

Regional Setting

The Marine 7.5-minute Quadrangle is located a few miles east of bluffs that overlook the Mississippi River valley (fig. 1). The landscape encompasses river valleys and uplands. River valleys, including terraces and fans on valley sidewalls, are mainly comprised of waterlain sediments. Uplands are a composite of glacial, stream, lake, and windblown sediment (loess). In addition, there are concealed deposits unrelated to surficial landforms and more affected by bedrock topography. The larger north to south trending stream valleys in the region, such as Silver Creek, were conduits of meltwater from the last glacier to cover this region. The Silver Creek drainage basin (fig. 1) is tributary to the Kaskaskia River valley to the south (not shown). Steep topography of smaller tributary valleys in the southwestern portion of the quadrangle is evidence of resistant till or bedrock near the surface. Although the upland topography is generally subdued, a few low ridges and steep mounds on the eastern portion of the quadrangle are related to more prominent ridges to the south and east beyond the quadrangle boundary. In the subsurface, the occurrence and thickness of deeper deposits are partly controlled by the bedrock topography (fig. 2).

The Quaternary sediment overlying bedrock was deposited during at least three episodes of glaciation, which were separated by relatively warm, interglacial episodes, including the present-day postglacial episode. Before the earliest known Quaternary glaciation, erosion had exposed much of the land surface to bedrock and created a broad, deep stream valley trending north to south across the quadrangle (fig. 2). Bedrock valley walls were probably deeply incised by tributary streams such as seen today in far southern and extreme northwestern Illinois. During the pre-Illinois and the Illinois glacial episodes, glaciers flowed over the region from the northeast to the southwest, extending across the Mississippi Valley to the St. Louis area (McKay 1979; Grimley et al. 2001). The glaciers sculpted the pre-existing landscape and left deposits of diamicton (a poorly-sorted mixture of rocks, sand, silt, and clay), deposited mainly as till at the glacier bed. Sorted silt, sand and gravel were deposited from meltwater streams. During the last (Wisconsin Episode) glaciation, ice only advanced into the northeastern quadrant of Illinois, reaching about 80 miles to the northeast of Marine. Its main influence in this area was to discharge large volumes of sediment into the Mississippi to create extensive plains of meltwater sediment. Silt was eroded by westerly winds off unvegetated floodplains in the Mississippi Valley, to be deposited across the upland landscape as blankets of loess. Between glaciations, streams continued to erode some sediment out of their valleys, and soils developed on the fresh land surface.

Postglacial stream sediment is derived mainly from erosion of the loess and till covering the uplands, but erosion has also exposed older Quaternary sediments and bedrock. Clearing of forests during early European colonization and possibly earlier during Amerindian civilization centered at the Cahokia Site in western Madison County, led to extensive upland erosion and sediment accumulation in creek valleys. Relatively recent stream incision into these sediments and older deposits is attributed to large water discharges with initially low sediment loads brought about by recent climate changes, land use changes, or both.

Methods

The surficial map was constructed by interpretations of parent materials from soils surveys (Goddard and Sabata 1982; NRCS 2002) that were validated with outcrop observations and modified to conform to topography, compilation of fieldnotes from previous ISGS research, and interpretations of borehole data. Some landforms were interpreted by airphoto analysis. Computer modeling was used to construct the bedrock topography. Outcrops described in this study provide critical two-dimensional perspectives of map unit variability and contact characteristics, but exposures are limited to near-surface units. Borehole data sources included stratigraphic borings acquired for this project, and geotechnical, water, and coal boring records stored in the ISGS Geological Records Unit. Stratigraphic boring descriptions and geotechnical logs typically provided the most detail and could be located most accurately. A set of coal borings with gamma logs were rare data that allowed identification of deeply buried units in the northern portion of the quadrangle. Except for a few select companies, water-well descriptions provided by drillers were generally of low value because few lithological boundaries were distinguished, typically only the drift/bedrock interface, and locations tend to be imprecise. Positions of well and outcrop locations shown on the map are based upon the best available information for each point. Their horizontal and vertical accuracy range between approximately 1 to 330 ft, and 1 to 20 ft, respectively. Surficial contacts were correlated between observation points by interpreting landform-sediment relationships on topographic maps. Buried unit boundaries are assumed to be well known within 1000 ft of each observation point. Boundaries extending further than that in the cross sections are dashed. Stratigraphic nomenclature follows Hansel and Johnson (1996) and Willman and Frye (1970), as appropriate.

