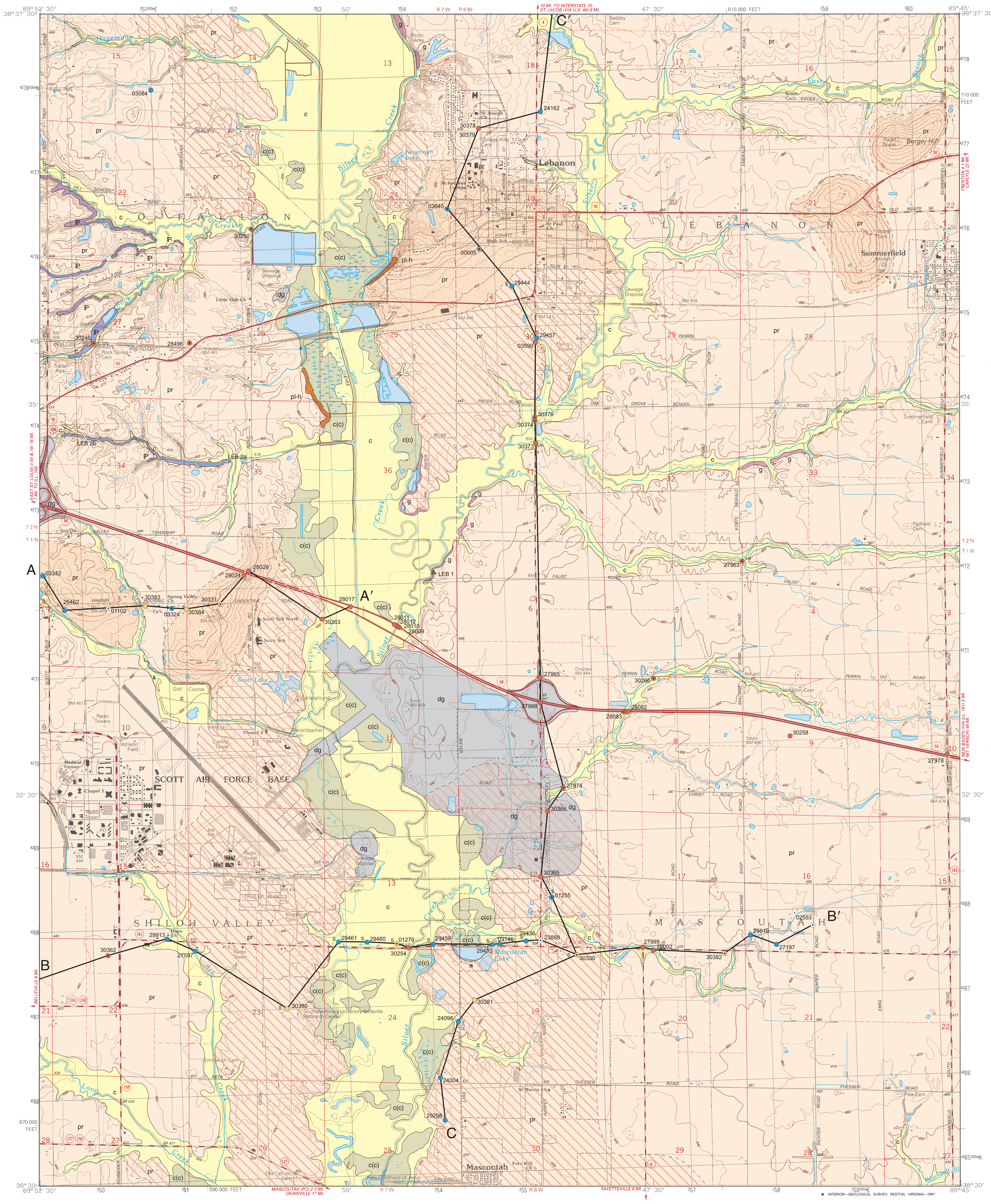
Illinois Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
William W. Shilts, Chief

Surficial Geology of Lebanon Quadrangle

St. Clair County, Illinois

STATEMAP Lebanon-SG

Andrew C. Phillips and Michael A. Aper
2006



QUATERNARY DEPOSITS

HUDSON EPISODE (~12,000 years before present (B.P.) to today)

Description	Unit	Interpretation
Fill or removed earth	Disturbed ground dg	**Extensive regrading** of upland and stream valley during construction of Mid-America Airport; fill in highway cloverleaf
Silty clay to silt loam to sandy loam to 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** deposited on floodplains and natural levees; mainly redeposited loess; may be coarser grained in lower portion where sediment derived from till and buried glacial stream deposits
Silty clay to silty clay loam; massive to weakly stratified near base; brown, leached, organic, very soft; moist to very moist; up to 20 ft thick	Cahokia Formation, clayey facies c(c)	**Stream sediment,** deposited in backwater lakes on floodplains

WISCONSIN EPISODE (~75,000 years–12,000 B.P.)

