

Illinois Geologic Quadrangle Map
IGQ New Athens East-SG

Surficial Geology of New Athens East Quadrangle

St. Clair County, Illinois

David A. Grimley and Nathan D. Webb

2009



ILLINOIS

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Institute of Natural Resource Sustainability
William W. Shilts, Executive Director
ILLINOIS STATE GEOLOGICAL SURVEY
E. Donald McKay III, Interim Director
Natural Resources Building
615 East Peabody Drive
Champaign, IL 61820-6964

<http://www.isgs.illinois.edu>

Introduction

This surficial geology map of the New Athens East 7.5-minute Quadrangle, located in Illinois about 25 miles southeast of downtown St. Louis, Missouri (fig. 1), provides an important framework for land and groundwater use, resource evaluation, engineering and environmental hazard assessment, and geological and archeological studies. This study is part of a broader geologic mapping program undertaken by the Illinois State Geological Survey (ISGS) in the St. Louis

Metro East region (Phillips 2004, Grimley 2008), which includes Madison, St. Clair, and Monroe Counties in Illinois.

The New Athens East Quadrangle is located in southeastern St. Clair County (fig. 1), about 20 miles northeast of the maximum extent of glacial ice during the Illinois Episode and a pre-Illinois Episode glaciation (Grimley et al. 2001). Glacial ice in southwestern Illinois generally advanced from the northeast, originating from the Lake Michigan basin during the Illinois Episode and from the Lake Michigan

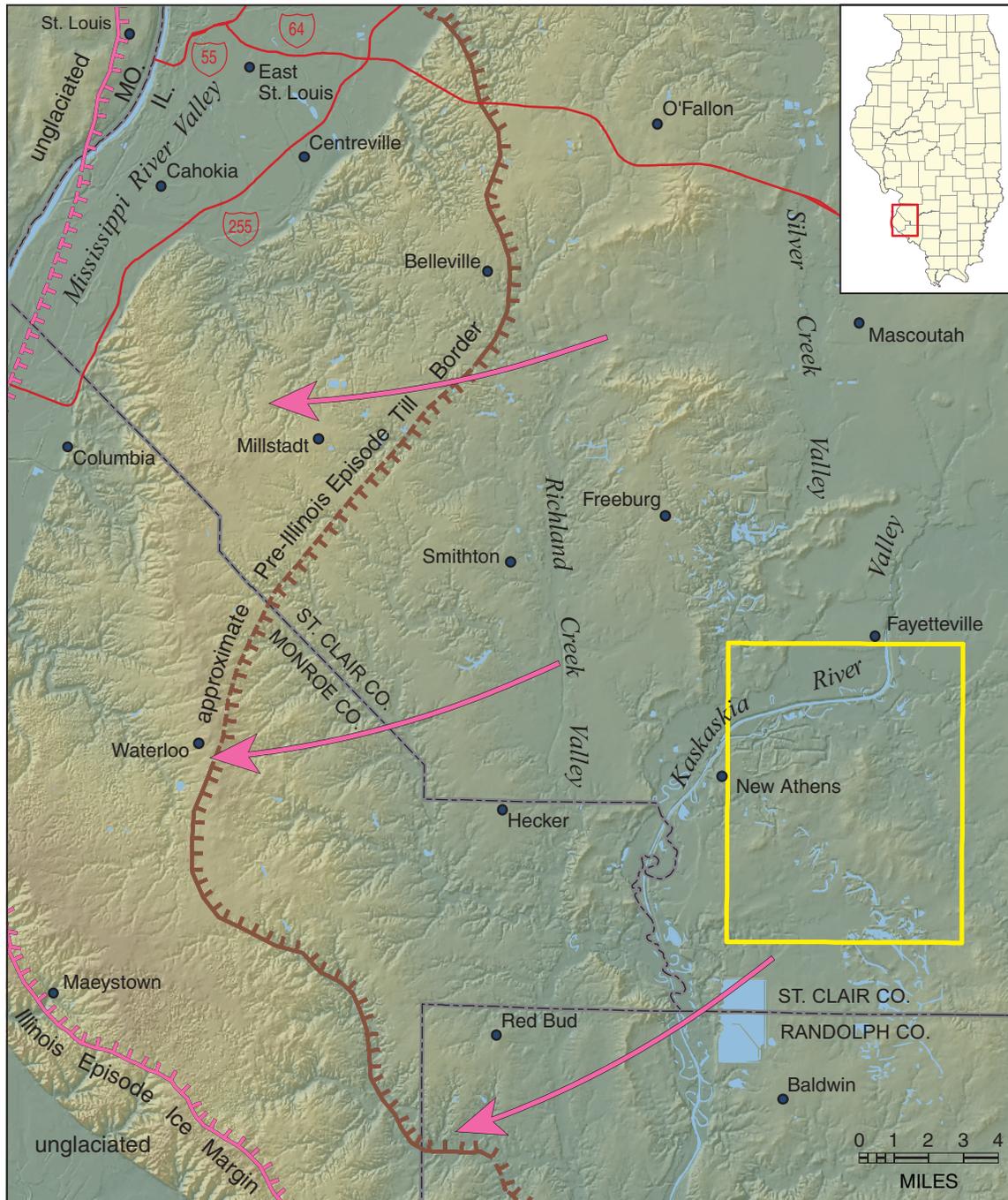


Figure 1 Shaded relief map of the St. Louis Metro East area (southern portion). The New Athens East Quadrangle is outlined in yellow. Pink arrows indicate approximate ice flow direction during the Illinois Episode.

basin and/or the more eastern Great Lakes region during a pre-Illinois Episode glaciation (Willman and Frye 1970). Various glacial deposits from both episodes have been reported by MacClintock (1929), McKay (1979), and Phillips (2004) in this region. Glacial ice did not reach the study area during the Wisconsin Episode; however, glacial meltwater streams from the upper Mississippi River drainage basin deposited outwash throughout the middle Mississippi River valley. This outwash was the source of the loess deposits (windblown silt) that blanket uplands in southwestern Illinois. During the Illinois and pre-Illinois Episodes, outwash was regionally deposited in the ancestral valleys of Silver Creek (Phillips 2004) and the Kaskaskia River (Grimley 2008), both of which drained to the south and southwest. In response to Mississippi River aggradation, large slackwater lakes formed in many tributary valleys, including glacial Lake Kaskaskia (late Wisconsin Episode) in the present-day Kaskaskia River valley (Shaw 1921, Willman and Frye 1970) and similar slackwater lakes that formed during earlier glaciations. During interglacial (Yarmouth and Sangamon Episodes) as well as postglacial periods, the Kaskaskia River and its tributaries were incised in response to periods of downcutting of the Mississippi River (Curry and Grimley 2006). Thus, the Kaskaskia River valley has experienced a succession of cut-and-fill sequences over approximately the last 500,000 years. The lower Kaskaskia River valley is also the site of numerous archeological sites (Conrad 1966).

Methods

Surficial Map

The surficial geology map is based in part upon soil parent material data (Wallace 1978, Natural Resources Conservation Service 1999), supplemented by data from outcrop studies, stratigraphic test holes obtained for this STATEMAP project, engineering borings from the Illinois Department of Transportation (IDOT) and the St. Clair County Highway Department, coal test borings, and water-well records. Map contacts were also adjusted according to the surface topography, geomorphology, and observed landform-sediment associations.