Sediment Assemblages And Properties

Uplands
Most of the upland surface is comprised of a blanket of loess which covers thick glacial and ice-marginal deposits. The Peoria Silt and the underlying Roxana Silt loess units are not differentiated here because their geotechnical properties are very similar (Table I), but they have been studied extensively by McKay (1979), Wang et al. (2003), and others. Original textures of silt loam to heavy silt loam were modified within the modern solum to heavy silt loam to silty clay loam (Goddard and Sabata 1982). The loess package is thickest (approximately 15 ft) closest to its Mississippi Valley source area in the west and thins to about 10 ft on uneroded uplands in the east.

Two distinctive relatively coarse-grained units buried beneath 10-15 ft of loess are depicted on the map by patterened areas. The Hagarstown Member of the Pearl Formation (stipple) includes sediment deposited in varied ice-contact environments, whereas the Pearl Formation, undifferentiated, (hachure) includes mainly sorted sediment deposited by outwash. The Hagarstown Member is associated with north-south trending ridges in the northeast and southeast quadrants and a conical mound (Neudecker's Mountain) just west of Marine. The sediments may have been deposited as debris flows at glacier margins, in kames, proglacial lakes, eskers, or meltwater streams. The materials are thus characteristically variable, including diamicton as well as sorted sediments. The ridges may contain sand and gravel up to tens of feet thick with interbedded diamicton based on well data and studies of similar ridges in south-central Illinois (Jacobs and Lineback 1969; Heigold et al 1985). Elongate sand and gravel bodies deposited from outwash streams may occur in inter-ridge areas with low relief (Stiff 1996). On the other hand, some landforms may be primarily composed of diamicton (Stiff 1996; Phillips 2004b). An electrical earth resistivity study of Neudecker's Mountain, for example, could not resolve specific sand bodies within the mound, although sand found in nearby boreholes may be correlatable to the mound. (cross section B-B'; ISGS Groundwater Section, unpublished data). Other similar but smaller mounds also occur across the quadrangle, but they have not been distinguished here because there is no supporting data. The upper few feet of the Hagarstown Member, as well as the uppermost of all other Illinois Episode units, contain the Sangamon Geosol, a buried soil formed during a warm interglacial episode. Distinctive alteration features include color mottling, strong soil structure, leaching of carbonate, extensive clay coatings, and common iron-manganese concentrations. The Pearl Formation (undifferentiated) is discussed below.

The Glasford Formation is shown on the surficial map along side slopes and valley walls where erosion has thinned the loess blanket to 5 ft or less. Sediments in the Glasford Formation include diamicton, weathered diamicton, and associated sorted sands and gravels. The sediment was deposited mainly as glacial till and ice-contact sediment. The ice-contact sediment is distinguished from the Hagarstown Member in that there is no topographic expression of the deposit and sorted sediments are a minor component. The Glasford Formation is pervasive under the uplands, reaching thicknesses of 70 ft. The till is loamy, very stiff, and has low water content (Table I). Lenses of sand and gravel up to 10 ft thick and hundreds of feet wide are most common in the upper portion of the unit, but may also occur at the base (see cross sections). The lower third of the Glasford Formation is slightly more clay-rich and softer, perhaps due to incorporation of underlying clayey units and shale. Similarly, within the weathering profile of the Sangamon Geosol, the Glasford Formation has relatively low strength and high moisture content, in part due to higher clay content.