Description	Unit	Interpretation
Silt loam; yellowish brown to gray to brown with pink hue, massive to blocky structure, friable, mainly leached but may be dolomitic; contains modern soil solum in upper 2 to 5 feet (commonly weathered to silty clay loam); up to 20 feet thick	Peoria and Roxana Silts pr	**Loess,** but including 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 gently sloping uplands in southwest and thinning eastward
Clay to silty clay; massive to laminated; gray, may have pink hue; stiff; moist; may contain wood and shell fragments; up to 5 feet thick	Equality Formation (cross sections only) e	**Sediment deposited in backwater lakes** formed when mouth of drainage was blocked by high aggradation in trunk valley; occurs locally below Cahokia Formation in Silver Creek upstream of Little Silver Creek confluence and below 410 feet elevation.

ILLINOIS EPISODE (~200,000 years–130,000 B.P.)

Description	Unit	Interpretation
Silt loam to silty clay loam and loam diamicton, may contain thin fine sand beds; massive to weakly stratified; brown to pale brown; locally strong redox features; leached; generally 5 feet but up to 15 feet thick	Berry Clay and Teneriffe Silt complex (cross sections only) bc-tr	**Accretion deposits (Berry Clay), loess and fine grained stream sediment (Teneriffe Silt);** limited in spatial extent, intertongues with Pearl Formation; contains cumulic Sangamon Geosol which can alter primary texture to diamicton
Sand, gravel, and loam diamicton; fining upwards, interbedded; reddish brown, brown, gray; leached to calcareous; soft to very stiff; up to 70 feet thick	Pearl Formation, Hagarstown Member (cross sections only) pl-h (stipples on map where buried)	**Ice marginal deposits** including debris flow, outwash, and till, characteristically variable; forms ridges and mounds on uplands but includes associated buried units; covered by up to 15 feet of loess, intertongues with Pearl Formation, overlies Glasford Formation; contains Sangamon Geosol in upper portions
Fine to coarse sand (sand to loam) with gravel and silt lenses; may be clay-rich in upper few feet where a buried soil occurs; reddish brown, brown, gray; leached to calcareous; medium dense to dense; up to 15 feet thick	Pearl Formation (cross sections only) pl (hachures on map where buired)	**Outwash;** thickest under Cahokia Formation in Silver Creek valley, forms terraces along south of Lebanon Ridge along Silver Creek where it is buried by loess, and Berry Clay - Teneriffe Silt complex; contains Sangamon Geosol in upper portions except where eroded
Pebbly loamy diamicton; massive; includes lenses of silt, sand and gravel (predominantly in upper part) up to 10 feet thick and tens of feet wide; brown and olive brown to gray; upper few feet is weathered, brown, softer, more clay rich, and relatively moist; lower portion is commonly more uniform, stiff to very hard, low moisture, and calcareous; up to 100 feet thick	Glasford Formation g	**Till;** weaker and more moist upper portion is supraglacial till, lower denser portion is basal till; eroded out below portions of main stream valleys and terraces in south, crops out along steep stream valley slopes; Sangamon Geosol developed in upper few feet

PRE-ILLINOIS EPISODES (~700,000–400,000 years B.P.)

Description	Unit	Interpretation
Silty clay loam, silt loam, and clay loam loam diamicton; crudely bedded to massive; few thin silt and sand lenses; very stiff; low to moderate moisture; upper part is reddish brown to brown, lower part is olive brown to gray; leached to calcareous, up to 70 feet thick	Banner Formation (cross sections only) b	**Till and ice marginal sediment;** Yarmouth Geosol may be developed in upper 10 feet but typically truncated; mainly basal till, but may include lake or stream sediment with organic matter in basal portions; in southeast, uppermost portion is thin, distinctly reddish brown diamicton (till)