Localities of important data used for the surficial geology map, cross sections, or landform-sediment associations are shown on the map. All outcrops and stratigraphic test holes are shown on the surficial map, as well as key engineering and water-well borings with confirmed locations. Coal and oil and gas type borings are shown only where utilized for cross sections. The locations of many water wells and coal borings were verified by plat books, permit maps, and/or field confirmations (for water wells only). Many data in this quadrangle are not shown due to poor descriptions of surficial materials or unconfirmed locations. Further information on all data shown, as well as other data, is available from the ISGS Geological Records Unit. Data can be identified based on their labeled county number (5-digit portion of the 12-digit API number).

Cross Sections

The cross sections portray unconsolidated deposits as would be seen in a vertical slice through the earth down to bedrock (vertically exaggerated 20 times). The lines of cross section are indicated on the surficial map. Data used for subsurface unit contacts (in approximate order of quality) are from studied outcrops, stratigraphic test holes, engineering boring records, water-well records, coal test borings, and oil-well records. Units less than 5 feet in maximum thickness are not shown on the cross sections. Dashed contacts are used to indicate where data are less reliable or are not present. The full extent of wells that penetrate deeply into bedrock is not shown.

Bedrock Topography Map

Maps of bedrock topography (fig. 2) and drift thickness (fig. 3) are based on data from which a reliable bedrock elevation could be determined (fig. 2). Data within about a mile of the map were also utilized (not shown). A total of 339 data locations were used, including 2 outcrops, 8 stratigraphic tests, 22 engineering borings, 42 water-well borings, 131 coal borings, 44 oil and gas test borings, and 90 other borings. The bedrock surface was modeled utilizing a “Topo to Raster” program in ArcMap 9.2 (ESRI). This program incorporated a combination of three information types: (1) the 339 data points coded with bedrock top elevations, (2) digitized contour lines coded with bedrock top elevations (from outcrops and soil survey observations), and (3) digitized “streams” (ArcMap term) that forced the bedrock surface model to conform to a typical stream drainage network, guided by geological insights.

Drift Thickness Map

A drift thickness map (fig. 3) was created by subtracting the bedrock topography digital elevation model (DEM) from a land surface DEM, both with a 30-m cell size. Areas shown to have a drift thickness less than zero were reevaluated and modified through use of additional “streams,” artificial points, or reinterpretations of original data. Multiple iterations of this process were repeated until reasonable bedrock surface and drift thickness maps were obtained, reflecting our visualized model of bedrock surface and land surface topographic relationships. For the final bedrock topography map, any bedrock elevations higher than the surface DEM were replaced with the value of the surface DEM, so that the final calculated drift thickness map does not have values less than zero.

Surficial Deposits

The surficial deposits can be divided into four landform-sediment associations: (1) bedrock-controlled uplands in the central portion of quadrangle, with a thin cover of glacial and windblown (loess) sediment; (2) isolated upland ridges and knolls, sporadically distributed, containing ice-contact sediment and capped with loess; (3) broad terraces and tributary valleys (primarily Doza and Mud Creek valleys),

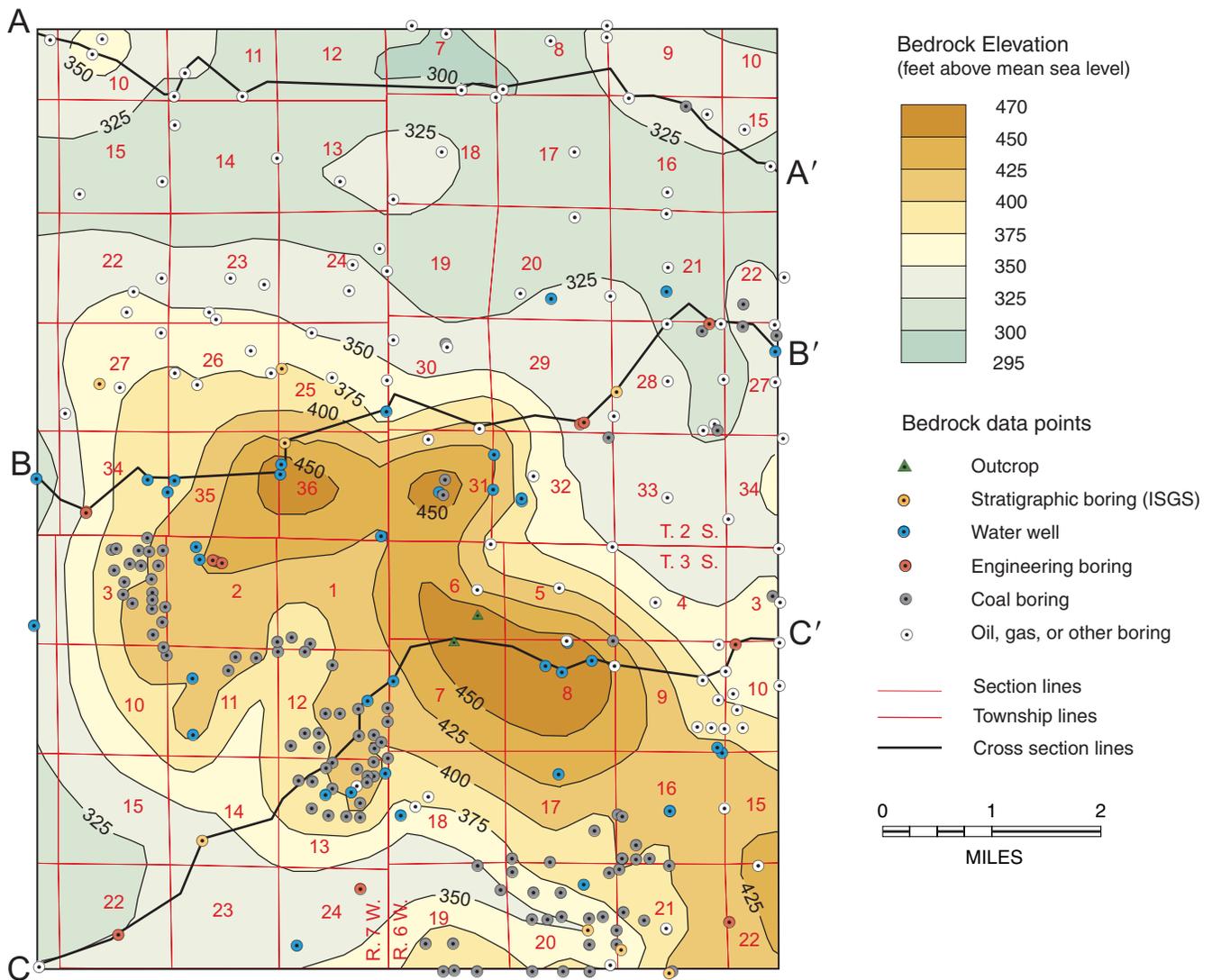


Figure 2 Bedrock topography of the New Athens East Quadrangle in St. Clair County, Illinois. Localities of all data that reliably indicate the bedrock surface are shown (many data are not shown on surficial map). Scale is 1:100,000.

containing up to 120-foot-thick successions of glacial and postglacial fluvial, lacustrine, and deltaic sediments, with loess cover on the older terraces; and (4) the Kaskaskia River valley floodplain, underlain primarily by fluvial sediment from glacial to recent times. There are also older concealed deposits associated with early glaciations and preglacial times. Their occurrence and thickness are more closely related to the bedrock surface topography (fig. 2). Finally, areas of anthropogenically disturbed ground are extensive (18% of map area) and include several former surface coal mines with artificial hills of waste material, areas of removed sediment and rock (under lakes), spoil piles along the Kaskaskia River navigation channel, and a landfill one mile northwest of Marissa (NE Sec. 20 and NW Sec. 21, T3S, R6W).

