Illinois Geologic Quadrangle Map
IGQ Keyesport-SG

Surficial Geology of Keyesport Quadrangle

Clinton, Bond, and Fayette Counties, Illinois

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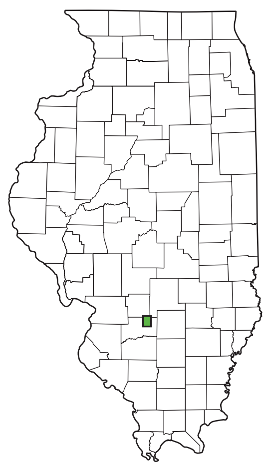
2017



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Introduction

The Keyesport 7.5-minute quadrangle is located in the Kaskaskia River basin of Clinton and Bond Counties, southwestern Illinois (Figs. M1and M2 [map sheet 2]). Surficial geology maps provide an important framework for land and groundwater use, resource evaluation, engineering and environmental hazards assessment, and geological or archeological studies. This study is part of a broader geologic mapping and research program undertaken by the Illinois State Geological Survey (ISGS) in southwestern Illinois (Grimley and Phillips 2006, 2011, 2015). The Keyesport Quadrangle surficial geology mapping project follows the recent mapping of the Stolletown Quadrangle to the immediate west (Grimley and Gemperline 2015).

The Keyesport Quadrangle is located within an area that was covered by glacial ice during the Illinois and pre-Illinois Episodes (Figs. M1 and M2; Grimley et al. 2001; Hansel and McKay 2010; Curry et al. 2011; Grimley and Phillips 2015). During a pre-Illinois Episode glaciation, ice likely advanced to southwestern Illinois from the Lake Michigan basin, the eastern Great Lakes region, or both (Willman and Frye 1970; Hartline 1981). After the ensuing Yarmouth interglacial episode, glacial ice once again advanced across the region during the Illinois Episode, originating from the Lake Michigan basin and reaching as far south as Carbondale, Illinois, and as far southwest as St. Louis, Missouri (Hansel and McKay 2010). During its recession, the expansive Illinois Episode glacial ice lobe likely divided into multiple sublobes, including a sublobe in the Kaskaskia River basin (Figs. M1 and M2; Webb et al. 2012). Various types of glacial hills, including ice-walled channels, kames, and morainal ridges, were formed within the Kaskaskia River basin. A period of overall glacial recession also included times of glacial surging or streaming (Webb et al. 2012; Grimley and Phillips 2015), perhaps affected by subglacial substrate and hydrology, followed by stagnation and ablation (Leighton 1959; Jacobs and Lineback 1969). During the advance and retreat of both the pre-Illinois and Illinois Episode glacial ice margins, proglacial outwash was deposited in parts of the southwest-trending, ancestral lower Kaskaskia River valley, a buried bedrock valley that underlies and closely follows the present valley (Grimley 2008; Phillips 2009; Grimley and Webb 2010). In response to periods of downcutting of the Mississippi River (Curry and Grimley 2006), the Kaskaskia River and its tributaries were incised during interglacials (Yarmouth and Sangamon Episodes) and during the early part of the Hudson Episode (early Holocene). Glacial ice did not reach the study area during the Wisconsin Episode; however, glacial meltwater streams from Illinois and the upper Midwest deposited outwash in the Mississippi River valley, which was the dominant source of the loess deposits (windblown silt) that blanket uplands in southwestern Illinois (Grimley et al. 2001). The Kaskaskia River valley likely contained a minor last-glacial meltwater river for a relatively short time (from ~25,000 to 22,500 calibrated years before present [B.P.]); thus, it did not serve as a major Wisconsin Episode loess source (Grimley and Phillips 2015).