PRE-QUATERNARY DEPOSITS

PALEOZOIC BEDROCK

Description	Unit	Interpretation
Shale, limestone, sandstone and local coal; upper portion may be weathered to clay, loam, or diamicton	Near-surface bedrock P	**Pennsylvanian bedrock;** crops out in tributary valley bottoms and steep valley walls west of Silver Creek; abandoned small coal mines occur across map south of Lebanon, and southwest of Scott Air Force Base and east of Mascoutah, abandoned small limestone mines occur in northwest; shale is most common lithology at depth

Data Type

- Outcrop
- Outcrop in field notes (ISGS archives)
- Stratigraphic boring
- Water well boring
- Engineering boring
- Coal boring
- Oil, gas, or other boring

SG 30363 — Labels indicate samples (S) or geophysical log (G). Boring and outcrop labels indicate the county number. Dot indicates boring or outcrop is to bedrock.

Contact

Inferred contact

A — A′ Line of cross section

Note: The county number is a portion of the 12-digit API number on file at the ISGS Geological Records Unit. Most well and boring records are available online at the ISGS Web site.

Base map compiled by Illinois State Geological Survey from digital data provided by the United States Geological Survey. Topography by photogrammetric methods from aerial photographs taken 1986. Field checked 1988. Map edited 1991. Supersedes map dated 1982.

North American Datum of 1927 (NAD 27)
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

SCALE 1:24,000
1 1/2 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

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

Released by the authority of the State of Illinois: 2006

Geology based on field work by A. Phillips, 2005–2006.
Digital cartography by J. Carrell and J. Domier, Illinois State Geological Survey.

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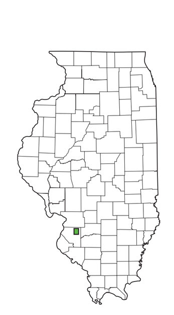

1	2	3
4		5
6	7	8

ADJOINING QUADRANGLES
1 Collinsville
2 Saint Joseph
3 Highland
4 O'Fallon
5 Trenton
6 Freeburg
7 Mascoutah
8 Venedy

MAGNETIC NORTH · TRUE NORTH · 1/2°
APPROXIMATE MEAN DECLINATION, 2006

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 Lebanon 7.5 minute quadrangle, St. Clair County, southwestern Illinois (fig. 1). The cross sections show the extent of surficial and buried units down to bedrock. Previously published geologic maps of the area have been at 1:500,000 scale (Lineback 1979, Stiff 2000). Jacobs (1971) published several applied maps at 1:250,000 as part of a county-wide mapping initiative. This project builds upon this earlier work by adding new observations of the surface and subsurface, incorporating them into a digital database, and interpreting them at large scale. Sediments forming prominent upland ridges were distinguished, variability of units was characterized, 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. This product can be used for preliminary geologic assessments of construction siting issues, geologic hazards, groundwater and materials 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.