Bedrock-Controlled Uplands

The upland area in the central portion of the quadrangle (~22% of map area) is primarily a bedrock-controlled highland (fig. 2) with a relatively thin cover of glacial deposits (fig. 3). The broad northwest-southeast-trending ridge in

the central area reflects the strike of a more resistant Pennsylvanian sandstone unit in the subsurface, perhaps correlative with the Gimlet Sandstone of the Shelburn Formation (Nelson 2005). Pennsylvanian rock units regionally dip gently northeastward toward the Illinois Basin. Thus, the bedrock topography (fig. 2) essentially portrays an ancient, buried cuesta with 10 to 50 feet of sandstone constituting the uppermost bedrock in ridges (cross section C–C') and shales mainly constituting the uppermost bedrock in preglacial valleys. The ISGS historical field notes indicated Pennsylvanian sandstone cropped out in uplands northeast of Lenzburg (Sec. 6, T3S, R6W). Several boring logs on these uplands indicate thin glacial drift (<40 feet thick) overlying sandstone (cross section C–C'). Thin drift and the lack of sandstone cover on the southwest side of the northwest-southeast-trending ridge explain the basic distribution of former surface coal mines (in Herrin Coal) parallel to bedrock strike.

The bedrock-controlled uplands are overlain by a relatively thin cover of diamicton (a massive, unsorted mixture of clay, silt, sand, and gravel), with minor sand and gravel lenses,

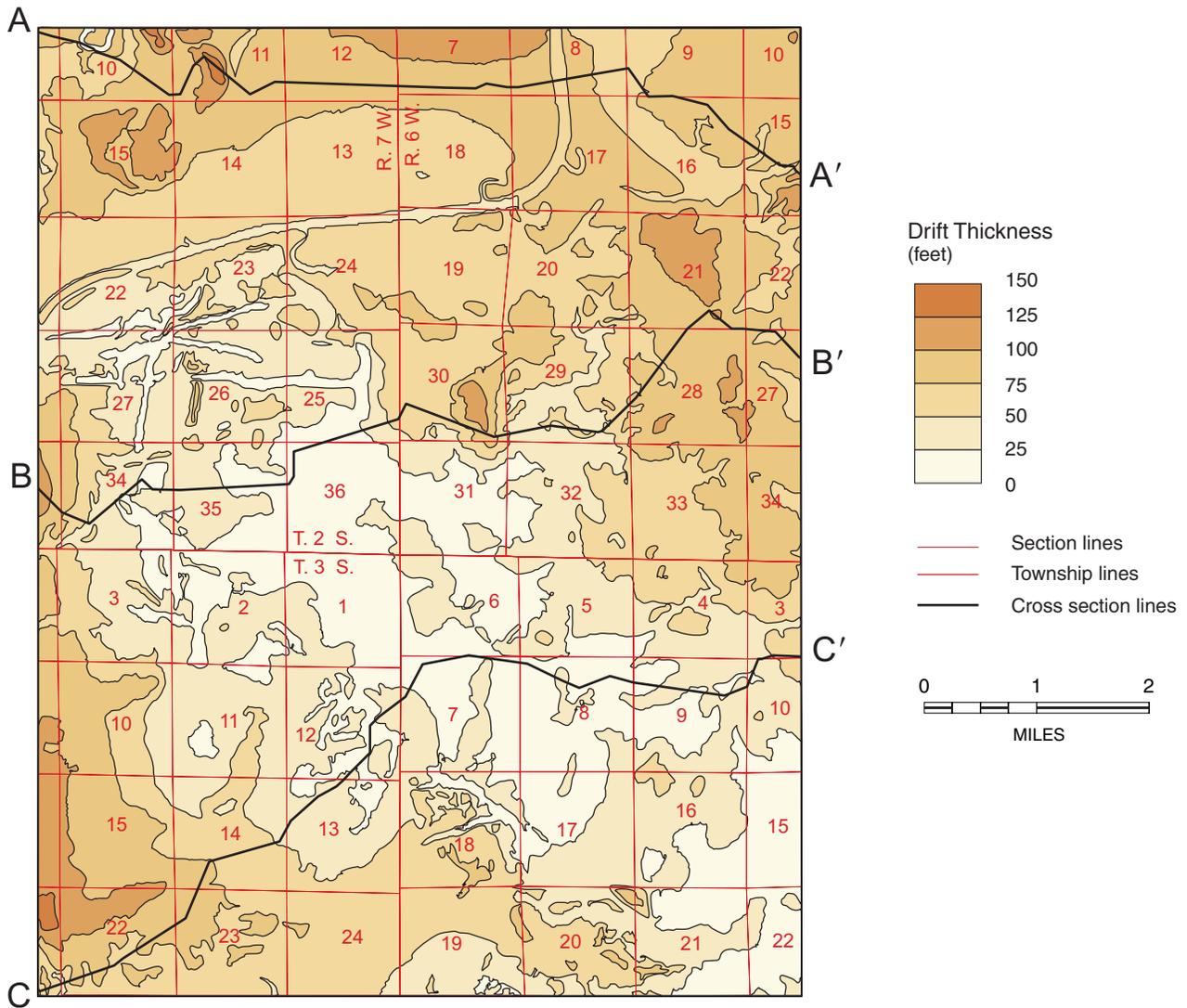


Figure 3 Drift thickness of the New Athens East Quadrangle. Drift includes all unconsolidated sediments above bedrock (loess, till, alluvium, lake sediment, etc.). Data point locations are the same as in figure 2. Map scale is 1:100,000.

and are blanketed by windblown silt (loess). Where mapped, the loess (Peoria and Roxana Silts) is typically 6 to 13 feet thick, with thinner deposits on steeper eroded slopes and an overall thinning trend to the southeast. The loess was deposited during the last glaciation (Wisconsin Episode) when silt-size particles in Mississippi River valley glacial meltwater deposits were periodically windswept and carried in dust clouds eastward to vegetated upland areas, where they gradually settled across the landscape. The Kaskaskia River valley possibly provided a minor local source of loess, but thicknesses here are comparable to that north of the valley near Mascoutah (Grimley 2008). Loess deposits are typically a silt loam where unweathered. In the modern soil solum (generally the upper 3 to 4.5 feet), the loess is altered to a heavy silt loam or silty clay loam (Wallace 1978). The Peoria Silt is the upper, younger loess unit. The Roxana Silt, with a slight pinkish hue, is the lower loess unit (Hansel and Johnson 1996). Both loess units in this quadrangle are slightly to moderately weathered, leached of carbonates, and fairly similar in physical properties.