The construction of a major dam formed Carlyle Lake between 1958 and 1967 and thus resulted in a significant anthropogenic impact to the land in the Keyesport Quadrangle. Carlyle Lake is now the largest reservoir in Illinois and is the largest lake contained within the state. About 38% of the quadrangle is mapped as water in Carlyle Lake as a result of the impoundment of the Kaskaskia River about 1 km south of the southern map edge. The lake's 445 ft above sea level (asl) normal pool level is shown on the map, although lake levels commonly fluctuate according to hydrologic conditions and U.S. Army Corps of Engineers planning. The 462 ft asl dashed line shown is societally significant in that areas below may be subjected to controlled inundation. The highest level reached since 1967 was 459.8 ft asl (in 2002). Lake levels above 450 ft have not been uncommon in recent years, such as a crest of 454.4 ft asl on July 5, 2015. Such high lake levels also cause slackwater flooding in lower tributary valleys, which seasonally alternate between fluvial and lacustrine regimes. The prime function of the lake is for flood control to lessen seasonal flooding on the lower Kaskaskia and Mississippi River valleys. Secondarily, the lake serves many recreational uses for fishing, boating, sailing, and swimming.

Methods

Surficial Map

This surficial geology map is based in part on interpretation of soil parent material data (Phillips and Goddard 1983; Hamilton 2002), supplemented by data from outcrop studies and stratigraphic test holes obtained for this STATEMAP project, engineering borings from the Illinois Department of Transportation and Clinton County Highway Department, and water-well records. Electrical resistivity transects were also utilized to help with mapping of surficial sandy deposits, both from extensive early studies of the ISGS in cooperation with the Clinton County Highway Department (Dobrovolny 1953, and unpublished original data from the ISGS Geophysics Section) and from two new transects obtained for this project (shown on map). Map contacts were also adjusted according to the surface topography, geomorphology, and observed landform–sediment associations.

Locations of 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 are key engineering, coal, petroleum type, and water-well borings that were utilized for mapping or for developing the geologic framework. Some of the stratigraphic and coal borings have geophysical logs that were used to confirm the unit contacts or bedrock surface elevation where geologic samples were lacking. The locations of many water-well borings were verified by plat books, permit maps, field confirmations (for water wells only), or their combination. Many other data in this quadrangle, particularly petroleum type borings, are not shown because of 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 or from the ILWATER Internet map service (http://www.isgs.illinois.edu/ilwater). Geologic data records can be identified based on their location and the 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, and are vertically exaggerated 20 times. The lines of cross section are indicated on the surficial map and inset figures (Figs. M3 and M4 [map sheet 2]). Data used for subsurface unit contacts (in approximate order of quality for the purpose of this map) are from studied outcrops, stratigraphic test holes, engineering boring records, water-well records, and coal and oil- or gas-well records. Units less than 5 ft 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 into bedrock is not shown. The bathymetry of Carlyle Lake is based on pre-dam topographic contours and does not consider post-dam sedimentation.

Bedrock Topography and Drift Thickness Maps
Maps of bedrock topography (Fig. M3) and drift thickness (Fig. M4) are based on data from which a reliable bedrock elevation could be determined (Fig. M3). Data within about a mile of the map boundary were also utilized (not shown). A total of 212 data locations were used in the map and buffer area, including 5 outcrops, 6 stratigraphic tests, 43 engineering borings, 60 water-well borings, 20 coal borings, 7 electrical resistivity profile estimations, and 71 oil and gas type borings. The bedrock surface was modeled utilizing the "Topo to Raster" module in ArcMap 10.3 (ESRI) using a vertical standard error of 3 ft and with "drainage enforcement," which attempts to make a hydrologically correct surface. This program incorporated a combination of two information types: (1) the 212 data points coded with bedrock top elevations, and (2) a few digitized "streams" (ArcMap term) that forced the bedrock surface model to conform to a typical stream drainage, guided by geological insights and surface topography where appropriate. The bedrock surface elevation in the Keyesport Quadrangle ranges from about 330 to 465 ft asl (135-ft relief).

A drift thickness map (Fig. M4) was created by subtracting an elevation model (grid format) of the bedrock topographic surface from a land surface digital elevation model (DEM), using a 30-m cell size. Because of the processing, the resulting drift thickness map had some irregular, detailed, or small polygons, which were generalized to some extent in Figure M4. Drift thickness ranges from 0 (bedrock outcrops) to about 145 ft thick in parts of South Shore State Park.