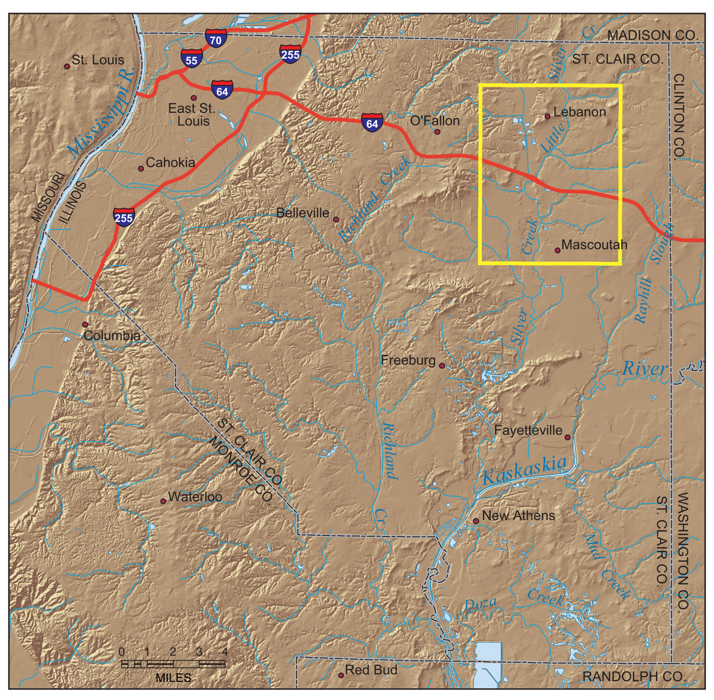

Figure 1 The landscape of the region around the Lebanon 7.5-minute Quadrangle (yellow outline) is depicted in shaded relief with a simulated light source from the northwest. The Illinois Episode glacier flowing out of the northeast constructed the relatively smooth upland surface at the glacier base, but left trains of ridges and mounds along stagnating margins, crevasses, and possibly subglacial streams. Silver Creek and Little Silver creek were meltwater outlets for the Illinois Episode glacier and are tributary to the Kaskaskia River, which was also an outlet for the Wisconsin Episode glacier. The entire surface is subdued by a blanket of loess deposited during the Wisconsin Episode. Small valleys incised into the uplands are mainly postglacial features.

Regional Setting

The Lebanon 7.5-minute quadrangle is located about 12 miles east of bluffs that overlook the Mississippi River valley, and near the margins of the Illinois and pre-Illinois Episode glaciations (fig. 1). The landscape can be considered as three geomorphic regions: 1) ridged to hummocky uplands crossing the north to northwest portion of the quadrangle, 2) low relief uplands with small tributary valleys extending southwards along the Silver Creek valley, and 3) the larger valleys of Silver and Little Silver creeks which transect the quadrangle. Uplands are composed of glacial, stream, and windblown sediment (loess). The ridges and mounds of the north portion of the quadrangle are are part of a regional train of ridges that trend northeast-southwest across southern Illinois (fig. 1). River valleys, including portions of alluvial terraces, are mainly comprised of waterlain sediments. The larger north to south trending stream valleys in the region, such as Silver and Richland creeks, were conduits of meltwater from the last (Illinois Episode) glacier to cover this region. They are tributary to the Kaskaskia River valley which was a major meltwater outlet for the later Wisconsin Episode glacier, which only covered northeastern Illinois. In addition to these geomorphic regions, there are concealed deposits whose occurrence is partly related to surficial landforms and partly 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. Regional drainage led to a large valley central to the quadrangle (fig. 2). Bedrock valley walls were probably deeply incised by tributary streams, creating a landscape perhaps similar to present-day northeastern Kentucky. 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; fig. 1). The glaciers sculpted the pre-existing landscape and left deposits of diamicton (a poorly sorted mixture of rocks, sand, silt, and clay) as till at the glacier bed or as sediment piles sloughed off of glacier margins or in crevasses. Sorted silt, and 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 Lebanon. Its main influence in this area was to discharge large volumes of sediment into the Mississippi and Kaskaskia rivers. During glaciation, silt was eroded by westerly winds off the unvegetated, extensive sandy floodplains in the Mississippi Valley, then deposited across the upland landscape as blankets of loess. As well, high sediment aggradation in the Kaskaskia River created slackwater conditions in tributary valleys such as Silver Creek. Sediment accumulated in these temporary lakes. Between glaciations, streams continued