Diamicton, weathered diamicton, and/or associated sorted sediment (together mapped as Glasford Formation) are found underneath the last glacial loess deposits. One such outcrop was observed on the west bank of Mud Creek (30692; Sec.10, T3S, R6W). The Glasford Formation was also observed to crop out below lake and stream sediments on the south bank of Silver Creek (site 30694; Sec.10, T2S, R7W) and the east bank of Mud Creek (30632; Sec. 20, T2S, R6W) and has been encountered in several stratigraphic and engineering test borings. In most cases, the diamicton deposits are interpreted as glacial till, although some deposits may include debris flows.

Strong alteration features are typically prevalent in the upper 4 to 6 feet of the Glasford Formation, including root traces, fractures, carbonate leaching, oxidation or color mottling, strong soil structure, clay accumulation, and/or clay skins. This weathering is due to the occurrence of a buried interglacial soil known as the Sangamon Geosol, which helps to delineate the Glasford Formation from overlying loess deposits

(Willman and Frye 1970). Oxidation and fracturing, with iron staining on the fracture faces, typically extends 10 to 20 feet or more into the Glasford till. Compared to overlying loess deposits, the Glasford till is considerably more pebbly and dense, has a lower moisture content (11–16%), and has greater unconfined compressive strength (Q_u , table 1). The upper 6 to 12 feet of Glasford Formation, where uneroded, is generally more weathered, is leached of carbonates, has a higher water content, and is less stiff than the majority of the unit.

Relatively unaltered portions of Glasford till in this quadrangle typically have a composition of about 35–55% illite in the clay mineral fraction and a loam to silt loam texture with about 19–25% <2 mm clay, 45–50% silt, and 25–35% sand (table 1). The Glasford Formation, deposited during the Illinois Episode, may also include sand and gravel lenses deposited from glacial meltwater streams within, in front of, or below glacial ice. Sand and gravel lenses are relatively uncommon on the highest areas of the bedrock-controlled uplands, but become more abundant within adjacent lowlands, terraces, and glacial hills and knolls. Similarly, pre-Illinois Episode deposits are likely not present at elevations above ~390 feet asl (above sea level) due to more limited deposition and/or postdepositional erosion.

Glacial Hills and Knolls

A few hills and knolls (~1% of map area) are found on the edge of the bedrock-controlled uplands that likely contain lithologically complex unconsolidated deposits (typical of such hills). These areas, interpreted principally to be of glacial origin rather than bedrock highs, were mapped as the Hagarstown Member of the Pearl Formation (Willman and Frye 1970, Killely and Lineback 1983). Since most of these areas are blanketed by 5 to 13 feet of loess, stipples on the map indicate the Hagarstown unit in the subsurface. One area of near-surface Hagarstown Member is mapped in the northwest portion of the quadrangle (solid reddish brown color) where the loess cover was eroded on a hillside to less than 5 feet thick. Previous studies in south-central Illinois have noted significant sand and gravel deposits in similar glacial ridges (Jacobs and Lineback 1969, Grimley 2008); however, some ridges contain a high proportion of intermixed diamicton and fine-grained sediment (Phillips 2004, Grimley 2008).

The hills and knolls regionally appear to have an association with the transitions to bedrock topographic highs, but their exact origin is not yet clear. Sediment within the hills is interpreted as ice-contact and may include various genetic types such as debris flows, melt-out till, and ice-marginal channels deposits. Although few new observations of Hagarstown deposits were acquired in this quadrangle, one water-well log from a typical hill (27139; Sec. 11, T2S, R7W; cross section A–A') notes the presence of about 15 feet of loose fine sand, along with beds of clay and sand and zones with clayey diamicton, perhaps debris flow deposits.

In Dutch Hill (SW $\frac{1}{4}$, SW $\frac{1}{4}$, NE $\frac{1}{4}$, Sec. 10, T3S, R7W), an unpublished ISGS report by J.W. Baxter and N.C. Hester noted 14 feet of loess over 3 feet of sandy, pebbly silt over 16 feet of fine to coarse sand with few, small pebbles (interpreted as Hagarstown Member) from a power-auger boring, suggesting a kamic origin. In other similar hills to the north, variable materials have been observed, such as well-sorted to poorly sorted sand interbedded with loam, diamicton, and inclusions of pre-Illinoian sediments (Grimley 2008). The upper 3 to 10 feet of the Hagarstown Member, below the loess, is typically altered to a clay loam to sandy clay loam and contains pedogenic alteration features, such as clay skins and root traces that formed during interglacial soil development (Sangamon Geosol).

Broad Terraces and Tributary Valleys

Areas of broad terraces and tributary valleys (together ~42% of map area) are found in much of the northeastern and southwestern portions of the quadrangle along and adjacent to Mud Creek, Little Mud Creek, and Doza Creek valleys. These areas, which tend to overlie former topographic lows on the bedrock surface (fig. 2), have been periodically infilled with lacustrine and fluvial deposits. Deposits are mainly fine-grained and stratified, but include some coarse-grained materials. The various terrace levels were formed as a result of alternating periods of sediment aggradation (mainly during glacial times) and river incision (mainly during interglacial times). The terraces observed today were formed as a result of processes during the last two glaciations (Illinois and Wisconsin Episodes) as well as during interglacial and postglacial times. Approximately 7 to 13 feet of loess (Peoria and Roxana Silts) covering the Illinois Episode terraces in uneroded areas distinguishes these from the younger terraces. In places, older pre-Illinois Episode slackwater deposits are preserved in the subsurface. It is conceivable that some high terraces visible today are, in part, palimpsest surfaces, with the younger deposits draped or superimposed on pre-Illinois Episode deposits and their former terraces.

Two divisions within a loess-covered Illinois Episode terrace are mapped: (1) loess-covered stratified sand and gravel (Pearl Formation) and (2) loess-covered accretionary or stratified fine-grained deposits (Berry Clay Member or Teneriffe Silt). All such areas are mapped as loess and given an appropriate diagonal line pattern and colored to indicate where more than 5 feet of either the Pearl Formation (reddish orange) or the Berry Clay Member-Teneriffe Silt (brownish gray), respectively, are predicted to occur at depth. In most cases, areas mapped as having Pearl Formation also have a thin overlying deposit of Berry Clay Member, but such areas are mapped as Pearl Formation because of the practical importance of the coarser-grained deposits.

The Pearl Formation terrace is mapped principally in the western portion of the map, south of New Athens and at elevations from about 420 to 440 feet asl. The Illinois Episode