Surficial Deposits

The surficial deposits are divided into four landform–sediment associations: (1) bedrock-controlled uplands with thin loess and till deposits (especially western areas); (2) glacial ridges and knolls containing either ice-contact sandy deposits, diamicton, or mixed lithology and all capped with loess; (3) broad, flat terraces with successions of glaciofluvial sediments covered by loess; and (4) postglacial river valleys with alluvial sediments. In a buried ancient Kaskaskia Bedrock Valley (Fig. M3), older concealed deposits (5), associated with a pre-Illinois Episode glaciation, are preserved in places as well. Areas of anthropogenically disturbed ground, ~1% of map area, consist mainly of spoil piles at sand and gravel pits, areas of fill below roadways, and railway or levee embankments.

(1) Bedrock-Controlled Uplands
Bedrock-controlled uplands (Fig. M3) with a relatively thin cover of loess and till deposits (Fig. M4), typically <40 ft thick, are found mainly in the western parts of the quadrangle (~25% of map area). Because of a more than 5-ft-thick loess cover, many such areas are mapped as Peoria and Roxana Silts, with subsurface till (Glasford Formation) mainly shown in cross sections (map sheet 2).

Pennsylvanian bedrock units in the area (the Bond and Shelbourne-Patoka Formations) regionally dip gently eastward toward the center of the Illinois Basin (Kolata 2005). Thus, the north–south- to northwest–southeast-trending bedrock surface highs of this quadrangle (Fig. M3) reflect the strike of a more resistant Pennsylvanian limestone or sandstone unit, including the Carthage Limestone (formerly Shoal Creek Limestone; Jacobson et al. 1985). The bedrock high is one of a regional series of ancient, buried cuestas, with sandstone or limestone constituting the uppermost bedrock in ridges, and shales mainly constituting the uppermost bedrock in preglacial valleys. In the southwestern Keyesport Quadrangle, exposures of bedrock revealed a few feet of Pennsylvanian sandstone, shale, or limestone. In Sections 32 and 33 (T3N, R2W), archived ISGS field notes from the 1930s (G. Ekblaw and others) indicate cutbank exposures of bedrock, as much as 20 ft thick, in areas now underneath Carlyle Lake's western inlets because of the dam construction and inundation of tributary valleys in the 1960s. Samples of Pennsylvanian shale from boreholes are predominantly illitic, with the remainder being kaolinite and chlorite in the clay mineral fraction (Table 1).

Above Pennsylvanian bedrock, and below surficial loess deposits, the western uplands contain relatively thin deposits of diamicton (a massive, unsorted mixture of clay, silt, sand, and gravel), with minor sand and gravel lenses. Diamicton, weathered diamicton, associated sorted sediment, or some combination of these are mapped together as Glasford Formation and are interpreted as till, debris flow, and ice-marginal sediment. The Glasford unit is shown on the surficial map where the loess cover has been eroded to less than 5 ft thick along slopes. Surface soils with till parent material within 5 ft of ground surface, mainly the Hickory soil series, were mapped in the U.S. Department of Agriculture county soil survey reports (Phillips and Goddard 1983; Hamilton 2002) in many sloping areas of the quadrangle. However, some areas mapped as Hickory soil series appear to be weathered Pearl Formation outwash (or Berry Clay Member of Pearl Formation; see later section on outwash terrace) rather than Glasford till, or some mixture of sand and diamicton. In spite of this discrepancy, till is found below loess deposits in the southwestern uplands of the quadrangle. Exposures of Glasford till were observed at a few outcrops, such as along the shores of Carlyle Lake in Hazlet State Park (e.g., 27126 [best], 27125, and 27124 in Secs. 27 and 33, T3N, R2W). Relatively unaltered Glasford till in this quadrangle has about 52 to 60% illite in the clay mineral fraction and has a loam texture with about 15 to 20% clay (<2 µm), 40 to 50% silt, and 30 to 45% sand (Table 1). Compared with overlying loess deposits, the Glasford till is considerably more pebbly, is more dense, has a lower moisture content (~10–13%), and has a greater unconfined compressive strength (Q_u; Table 1). Much of the Glasford till on the map and in cross sections is classified as the Vandalia facies, based on its physical properties (Jacobs and Lineback 1969; Willman and Frye 1970). However, in the nearby Stolletown Quadrangle, a lower unit of the Glasford till, with a slightly finer grained, less sandy, and less illitic till, is likely correlative with the Smithboro facies (Grimley and Gemperline 2015). Sand and gravel lenses in the Glasford Formation are relatively uncommon on the bedrock-controlled uplands, but some occur. Pre-Illinois Episode deposits are absent from the bedrock surface highlands of the western portion of the quadrangle (see cross sections C–C′ and D–D′) because of a combination of more limited deposition and post-depositional fluvial or glacial erosion during the Illinois Episode.