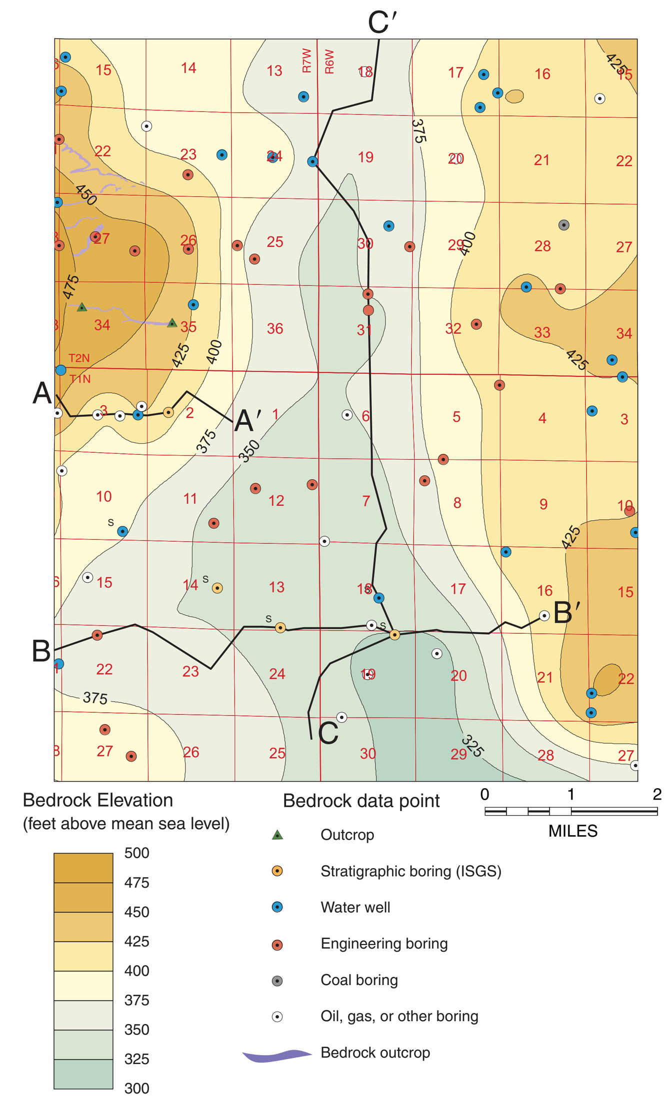

Figure 2 This map of the bedrock surface topography shows a broad valley traversing the quadrangle from north to south. Along the northwestern margin of the quadrangle the surface rises abruptly and shale and limestone bedrock crop out in modern tributary valleys. The bedrock surface rises more gradually eastwards. Drift is thickest in the ridge under the town of Lebanon.

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 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 the Mississippi Valley, 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 (NRCS 1999) that were validated with outcrop observations and modified to conform to topography, interpretations of borehole data, and compilation of fieldnotes and groundwater reports from previous ISGS research. Borehole data sources included new borings acquired for this project, and stratigraphic, geotechnical, water, and coal boring records stored in the ISGS Geological Records Unit. Some landforms were interpreted by airphoto analysis. Computer modeling was used to construct the bedrock topography. The quality of the geologic and locational descriptions of archived data vary considerably in detail and accuracy. Stratigraphic boring descriptions and geotechnical logs typically provided the most detail and could be located most accurately. Except for a few select companies, descriptions provided by water-well drillers were generally of low value because few lithological boundaries were distinguished, typically only larger sand and gravel bodies or the drift/bedrock interface, and locations tend to be imprecise. 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. Positions of well and outcrop locations shown on the map are based upon the best available information for each point. Horizontal and vertical accuracy of data used in the cross sections range between approximately 5 to 200 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, ice-marginal, and glacial stream (outwash) deposits. The Peoria Silt and the underlying Roxana Silt loess units are not differentiated here because their geotechnical properties are very similar (table 1), but they have been studied extensively by McKay (1979), Wang et al. (2003), and others. Original textures of silt loam to heavy silt loam have been modified within the modern solum to heavy silt loam to silty clay loam (NRCS 1999). The loess is thickest (maximum 20 ft but typically 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, the Pearl Formation-Hagarstown Member and the Pearl Formation, undifferentiated, buried beneath 5 -15 ft of loess are depicted on the map by patterned areas. The Hagarstown Member of the Pearl Formation is associated with northeast-southwest trending ridges and irregular to conical mounds. The sediments may have been deposited in ice-contact environments such as end moraines, kames, eskers, or meltwater streams, or proglacial lakes. The Hagarstown Member is characteristically variable. Although sand and gravel bodies tens of feet thick may occur, especially in the elongate landforms and even in inter-ridge areas, their lateral extent may be very restricted and some landforms may be primarily composed of diamicton (Jacobs and Lineback 1969; Heigold et al. 1985; Stiff 1996). Indeed, the ridge on which the town of Lebanon is built appears to be a complex landform of mainly till of the Glasford Formation (below) on the northeast (up-ice) side and and mixture of till, debris flow, and outwash deposits on the south-southwest (down-ice) side (cross section C–C′). A similar structure was found 5 miles north of Lebanon in the Terrapin Ridge (fig. 1; Phillips 2004, 2005). In Choctaw Ridge just north of Scott Air Force Base, by contrast, the Hagarstown Member was shown to be predominantly sand and gravel, although the upper 20 ft is mixed diamicton (both till and debris flow deposits) and thin sand lenses. The upper few feet of the Hagarstown Member typically contains truncated Sangamon Geosol, which can be used to distinguish Illinois from Wisconsin Episode sediment.