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

Unit	Geotechnical properties ¹				Particle size and composition ²				Geophysical data ³	
	w (%)	Q _u (tons/ft ²)	N	Sand (%)	Silt (%)	Clay (%)	Clay mineralogy	Carbonate content	Natural gamma	MS
Cahokia Formation	25–44	0.5–1.5	3–12	—	ND ⁴ , variable	—	ND	none	ND	ND
Cahokia Formation (clayey - Kaskaskia)	23–40	0.75–1.5	ND	—	ND	—	>50% expandables	none	ND	7–20
Cahokia Formation (sandy - Kaskaskia)	ND	<0.25–1.0	ND	—	ND	—	ND	none	ND	ND
Equality Formation ⁵	25–41	0.25–2.25	5–12	0–11	48–71	20–52	high expandables (10–50% illite)	5–20% (unleached)	high	8–26
Henry Formation	—	ND	—	—	ND	—	ND	low–moderate	low	ND
Peoria and Roxana Silts	22–30	0.5–2.5	5–10	0–7	65–85	15–30	>60% expandables	none (leached)	moderate	7–50
Berry Clay Member/Teneriffe Silt	18–31	1.0–3.5	ND	0–25	45–83	16–36	high expandables (10–40% illite)	0–22% (in Teneriffe only)	high	5–30
Hagarstown Member	—	ND	—	—	ND, variable	—	ND	leached to moderate	ND	ND
Pearl Formation	16–25	<0.25–1.25	5–23	—	ND	—	ND	leached to moderate	low	15–35
Glasford Formation ⁵	11–20	2.0–>4.5	11–24	25–35	45–50	19–25	37–55% illite	10–22% (unleached)	moderate	8–25
Petersburg Silt ⁵	21–28	1.5–3.5	10–25	0–10	40–60	30–60	35–65% illite	0–30%	high	8–30
Lierle Clay Member	13–23	3.0–4.0	ND	25–50	35–50	20–40	limited data	none (leached)	moderate	5–15
Omphghent Member ⁵	21–25	2.5–3.5	16–23	10–30	35–50	30–45	limited data	leached to moderate	ND	10–30
Harkness Silt Member	12–21	0.5–4.0	ND	25–50	40–67	8–15	45–55% illite	10–15%	low to moderate	15–45
Canteen member (clayey facies only)	18–24	3.0–4.5	8–19	10–20	40–60	27–45	20–35% illite (high in kaolinite/chlorite)	0–3%	high	7–20
Pennsylvanian shale	12–16	>4.5	>50	—	ND	—	high in illite and kaolinite/chlorite	none to low	very high	5–15

¹Geotechnical properties are based on hundreds of measurements (total for all units) from about 25 engineering (bridge) borings and 7 stratigraphic test borings in the quadrangle. w, moisture content = mass of water/mass of solids (dry); Q_u, unconfined compressive strength; N, blows per foot (standard penetration test).

²Particle size and compositional data are based on a limited data set (~30 samples) from 7 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) using Scintag X-ray diffractometer (about one-fourth more illite than previous results by H.D. Glass with General Electric diffractometer). Carbonate content determined on <74-µm fraction.

³Geophysical data: natural gamma, relative intensity of natural gamma radiation (data from 2 stratigraphic borings and some oil and gas borings). MS, magnetic susceptibility ($\times 10^{-6}$ m³/kg) (detailed data from 7 stratigraphic borings).

⁴ND, no data available.

⁵Excludes sand and gravel lenses and strongly weathered zones.

age for this terrace is based on the presence of interglacial soil alteration features (Sangamon Geosol) and accretionary deposits at the top of the outwash sequence and below loess deposits (Peoria and Roxana Silts). Due to the loess cover as well as accretionary and pedogenically altered material, elevations for the top of the underlying loose sand (typically fine to medium grained) are more typically 400 to 420 feet asl. Outwash at these elevations is common along the lower Kaskaskia River valley in adjacent areas (Grimley 2008) and likely reflect high-level glacial meltwater torrents concurrent with melting of the Illinois Episode ice sheet in the Kaskaskia drainage basin. The Pearl sand and gravel typically overlies diamicton of the Glasford Formation. Sand and gravel up to 40 feet thick also occurs below Glasford diamicton in some areas of the northwestern part of the quadrangle (western portion of cross section A–A'), based mainly on water-well logs. Although also of probable glaciofluvial origin, these sand deposits are included within the Glasford Formation rather than the Pearl Formation because they are stratigraphically below Glasford diamicton (Willman and Frye 1970). These basal Glasford deposits probably record Kaskaskia River valley outwash in advance of an approaching Illinois Episode ice front or may possibly be related to older glaciations. Because the Kaskaskia River drains to the southwest, it would have been positioned to provide drainage away from glacial ice that advanced from the northeast and ultimately would have buried its proglacial deposits.

The combined Berry Clay Member-Teneriffe Silt terrace includes (1) pedogenically altered accretionary deposits; (2) stratified, fine-grained lake sediments; and (3) eolian silt additions; combined thickness is about 5 to 20 feet. These deposits generally overlie Glasford Formation till deposits, contain interglacial soil alteration features (Sangamon Geosol) developed into upper portions, and have a loess cover. Similar to the Pearl terrace, the elevations of the Berry Clay-Teneriffe terrace are also in the 420- to 440-foot range, and deposits within these two terraces appear to be in facies, with sandier deposits occurring closer to the axis of the Kaskaskia River valley.

Teneriffe Silt deposits were most notably found in stratigraphic test hole no. 30676 (eastern cross section B–B'). Here, the Teneriffe Silt (~15 feet thick) is a massive to faintly stratified, calcareous, silt loam with thin beds of loamy sand and very fine sand. This unit is interpreted as lake sediment that may have been deposited as a result of slackwater or ice-dammed conditions in Mud Creek and Doza Creek valleys during the late Illinois Episode. Slackwater environments may have resulted from glaciofluvial aggradation in the Mississippi River valley or locally from aggradation in the Kaskaskia River valley. Sandier beds may represent fluvial or deltaic conditions during periods of lower lake levels. A moraine-dammed or ice-dammed lake is another possible explanation for the lake deposits.

Clayey and silty accretionary deposits in upland depressions or lowlands, up to 20 feet thick, are included in the Berry Clay Member, an upper member of the Glasford Formation (Willman and Frye 1970) or Pearl Formation (Grimley 2008), generally deposited during the Sangamon Episode (interglacial). The Berry Clay Member is typically a silty clay to silty clay loam, but can be clay loam diamicton where the unaltered parent material is more sandy.

Because weathered Teneriffe Silt and Berry Clay Member are difficult to distinguish (especially from well log descriptions), these units are combined for mapping purposes. Much of the area mapped Teneriffe-Berry Clay was formerly mapped as Pearl Formation terrace at the statewide scale (Lineback 1979); however, sand and gravel more than one or two feet in thickness was not found in these areas, and so the Pearl terrace is here restricted to areas more proximal to the Kaskaskia River valley.

Extensive areas of the younger terraces (Wisconsin Episode) are found in northeastern, northwestern, and southwestern portions of the map and contain lake sediment related to renewed slackwater conditions in Mud Creek, Little Mud Creek, Doza Creek, Silver Creek, and the Kaskaskia River valleys. Similar to the Illinois Episode fine-grained terraces, these terraces likely formed during the peak of the Wisconsin Episode when Mississippi River sediment aggradation was at its peak level, causing slackwater conditions far up the low-gradient Kaskaskia River valley and its tributaries (sometimes called glacial Lake Kaskaskia). The terraces are typically capped with about 3 feet of Peoria Silt (but not Roxana Silt), which includes the upper modern soil profile. Deposits in this terrace, mapped as Equality Formation, consist of faintly to well-stratified silt loam to silty clay with minor beds of fine sand. Secondary carbonate nodules are commonly found along bedding planes. The environment of deposition was primarily lacustrine, with sediments probably consisting of significant amounts of redeposited loess into a lake or lowland area.