Concealed Deposits
Pre-Illinois episode Quaternary deposits (Banner Formation) are distinguished from the Glasford Formation by selected physical and chemical properties (Table I), and by the weathering profile of an interglacial soil (Yarmouth Geosol) developed in the upper part. The Yarmouth Geosol was typically truncated by the Illinois Episode glacier and may be recognized only by an oxidation zone. Within the Marine quadrangle, three units of the Banner Formation are distinguished. They include fine sediment that accumulated in depressions on the land surface during an interglacial episode (the Lierle Clay Member), diamicton interpreted as till (the informal Omphghent member; McKay 1986), and weathered fine to medium textured sorted sediments (the informal Canteen member; Phillips 2004a). The Lierle Clay Member, the uppermost unit where present, is weathered, clay-rich, and limited in spatial extent. The upper portion of the Omphghent member east of Silver Creek has a pinkish cast, and is similar to the Glasford Formation in texture and hardness. These properties could possibly be correlated to the Hillery Member in north-central Illinois (Johnson et al. 1972). The properties grade downwards to finer textures (silt loam), lower strengths, and moderate water contents more typical of the Omphghent member as found further west (McKay 1986; Table I). There are fewer and thinner sand lenses in the Omphghent member than in the Glasford Formation. However, a thick, approximately ½ mi-wide valley-train of sand and gravel occurs along the western wall of the main bedrock valley (cross section A-A'; fig. 2). Similar glacial stream sediment has not been found in mapping of the Omphghent member west and north of this quadrangle and suggests that the bedrock valley was an important meltwater outlet for the Pre-Illinois episode ice.

A weak paleosol (sediment leached of carbonate and an olive color), variable textures, lack of erratic pebbles, and clay mineralogy similar to bedrock distinguish the Canteen member from the overlying Omphghent member. The Canteen member may contain stream, lake, and slope sediment, as well as additional paleosols. The sediments are intepreted to be non-glacial in origin and directly overlie bedrock. The Canteen member is restricted to bedrock valleys (cross sections, fig. 2), and has been found in boreholes penetrating buried bedrock valleys from northern St. Clair to northern Madison Counties (fig. 1; Phillips 2004a, 2004b).

Stream Valleys
The Silver Creek valley is filled with fine-grained postglacial stream sediment (Cahokia Formation) that overlies coarse-grained glacial stream sediment (Pearl Formation, undifferentiated). The occurrence of the Pearl Formation (undifferentiated) in Silver Creek is evidence that the valley was as a meltwater outlet during the Illinois Episode. All other valleys contain only the Cahokia Formation and are thus more recent features, or the Pearl Formation was eroded out. The Cahokia Formation is generally fine grained because the sediment source was primarily loess, but varies from silty clay deposited in backwater environments and abandoned meanders, to loamy sediments associated with deposition near channels or where is the local sediment source. Layers of sand occur at depth, and up to several feet of sand to gravel that was concentrated by stream processes from older deposits (till or glacial stream sediment) may occur at the base of the unit. The textures of the lower Cahokia Formation and upper Pearl Formation can be very similar, but some geotechnical records distinguish brown colors that can be attributed to the weathering profile of the Sangamon Geosol in the upper few feet of the Pearl Formation. Terraces of the Pearl Formation (undifferentiated) buried by less than 5 ft of loess (solid color) and 10-12 ft of loess (hachure) are shown along the northeast and southwest margins of the Silver Creek valley, respectively. Terraces in the northeast are interpreted from soil surveys and topography (NRCS 2002). Their surface elevations are 500-510 ft above sea level, approximately 40 ft higher than the southwestern terrace. This gradient is about 25% steeper than the modern valley gradient, consistent with the coarser sediment and presumed higher water discharge, although some of the elevation difference could be attributed to post-glacial erosion. Although the original texture of the Pearl Formation varied from fine to medium sand with gravel, weathering during development of the Sangamon Geosol may have altered the texture of the upper portion to loam or even diamicton.