The Pearl Formation, undifferentiated, is mainly meltwater stream sediment. In low terraces along Silver Creek with upper elevations of about 450 ft, the Pearl Formation, undifferentiated, is covered by about less than 10 ft of the Peoria and Roxana silts (cross section A–A′). The fine to medium sand and some gravel were deposited when Silver Creek was an outlet for meltwater from the Illinois Episode glacier. The terrace adjacent Lebanon Ridge on the northwest appears to be mainly erosional, with loess lying directly on dense till of the Glasford Formation (below). Where weathered during development of the Sangamon Geosol, the texture may have been altered to loam, or may even have sufficient clay to have a diamicton texture. Locally, below the loess and overlying and interfingering with the Pearl Formation, undifferentiated, are lenses of weathered fine sediment that appears to be a mixture of loess, stream, slopewash, and accreted sediment. Some of this Berry Clay – Teneriffe Silt complex has been pedogenically altered from originally sandy textures to silty clay loam and sandy clay.

Along side slopes and valley walls, where erosion has thinned the loess blanket to 5 ft or less, the Glasford Formation is shown on the surficial map. Sediments in the Glasford Formation include diamicton, weathered diamicton, and associated sorted sands and gravels. The sediment was deposited mainly as till and ice-contact sediment. The ice-contact sediment is distinguished from the Hagarstown Member in that it lacks topographic expression of the deposit and sorted sediments are a more minor component. The Glasford Formation is typically pervasive under the uplands of the Metro-East region, and in the Lebanon Quadrangle reaches thicknesses of 50-60 ft. However, it was completely eroded out or never deposited in portions of southern Lebanon Quadrangle near the Silver Creek valley. Diamicton of the Glasford Formation is loamy, very stiff, with low water content (table 1). Lenses of sand and gravel, up to 10 ft thick and hundreds of feet wide, have been described in the upper part and base of the Glasford Formation in neighboring quadrangles in Madison County (Phillips 2004; Phillips and Grimley 2004). The lower third of the Glasford Formation is slightly more clay-rich and softer, probably because of incorporation of underlying clayey units and shale. Sheared inclusions of pre-Illinois Episode diamicton and weathered shale were identified in several stratigraphic borings. Within the weathering profile of the Sangamon Geosol, as well, the Glasford Formation has relatively low strength and high moisture content, in part due to higher clay content.

Stream Valleys

The Silver Creek and Little Creek valleys are filled with postglacial stream sediment (Cahokia Formation) which lies mainly on outwash and till of the Pearl and Glasford Formations. Terraces and small outcrops of outwash (Pearl Formation, undifferentiated) show that these larger streams were meltwater outlets during the Illinois Episode. Tributary valleys contain only the Cahokia Formation incised into older deposits and are thus more recent features. The Cahokia Formation is up to 30 ft thick. It is generally fine grained because the sediment source was primarily loess, but the texture varies from silty clay deposited in backwater environments and abandoned meanders, to loamy sediments associated with deposition near channels. Layers of sand occur at depth, and up to several feet of sand and gravel that was concentrated by stream processes from older deposits (till or outwash) may occur at the base of the unit.

Thin deposits of slackwater lake sediment of the Equality Formation were interpreted from borehole data in Silver Creek upstream of the Little Silver Creek confluence. A slackwater lake was formed in the Silver Creek valley during the Wisconsin Episode when outwash in the Kaskaskia Creek valley aggraded sufficiently to block the mouth of Silver Creek. The Equality Formation occurs below the Cahokia Formation and above all other strata. It is much more extensive to the south on Mascoutah Quadrangle (Grimley 2006).

The deepest stream valley unit is outwash of the Pearl Formation, undifferentiated. It is continuous with the Pearl Formation deposits on the terraces, and is incised into all older units.

Tributary streams are incised into upland sediments. The thickness of alluvial sediments (Cahokia Formation) in the upper reaches of tributary streams varies from a thin veneer to less than 10 ft, but thickens to ~25 ft near confluences with the trunk valleys. Tributary valleys are relatively narrow with steep walls where incision has progressed below the surficial loess into till (Glasford Formation), whereas valleys are wider and gentler where sandy deposits are the uppermost subsurface unit (Pearl Formation). In the upper reaches of several streams, bedrock is exposed in the channel bed or covered by a thin lag deposit (fig. 2).

Concealed Deposits

Pre-Illinois Episode Quaternary deposits (Banner Formation) are distinguished from the Glasford Formation by selected physical and chemical properties (table 1) 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 only be recognized by a zone leached of carbonate. Although till of the Banner Formation is typically uniform in this region with moderate strength, fine matrix texture, low gravel content, and massive fabric, boreholes 30330 and 30382 were relatively complex. The upper few feet of the Banner Formation is a hard, distinctively reddish brown loam. It correlates to several sample sets and water well borings in the immediate area, and has been noted in a few stratigraphic tests to the north (Phillips 2004; Phillips and Grimley 2004). In 30382, the unit was stratified with 1-2 ft beds of diamicton, silt, and sand. The stratification could be evidence of an ice-contact facies.