Where relatively thick and unweathered, the middle and lower portions of the Equality Formation are calcareous and fossiliferous, containing small gastropods and sparse conifer wood. Fossil gastropod shells were found at several outcrops (nos. 30631, 30635, 30636, 30641, 30643) and consist predominantly of *Stagnicola caperata* (seasonal lakes), *Fossaria* sp. (aquatic to amphibious), and *Valvata tricarinata* (permanent lakes), with minor occurrences of *Ammicola limosa* (shallow lake), *Gyraulus* sp. (shallow lake), *Probythinella lacustris* (permanent lakes), and *Pomatiopsis lapidaria* (amphibious). Most of the aquatic species common today live among aquatic vegetation in shallow water conditions (<1 m) of alkaline freshwater lakes (Baker 1935). The genera *Fossaria*, *Stagnicola*, and *Pomatiopsis* have lungs and can thus tolerate periodic drying conditions along shorelines or temporary lakes. The ostracode *Candona rawsoni*, as well as small bivalves (3–10 mm), were also observed in a sample

of Equality Formation from site 30643, associated with an aquatic gastropod assemblage. The overall assemblage is consistent with fluctuating water levels in a slackwater lake, an interpretation also noted by Shaw (1921) for deposits in glacial Lake Kaskaskia.

Fossil conifer wood and needles, probably of *Picea* sp., were encountered at a depth of 27 feet in stratigraphic test hole no. 30678 (near Fayetteville, cross section A–A'), below Cahokia Formation alluvium. Wood in the Equality Formation at this site was radiocarbon dated at $15,280 \pm 400$ ^{14}C years before present, confirming a last glacial age. Because the base of the unit was not encountered, it is suspected that the lake was present at considerably earlier times as well.

At some sites (including 30636 and 30694), the lower Equality Formation has a slight pinkish brown cast, is more clayey than above (a silty clay loam), and tends to be weakly calcareous or leached; fossil gastropods (*Stagnicola caperata*) are present at some sites. Small conifer wood fragments at the base of a 40-foot sequence of Equality Formation deposits at outcrop 30636 along Silver Creek were dated at $21,570 \pm 160$ ^{14}C years before present. This radiocarbon age likely represents a minimum age of initial aggradation for most of the Equality Formation in New Athens area terraces and corresponds to the maximum extent of the last glaciation in northeastern Illinois (Hansel and Johnson 1996) and in the Upper Midwest. Earlier periods of Equality Formation deposition likely occurred on more downstream reaches of the Kaskaskia River valley, at lower elevations, as found by Curry and Grimley (2006) on the edge of the American Bottoms near St. Louis.

Postglacial stream deposits in Silver Creek, Mud Creek, Doza Creek, and other tributary valleys are mainly fine grained (silty clay loam to silt loam) and weakly stratified. These deposits, mapped as Cahokia Formation, can include loamy zones or beds of fine sand. The Cahokia Formation in these valleys is less than 20 feet thick and consists mainly of reworked loess, lake deposits, and other fine-grained sediments. The fine-grained nature of these deposits can be explained by the rare occurrence of sand, gravel, or diamicton exposures in the creek watersheds. Due to periodic flooding during postglacial times, areas mapped as the Cahokia Formation have relatively youthful, modern soil profiles that generally lack B horizons compared with profiles for upland soil (Wallace 1978, Natural Resources Conservation Service 1999).

Kaskaskia River Valley

Near-surface deposits in the postglacial Kaskaskia River valley (~16% of map area) consist of interstratified fine to medium sand with silt loam, silty clay loam, and silty clay. Sandy deposits (up to 25 feet thick) in channels and point bars of the Kaskaskia River are mapped as sandy facies of the Cahokia. These deposits are typically fine to medium

sand, moderately well sorted, and noncalcareous. They range in age from recent in modern point bars to possibly several thousand years old (mid to early Holocene) at higher elevations and in the subsurface. The clayey facies of the Cahokia Formation is divided into two units: c(c)-2, older deposits generally on low terraces between about 390 and 405 feet asl, and unit c(c)-1, younger deposits at lower elevations on the modern floodplain. Both deposits range from silt loam to silty clay loam to silty clay and are interpreted mainly as overbank flood deposits and swale fills. Deposits of c(c)-2 are relatively thin (5 to 20 feet thick) and overlie Cahokia sandy facies or the last glacial deposits of the Equality or Henry Formations. Aerial photographs show many abandoned meander channels within the modern floodplain, all now infilled with clayey sediment c(c)-1, up to about 20 feet thick. Both c(c)-2 and c(c)-1 are interstratified laterally with the Cahokia sandy facies. Numerous archeological sites with projectile points, tools, and fire-cracked rocks have been noted in the lower Kaskaskia River floodplain (Conrad 1966), including areas in this quadrangle mapped as Cahokia Formation (clayey or sandy facies).

In many areas in the Kaskaskia River valley, fine to medium sand deposits immediately below the Cahokia and/or Equality Formations are interpreted as Henry Formation (typically Wisconsin Episode age), although the exact age of these deposits are unknown and may include Sangamon Episode fluvial deposits. As the distinction among alluvial units can be subtle and difficult to differentiate, areas noted as Henry Formation in cross section may include sandy Cahokia Formation in upper portions or Pearl Formation near the unit base. In general, the Pearl Formation tends to contain more coarse sand and gravel than the Henry Formation in the Kaskaskia River valley area (probably due to closer proximity to the ice margin), but there may be considerable overlap in the grain size of these units. Sand in the Henry Formation can be noncalcareous or calcareous and may be intercalated with or overlain by calcareous silt loam beds of the Equality Formation.

In some areas, the Cahokia or Equality Formations may directly overlie the older Pearl Formation where the Henry Formation was eroded or was absent (see cross section A–A'). The Illinois Episode Pearl Formation is of significant thickness in the Kaskaskia River valley (up to 55 feet thick) and occurs below the younger river or lake deposits. The Pearl Formation could possibly include pre-Illinois Episode fluvial deposits that cannot be differentiated based on limited data. Several coal and oil borings (not shown on map) were drilled in the Kaskaskia River valley in this quadrangle, but provide only very minimal descriptions of unconsolidated surficial materials in the subsurface. In sum, the Kaskaskia River valley contains a complex record of fluvial and glacial deposits from perhaps the past 500,000 years, all overlying Paleozoic bedrock.

Concealed Deposits (Mainly in Bedrock Valleys)

In ancestral bedrock valleys, tributary to the Kaskaskia River valley, early Illinois Episode fine-grained deposits (Petersburg Silt) and/or pre-Illinois Episode deposits (classified as the Banner Formation) are preserved between the overlying Glasford Formation and bedrock below (see cross sections). Such areas include primarily the northeastern and southwestern portions of the quadrangle, which have experienced numerous alternating periods of fluvial incision and alluvial/lacustrine infilling from the pre-Illinois Episode to the present.

The Petersburg Silt, a stratified silty clay loam to silty clay with some fine sand beds, is 47 feet thick in stratigraphic test hole no. 30655 (cross section C–C') and is interpreted as similar in thickness based on descriptions of “tacky gray or reddish brown clay” material in water-well boring no. 29644 (cross section B–B'). The Petersburg Silt occurs stratigraphically below the Glasford Formation by definition (Willman and Frye 1970). This unit, where mapped, is here mainly interpreted as slackwater lake sediment resulting from impoundment of the Kaskaskia River valley in response to Mississippi River valley aggradation during the advance of the Illinois Episode ice sheet. The lake would have been present prior to the area being buried by glacial ice and the deposition of Glasford till and ice marginal sediment.