Tributary streams are incised into upland sediments. In valleys that drain into Silver Creek from the west, the Glasford Formation or bedrock may be exposed in the channel bed or covered by a thin lag deposit of gravel.

Geologic Resources

Groundwater Resources
There are limited groundwater resources in the drift of the Marine Quadrangle. Although the Pearl Formation (undifferentiated) and sand and gravel lenses within the Glasford Formation are potentially productive, the bodies are generally restricted in extent, varied in location, and thus are difficult to target for drilling. Many rural residences use large-diameter wells bored into the Glasford Formation to exploit water draining from thin sand lenses and fractures. Sands at the base of the Omphghent member (cross sections) are exploited by a small town just north of this quadrangle. They may be also productive here. Contamination potential for shallow aquifers in uneroded uplands is low to moderate. Although potential confining layers of loess and till are sufficiently thick over much of the quadrangle, sand and gravel lenses in the shallow-buried Hagarstown Member, Pearl, and Glasford Formations provide potential subsurface pathways for contaminants (c.f. Berg et al. 1984). As well, the Sangamon Geosol provides a thick clay-rich horizon, up to 3 ft thick, that could substantially retard downward groundwater flow (c.f. Herzog et al. 1989), but soil structure and fractures up to 20 ft deep may provide pathways for contaminants to underlying layers.

Acknowledgements

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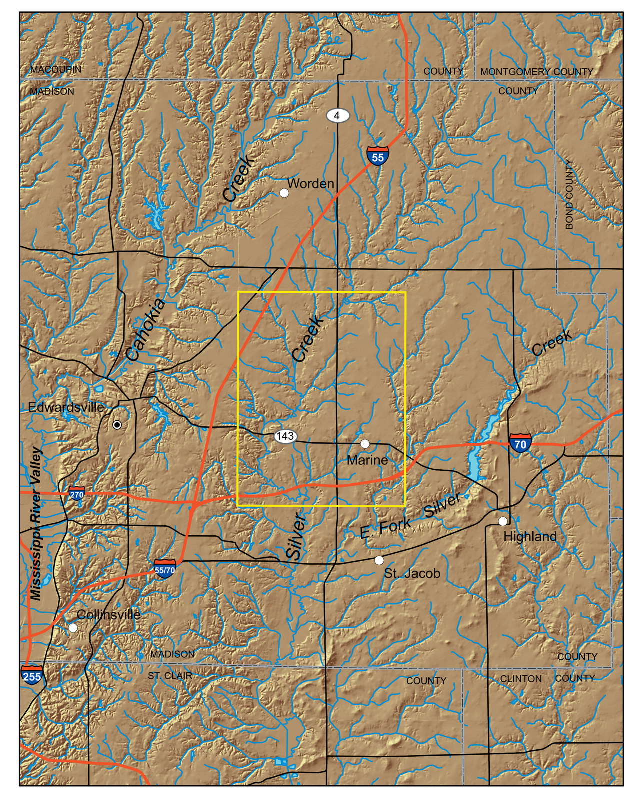

Figure 1 This map depicts the three dimensional landscape in the map region with a simulated light source from the northwest. The Marine quadrangle (yellow outline) lies east of the Mississippi River floodplain on the western edge of the Kaskaskia River basin. The upland surface is a marginal portion of the Illinoian Till Plain and is deeply dissected by small streams. Silver Creek and other major valleys were meltwater channels for the Illinois Episode glacier.