Geologic Resources

Groundwater Resources

There are limited groundwater resources in the drift of Lebanon Quadrangle. Although the Pearl Formation 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. Nonetheless, there is anecdotal evidence that reliable water for private wells can be obtained from sand and gravel in ridges and mounds, although only a few water wells occur on those features in Lebanon Quadrangle. From data in the ISGS Geological Records Unit, most wells developed within drift are between 25 and 50 feet deep with large diameters. Only about one fourth are screened in gravel or sand lenses 2-10 feet thick, despite our finding that the Pearl Formation occurs over much of the southern and southwestern area. Possibly, the sand is too fine, in general. The remaining water wells are screened in till and probably capture water from thin, discontinuous sand lenses and fractures. Contamination potential for shallow aquifers in uneroded uplands is low to moderate (Berg et al. 1984). Although potential confining layers of loess and till are sufficiently thick over much of the quadrangle, sand and gravel lenses in shallowly buried Hagarstown Member, Pearl Formation, and Glasford Formation provide potential subsurface pathways for contaminants (c.f. Berg et al. 1984). The Sangamon Geosol likewise provides a clay-rich horizon, up to 3 ft thick, that could substantially retard downward groundwater flow (c.f. Herzog et al. 1989). However, soil structure, fractures, as well as the many small lenses of sand within the upper part of the Glasford Formation may provide pathways for contaminants to underlying layers.

Geologic Hazards

Buried fine sands of the Pearl Formation

On the terraces (hachured regions) along Silver Creek represent potential liquefaction hazards. Potential confining layers include the pedogenically-altered accretion and fine-grained stream deposits of the Berry Clay – Teneriffe Silt complex. Tuttle (2005) identified paleoseismic features including sand blows in stream outcrops along the Kaskaskia River and Silver Creek south of the Lebanon quadrangle, as well as many other locations in the region. They were correlated to earthquake activity centered on the New Madrid Seismic Zone in southern Illinois

Acknowledgements

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

Unit	Geotechnical Properties[1] w(%)	Q_u (tsf)	N	Particle Size Data[2] Sand	Silt	Clay	Clay mineralogy	Geophysical Data[3] Natural gamma	MS
Cahokia Fm.	21–29	0.25–1.25	2–8		coarse sand to silt loam		ND[4]	ND	ND
Peoria and Roxana Silts	19–25	1.0–2.25	4–8	1–8	70–78	19–23	very high expandables	30–50	8–15
Equality Formation	30–50	2–2.5	6–10		silty clay to clay		ND	ND	ND
Pearl Fm., undivided	20–40	ND	2–22		fine to medium sand with gravel		ND	<10	8–30
Hagarstown M.	ND	ND	ND		loam, sand, gravel, loam diamicton		very high expandables	35–50	ND
Glasford Fm.[5]	16–24	3.0–>4.5	3–25	26–43	37–54	20–29	50–78% illite	30–60	ND
Banner Fm., undifferentiated[5]	18–22	3.0–4.5	ND	22–52	19–50	28–30	~58% illite, ~16% expandables	30–50	20–30
Pennsylvanian shale (bedrock)	10–18	3.5–>4.5	>50	ND	ND	ND	high illite	very high	ND

[1]Geotechnical Properties: Compiled from 3–15 bridge borings and 1 stratigraphic boring from across the quadrangle
w = % moisture content = mass of water / mass of solids (dry)
Q_u = unconfined compressive strength, Pocket Penetrometer method
N = blows per foot (Standard Penetration Test)

[2]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 indicate about ¼ more illite than previous results by H.D. Glass with General Electric X-ray diffractometer.

[3]Geophysical Data:
Natural gamma radiation interpreted from continuous downhole logs of 1 stratigraphic boring
MS = magnetic susceptibility (x 10^{-5} SI units), determined from quasi-continuous sampling of 1 outcrop

[4]ND = no data available

[5] Properties for Glasford Fm. and Omphghent m., Banner Fm. are mainly for calcareous till (excludes sand and gravel lenses and strongly weathered zones).