Strong alteration features are prominent in the upper 4 to 6 ft of the Glasford Formation (where not buried by other Illinois Episode deposits), such as root traces, fractures, carbonate leaching, oxidation or color mottling, strong soil structure, clay accumulation, and clay skins. These features are evidence of a buried interglacial soil known as the Sangamon Geosol, which marks the boundary between the Glasford Formation and overlying Wisconsin Episode loess deposits (Willman and Frye 1970). Oxidation and fracturing, with iron staining on the fracture faces, can extend 10 to 20 ft or more into the Glasford till (or diamicton). The upper 5 to 10 ft of Glasford Formation, where uneroded, is generally more weathered, has a higher water content, can have more small sand lenses, and is less stiff than the majority of the unit. Carbonate leaching typically extends about 7 to 11 ft into the Glasford Formation, below the top of the Sangamon Geosol.

Surficial loess deposits (Peoria and Roxana Silts combined) are typically 5 to 7 ft thick where uneroded, with thinner deposits on steeper eroded slopes. The loess deposits covering Illinois Episode deposits (Glasford or Pearl Formation) are shown on the surficial map where ~5 ft or thicker. The loess was deposited during the last glaciation (Wisconsin Episode). During this time, silt-sized particles in Mississippi Valley glacial meltwater deposits were periodically windswept and carried in dust clouds eastward to vegetated upland areas, where the silt accumulated. Loess deposits are typically a silt loam where unweathered, but in the modern soil solum (about the upper 4 ft), they are altered to a heavy silt loam or silty clay loam (Hamilton 2002). The Peoria Silt is the upper, younger loess unit and is contained mostly within the modern soil solum. The Roxana Silt, with a slight pinkish or darker brown hue, is the lower loess unit (Hansel and Johnson 1996) and ranges from a heavy silt loam to a loam near the unit base, where it has been pedogenically mixed with sandy Illinois Episode deposits. Both loess units in this quadrangle are slightly to moderately weathered, leached of carbonates, fairly thin, and relatively similar in physical properties (Table 1), so they have not been differentiated for mapping purposes.

(2) Glacial Ridges and Knolls

Areas of Illinois Episode glacial ridges and knolls in the Keyesport Quadrangle (~8% of the map area) consist of two mapped types: (A) sandy ridges—esker-type ridges or other hills with coarse-grained material, predominantly glaciofluvial sand and gravel (sandy facies, Hagarstown Member, Pearl Formation); and (B) mixed-lithology ridges—ridges composed of intercalated sorted sediment (mainly sand) and diamicton (mixed facies, Hagarstown Member, Pearl Formation). Both ridge–sediment associations are blanketed by about 5 to 7 ft of Wisconsin Episode loess deposits, below which the Sangamon Geosol has developed into the upper portion of the Illinois Episode glacial deposits. The various ice-contact glacial hills are consistent with the idea of ice stagnation in the region (Jacobs and Lineback 1969) and the hills may represent an ice-walled distributary fan system, similar to that described southwest of Vandalia in southwestern Fayette County (Grimley and Phillips 2015). An electrical resistivity survey acquired for this project, in conjunction with subsurface drilling, aided differentiation of mixed and sandy glacial ridge deposits (Fig. 1). Less detailed, but spatially more extensive, electrical resistivity transects from the 1950s (Dobrovolny 1953, and ISGS unpublished data) were also helpful for distinguishing sandy versus mixed-composition ridges in some areas.