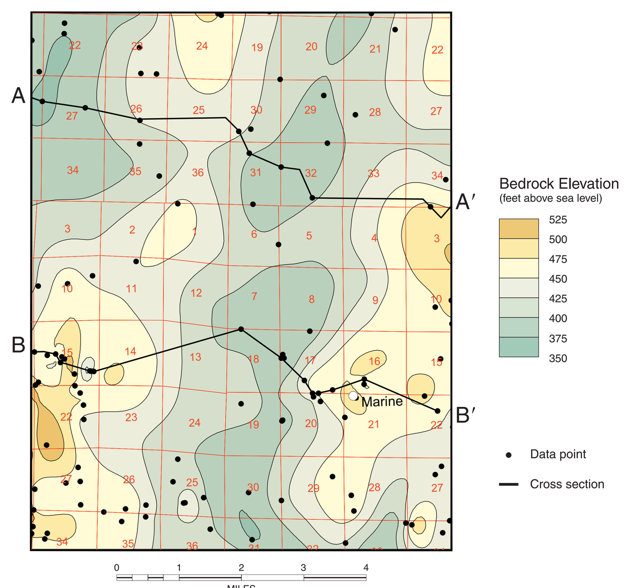

Figure 2 This map of the bedrock surface shows pre-glacial ridges and valleys that follow the general north-south strike of the bedrock. The central valley drains towards the Kaskaskia valley. The valley in the northwest drains west towards the Mississisppi Valley.

Table 1 Physical and chemical properties of selected map units (typical ranges listed)

UNIT	w (%)	Qu (tsf)	N	sand	silt	clay	clay mineralogy	natural gamma	MS
Cahokia Fm.	18 - 30	<0.25 - 1.5	2 - 10	variable texture			*n.d.*	variable	*n.d.*
Peoria and Roxana Silts	19 - 29	0.50 - 1.75	5 - 13	0-5	65-85	15-30	very high expandables	mod.	5 - 70
Pearl Fm., undifferentiated	20 - 24	0.5 - 2.5	5 - 35	*n.d.*	*n.d.*	*n.d.*	60 - 80 % illite	low	*n.d.*
Glasford Fm. *	8 -20	1.5 - 8.5	15 - 75	27 - 44	36 - 49	17 - 27	56 - 68 % illite	mod.-high	10 - 45
Lierle Clay M.	*n.d.*	2.5 - 3.0	*n.d.*	*n.d.*	*n.d.*	*n.d.*	high expandables	high	10 - 15
Omphghent m. *	15 - 27	1.0 - 4.5	10 - 50	19 - 31	40 - 56	23 - 31	46 - 57 % illite	high	15 - 50
Canteen m.	*n.d.*	1.5 - 4.5	*n.d.*	*n.d.*	*n.d.*	*n.d.*	high expandables	mod. to high	5 - 20
shale bedrock	10 - 20	4.0 - >4.5	> 50	*n.d.*	*n.d.*	*n.d.*	*n.d.*	very high	10 - 20

Geotechnical Properties: Compiled from 70-80 bridge borings from across the quadrangle and 3 stratigraphic borings
w = % moisture content = mass of water / mass of solids (dry)
Qu = unconfined compressive strength, Pocket Penetrometer method
N = blows per foot (Standard Penetration Test)

Particle size distribution and clay mineralogy: Compiled from discrete sampling of 3 stratigraphic borings
sand = % > 63 µm; silt = % 4-63 µm; clay = % < 4 µm (proportions in the < 2 mm fraction)
clay mineralogy = proportions of expandables, illite, and kaolinite/chlorite (in < 4 µm clay mineral fraction); these calculations using Scintag diffractometer calculations indicate about 25% more illite than previous results by H.D. Glass with General Electric X-ray diffractometer

Geophysical Data:
MS = magnetic susceptibility (x 10^{-5} SI units), compiled from quasi-continuous sampling of 3 stratigraphic borings
natural gamma radiation compiled from continuous downhole logs of 3 stratigraphic borings and 9 coal borings

n.d. = no data available
* properties for Glasford Fm. and Omphghent m. are mainly for calcareous till (excludes sand and gravel lenses and strongly weathered zones)