Fossil gastropods in the Petersburg Silt (in boring 30655) include *Fossaria* sp., *Valvata tricarinata*, *Gyraulus* sp., and fragments of *Stagnicola caperata*. Other Petersburg Silt fossils include sporadic occurrences of small bivalves (~3 mm, *Pisidium* sp.) and the ostracode *Candona rawsoni*. The overall assemblage of fossils in the Petersburg Silt is very similar to that found in the Equality Formation, and thus the environment of deposition (shallow aquatic with fluctuating lake levels) and ecology are envisioned to have been similar in the Illinois Episode and Wisconsin Episode slackwater lakes. Some thin beds of loamy sand or fine sand in the Petersburg Silt probably reflect fluvial or deltaic deposits during periods of lake regression. In boring no. 30655, some of these sandy beds contain abundant coal fragments (up to 1 cm), suggesting a northeastern source for these deposits from the Herrin Coal subcrop.

Interglacial soil development (Yarmouth Geosol), where preserved within the uppermost Banner Formation (pre-Illinois Episode diamict, sand, gravel, and silt), by definition helps distinguish this unit from Illinois Episode deposits in the Glasford Formation or Petersburg Silt (Willman and Frye 1970). The Banner Formation does not occur near-surface, but is found mainly in preglacial tributary bedrock valleys or lowlands (fig. 2 and cross sections) where it has been protected from erosion during later geologic events. In many areas, the Banner Formation was likely removed by stream incision and erosion during the succeeding interglacial (Yarmouth Episode) or the Illinois Episode glacial advance and associated meltwater streams. The unit's distribution

is thus sporadic and is absent from bedrock highlands in the central part of the quadrangle. The Banner Formation here is divided into four units (stratigraphically from top to bottom): (1) pedogenically altered sandy clay loam to clay loam accretionary or fluvial deposits (Lierle Clay Member), (2) a sandy clay loam to silty clay diamict (Omphgent member), (3) calcareous, stratified sandy loam to silt loam to loamy fine sand (Harkness Silt Member), and (4) a brown to greenish gray, faintly laminated clay to loamy sand with basal beds of angular gravelly sand (Canteen member).

The uppermost unit of the Banner Formation is the Lierle Clay Member, which is typically an accretionary deposit in paleo-lowlands or depressions. The unit is clay-rich, leached of carbonates, and high in expandable clay minerals (Willman and Frye 1970). In this quadrangle, a sandier facies of the Lierle Clay is present in an ancestral lowland near Mud Creek (stratigraphic test no. 30654, Sec. 28, T2N, R6W). This unit is a clay loam to sandy clay loam, with faint stratification in lower zones, and probably represents a weathered fluvial deposit. Pedogenic alteration (including clay skins, gleying, iron staining, and soil structure) within this unit likely records interglacial soil development of the Yarmouth Geosol in a lowland environment. Grayish brown or greenish gray colors are the norm due to relatively poor drainage conditions where this unit is preserved below Illinois Episode deposits.

The Omphgent member of the Banner Formation is interpreted mainly as till and ice-marginal sediment. Few direct observations of Omphgent till were made in this quadrangle, and its physical characteristics appear to be variable, ranging from a sandy clay loam to clay loam to silty clay diamict. Erratic pebbles (e.g., granite) up to 2 cm in diameter were noted. The upper portions of this unit are altered by Yarmouth Geosol interglacial soil development. Sand and gravel lenses may be present within the Omphgent member, but few were observed. The variable character and relative thinness of the unit, compared with its occurrence farther north, are probably related to being within several miles of the terminus of pre-Illinois Episode ice, suggesting relatively thin ice (of limited duration) and thus more local influence to till composition.

A relatively thick deposit (up to 20 feet) of calcareous, stratified coarse silt and fine sand (Harkness Silt Member) was observed below thin Banner Formation diamict (possible glacial debris flows) in stratigraphic test no. 30654. The Harkness Silt Member in this boring is dark grayish brown and contains conifer wood fragments (probably *Picea* sp.) up to 5 cm long and horizontally oriented, implying the wood was washed from adjacent uplands into a stream or lake-shore. The environment of deposition of the Harkness Silt likely alternated between alluvial, lacustrine, and deltaic, and the unit probably accumulated in a proglacial environment. The Canteen member, a basal unit of the Banner Formation, includes mainly noncalcareous to weakly calcareous,

faintly stratified, fine-grained sediment, but can include beds of sand and gravelly sand near the unit base. The Canteen member tends to infill the deepest portions of preglacial bedrock valleys tributary to the Kaskaskia River valley (fig. 2), as has been found regionally (Phillips and Grimley 2004). In this quadrangle, the Canteen member was found to occur at elevations between 300 and 340 feet asl. This unit was observed as 17 feet thick in one stratigraphic test boring (no. 30654, cross section B–B') and was also interpreted from a few water-well and engineering log descriptions. In its upper few feet, the Canteen member may contain weak to moderate soil structure and reddish to greenish color mottling, indicative of a paleosol. The lithology of the gravel fragments in basal portions include subangular shale, sandstone, and chert, all typical of local bedrock sources. The unit is interpreted as preglacial Quaternary alluvium and colluvium because it lacks glacial erratics, has low magnetic susceptibility, and low carbonate content and is high in kaolinite/chlorite (table 1). All of these characteristics are typical of a more weathered Pennsylvanian bedrock source. Basal portions of the Canteen member may in places include bedrock residuum of possible Tertiary or early Quaternary age.

Economic Resources

Sand and Gravel

Potentially minable deposits in the quadrangle include sand with some gravel in the Henry and Pearl Formations. The Hagarstown Member of the Pearl Formation is an unlikely source based on information to date, due to the limited quantity of sand and the apparently fine grain size of sand noted in one boring. The Henry and Pearl Formations in the Kaskaskia River valley have potential reserves, but high-quality data are relatively limited, and flooding is common in this area. Additional boreholes or geophysical tests would be necessary for site-specific projects to determine the economic viability of resources.

Groundwater

Groundwater is extensively used for household, public, and industrial water supplies in southwestern Illinois. Surface water resources such as the Kaskaskia River are also present in this quadrangle. Saturated sand and gravel in the Henry Formation, Pearl Formation (outwash facies and Hagarstown Member), Glasford Formation, and Banner Formation constitute the predominant glacial aquifer materials in the New Athens East Quadrangle. Known sand and gravel lenses are stippled in the cross sections. Aquifer material in the Henry and Pearl Formations (outwash facies) in the northern portion of the map area is fairly extensive and is used for household water supply. In upland areas, saturated sand and gravel bodies within the Glasford Formation or Hagarstown Member are sometimes utilized for household water supply. Several water wells on the bedrock-controlled ridge in the central areas did not encounter adequate water supply in unconsolidated surficial materials due to a lack of sand and gravel bodies and a greater depth to water-saturated mate-

rial. In such areas, deeper bedrock aquifers are commonly utilized for water supply, particularly sandstones or fractured limestones that are buried by protective shale units.