(A) Sandy Ridges Prior studies in southern Illinois have noted significant sand and gravel in glacial ridges of the Vandalia region (Jacobs and Lineback 1969) and southwestward (Grimley and Gemperline 2015; Grimley and Phillips 2015). Such deposits consist of poorly to well-sorted sand, gravelly sand, and gravelly diamicton that, together, have been termed the Hagarstown sandy facies [unit pl-h(s)] (Grimley 2008), a unit similar to the original definition of the Hagarstown Member (Willman and Frye 1970; Killey and Lineback 1983). In the Keyesport Quadrangle, glacial

Table 1 Typical ranges of the various physical and chemical properties within typical materials for each geological unit

	Geotechnical properties[1]			Particle size and compositional data[2]					
Unit	w (%)	Q_u (tons/ft^2)	N	Sand (%)	Silt (%)	Clay (%)	Clay mineralogy	Carbonate	MS
Cahokia Fm.	13–27 (8)	0.5–1.5 (8)	3–15 (8)	Silt loam to silty clay loam to sandy loam			ND[3]	Mainly noncalcareous	ND
Equality Fm.	27 (1)	0.5–1.5 (2)	ND	Typically silty clay loam			50–65% expandables; 8–17% illite	Mainly noncalcareous	ND
Peoria and Roxana Silts	18–22 (3)	0.5–2.0 (12)	ND	0–30	45–75	15–30	55–72% expandables; 7–20% illite	Noncalcareous	20–70
Berry Clay Member, Pearl (or Glasford) Fm.	24–26 (2)	1.5–3.5 (8)	ND	Clay loam to sandy loam			62–77% expandables	Noncalcareous	ND
Hagarstown Member (sandy facies), Pearl Fm.	ND	<0.25–1.0 (6)	ND	50–98	5–22	<30	ND	Leached to calcareous	8–60
Hagarstown Member (mixed facies), Pearl Fm.	ND	<0.5–2.0 (4)	ND	Variable			40–70% illite	Leached to calcareous	ND
Mascoutah facies, Pearl Fm. (outwash)	ND	<.0.25–1.5 (17)	3–25 (3)	>85	<10	<5	ND	Leached to calcareous	<20
Glasford Fm. (till)	9–13 (12)	2.0–8.0 (17)	16–75 (4)	32–47	38–48	15–21	52–63% illite; 20–33% kaolinite + chlorite	Mainly calcareous	6–30
Grigg tongue, Pearl Fm. (outwash)	ND	<0.5 (7)	ND	Fine sand to gravelly sand			ND	Calcareous	ND
Banner Fm. (till)	ND	ND	ND	Silt loam to loam diamicton, sand or gravelly sand			ND	Weakly to moderately calcareous	ND
Pennsylvanian bedrock	10–17 (shale)	>4.5	>50	ND			~60–65% illite; 35–40% kaolinite + chlorite (shale)	None to very high (in limestone)	2–18 (higher for shale, lower for limestone)

[1]Geotechnical properties are based on tens of measurements (total for all units) from ~30 engineering (bridge) borings and 11 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). Number in parentheses after geotechnical properties indicates number of cores or borings used for data; each core may have one or more depths with data.

[2]Particle size and clay mineralogy are based on a data set (~38 samples) from 11 stratigraphic borings. Sand = % >63 μm; silt = % 2–63 μm; clay = % <2 μm (proportions in the <2-mm fraction from hydrometer analyses). Clay mineralogy = proportions of expandables, illite, and kaolinite + chlorite (in <2-μm clay mineral fraction) using a Scintag X-ray diffractometer. MS, magnetic susceptibility ($\times 10^{-8}$ m^3/kg) from 4 stratigraphic borings using a Bartington MS2 meter and MS2B attachment.

[3]ND, no data available.