Environmental Hazards

Groundwater Contamination

Surface contaminants pose a potential threat to groundwater supplies in near-surface aquifers that are not overlain by a protective confining (clay-rich and unfractured) deposit such as till or lake sediment (Berg 2001). Groundwater in near-surface sand and gravel units (e.g., the Hagarstown Member and Cahokia Formation sandy facies) is most vulnerable to agricultural, surface mining, or industrial contaminants. The potential for groundwater contamination depends on the thickness and character of fine-grained alluvium, loess, or till deposits that overlie an aquifer. Due to lateral and three-dimensional groundwater flow, the position of a site in the overall groundwater flow system also needs to be considered. Deeply buried glacial aquifers in the basal Glasford Formation or within the Banner Formation generally have a lower contamination potential than more shallow aquifers if the groundwater is protected by a considerable thickness of unfractured, clay-rich till or clayey lake sediments. Aquifer material in the Henry and Pearl Formation (outwash facies), in the subsurface in the northern third of the quadrangle, is in some areas moderately protected by 20 to 30 feet of fine-grained lake sediments (Equality Formation), but in other areas may be in contact with overlying sandy materials that can provide connection to surface contaminants.

Subsidence in Mined-Out-Areas

Approximately 10% of the quadrangle's area was mined underground for coal between 1888 and 1966 (Chenoweth and Borino 2001). Underground mined-out areas are located primarily in the area between Marissa and New Athens immediately northeast of the former surface mines. Coal, 6 to 7 feet thick, was mined from the Herrin (No. 6) Coal Member of the Carbondale Formation and was extracted primarily by the room-and-pillar method at depths of 47 to 100 feet below the ground surface. Land subsidence in mined-out areas can be a serious potential problem for developers and construction projects (Bauer 2006). Surface mines for coal operated between 1949 and 1992. The coal typically occurred at depths of 28 to 80 feet (Chenoweth and Borino 2001).

Seismic Hazards

Near-surface fine sand in the Pearl, Henry, and Cahokia Formations are potentially liquefiable where materials are saturated (below the water table) and are subjected to strong ground shaking. Tuttle (2005) identified paleoliquefaction features, such as ancient sand blows, in outcrops along the Kaskaskia River upstream and downstream of the New Athens East Quadrangle, as well as other locations in the region. These features likely formed during past earthquake activity in the New Madrid Seismic Zone or other seismic activity in southern Illinois or southeastern

Missouri. Seismic shaking hazards are also an important issue, especially in areas with loose sand, disturbed ground (fill), and soft clay in Illinois (Bauer 1999). Areas with near-surface Equality Formation or especially Cahokia Formation sand and clay can be susceptible to seismic shaking because they are relatively soft and unconsolidated and have low density. These conditions amplify earthquake ground motions.

Acknowledgments

Appreciation is extended to the many landowners who allowed access to their property for outcrop studies and drilling. Assistance and advice were provided by many ISGS staff. This research was supported in part by the U.S. Geological Survey (USGS) National Cooperative Geologic Mapping Program under USGS STATEMAP award number 07HQAG0109. 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

- Bauer, R.A., 1999, Compilation of databases and map preparation for regional and local seismic zonation studies in the CUSEC region: Collaborative research: Organization of CUSEC State Geologists with assistance from USGS and administrative support from CUSEC, Final Technical Report for External Grant, Award Number 1434-HQ-97-Gr-03150, 23 p.
- Bauer, R.A., 2006, Mine subsidence in Illinois: Facts for homeowners: Illinois State Geological Survey, Circular 569, 20 p.
- Baker, F.C., 1935, Land and freshwater mollusca from North Star Lake and vicinity, Itasca County, Minnesota: *American Midland Naturalist*, v. 16, p. 257–274.
- Berg, R.C., 2001, Aquifer sensitivity classification for Illinois using depth to uppermost aquifer material and aquifer thickness: Illinois State Geological Survey, Circular 560, 14 p.
- Chenoweth, C., and M.L. Borino, 2001, Directory of coal mines in Illinois, 7.5-minute Quadrangle Series, New Athens East Quadrangle, St. Clair County, Illinois: Illinois State Geological Survey, 25 p., with Coal Mines in Illinois, New Athens East Quadrangle, Illinois State Geological Survey Map, 1:24,000.
- Conrad, L.A., 1966, An archeological survey of the lower Kaskaskia channelization project: Carbondale, Illinois, Southern Illinois University Museum, Archeological Salvage Report No. 26, p. 1–38.
- 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.
- Grimley, D.A., 2008, Surficial geology of Mascoutah Quadrangle, St. Clair County, Illinois: Illinois State Geological Survey, Illinois Geologic Quadrangle Map, IGQ Mascoutah-SG, 2 sheets, 1:24,000; report, 9 p.
- Grimley, D.A., A.C. 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.
- Hansel, A.K., and W.H. Johnson, 1996, Wedron and Mason Groups: Lithostratigraphic reclassification of deposits of the Wisconsin Episode, Lake Michigan Lobe: Illinois State Geological Survey, Bulletin 104, 116 p.
- Jacobs, A.M., and J.A. Lineback, 1969, Glacial geology of the Vandalia, Illinois region: Illinois State Geological Survey, Circular 442, 23 p.
- Killey, M.M., and J.A. Lineback, 1983, Stratigraphic reassignment of the Hagarstown Member in Illinois, in *Geologic Notes*: Illinois State Geological Survey, Circular 529, p. 13–16.
- Lineback, J.A. (compiler), 1979, Quaternary deposits of Illinois: Illinois State Geological Survey, 1:500,000.
- MacClintock, P., 1929, Part I: Physiographic divisions of the area covered by the Illinoian drift sheet in southern Illinois, and Part II: Recent discoveries of pre-Illinoian drift in southern Illinois: Illinois State Geological Survey, Report of Investigation, no. 19, 57 p.
- McKay, E.D., 1979, Stratigraphy of Wisconsinan and older loesses in southwestern Illinois, in J.D. Treworgy, E.D. McKay, and J.T. Wickham, eds., *Geology of western Illinois*, 43rd Annual Tri-State Geological Field Conference: Illinois State Geological Survey, Guidebook 14, p. 37–67.
- Nelson, W.J., 2005, Bedrock geology of Freeburg Quadrangle, St. Clair County, Illinois: Illinois State Geological Survey, Illinois Preliminary Geologic Map, IPGM Freeburg-BG, 2 sheets, 1:24,000; report 9 p.
- Natural Resources Conservation Service, 1999, Soil survey geographic (SSURGO) database for St. Clair County, Illinois: Fort Worth, Texas, U.S. Department of Agriculture, Natural Resources Conservation Service, <http://SoilDataMart.nrcs.usda.gov/>.
- Phillips, A.C., 2004, Surficial geology of St. Jacob Quadrangle, Madison and St. Clair Counties, Illinois: Illinois State Geological Survey, Illinois Preliminary Geologic Map, IPGM St. Jacob-SG, 2 sheets, 1:24,000.
- Phillips, A.C., and D.A. Grimley, 2004, Surficial geology of Marine Quadrangle, Madison County, Illinois: Illinois State Geological Survey, Illinois Preliminary Geologic Map, IPGM Marine-SG, 2 sheets, 1:24,000.

Shaw, E.W., 1921, Description of the New Athens and Okawville Quadrangles: Washington, DC, United States Geological Survey, Folio No. 213, 1:62,500, 12 p.

Tuttle, M.P., 2005, Paleoseismological study in the St. Louis region: Collaborative research: U.S. Geological Survey, Final Technical Report, Contract Award 1434-99HQGR0032, 29 p.

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

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