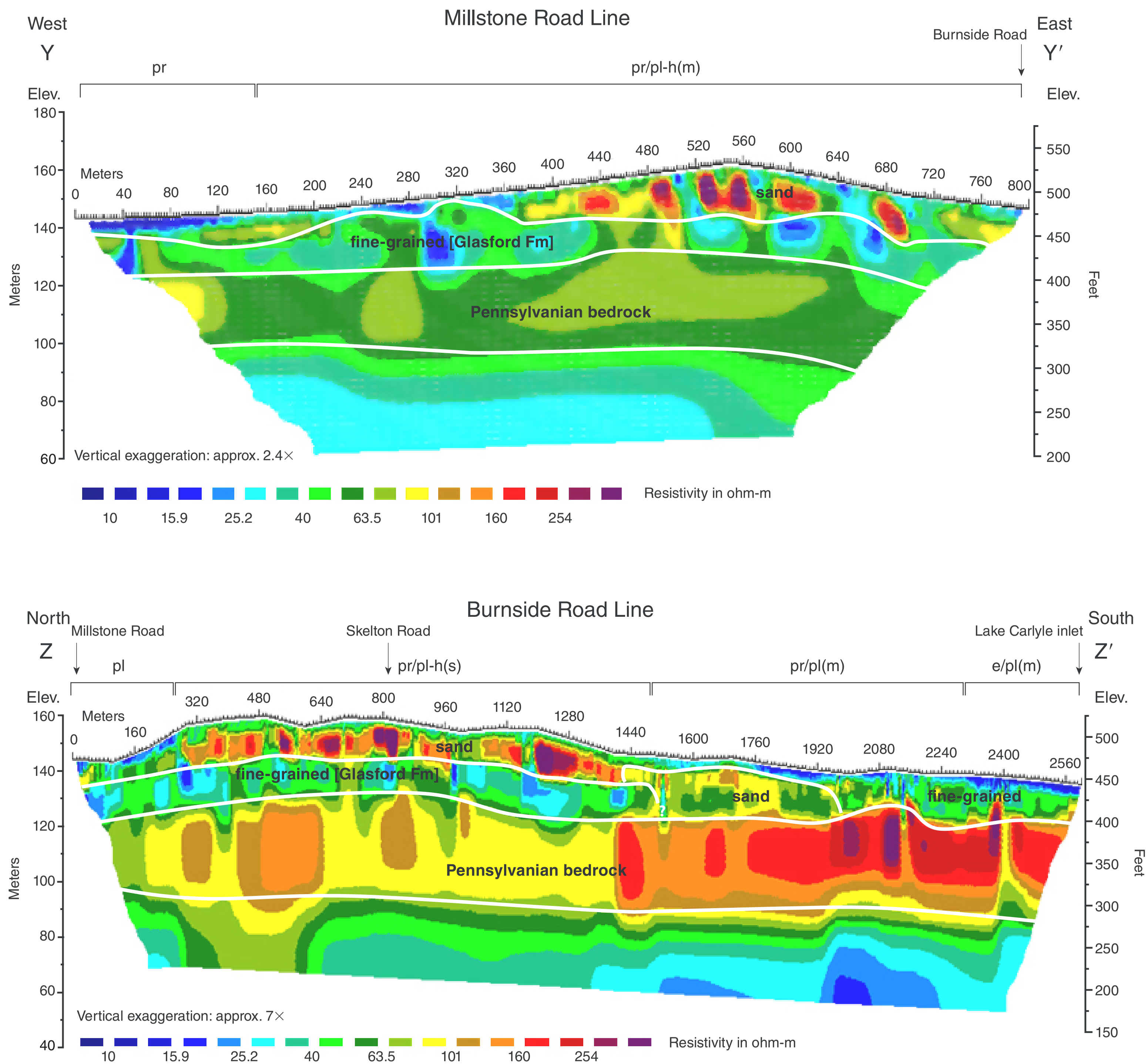

Figure 1 Two electrical resistivity profiles in the central Keyesport Quadrangle (locations on surficial geology map). Lower resistivities typically occur in fine-grained clayey deposits. Higher resistivities are found in coarse-grained (sandy) deposits or local bedrock (mainly limestone). The horizontal scale and vertical exaggeration of Y–Y′ and Z–Z′ are different. Geologic units from the surficial map are labeled on the profiles. Locations of profiles are shown on map sheet 1.

hills mapped as pl-h(s) are found mainly in the northern part of the quadrangle and have up to 90 ft of sandy material below the loess cover and Sangamon paleosol (e.g., Fig. 1 and cross section A–A′). A few areas are mapped pl-h(s) near surface, where the loess has been eroded along steep slopes. Most areas of hills and ridges that contain pl-h(s), where the loess cover is greater than 5 ft, are boldly stippled with a reddish brown color. The upper 5 to 10 ft of the Hagarstown Member, below the loess, is typically altered to a clay loam and contains pedogenic alteration features, such as clay skins and root traces that formed during interglacial soil development (attributed to the Sangamon Geosol).

Many of these sandy-type ridges are aligned north–south or northeast–southeast near the Village of Keyesport and southward. The shape and height of many sandy ridges, about 25 to 75 ft in relief above surrounding plains, are suggestive of eskers or ice-walled channels. Taken together, this set of sandy ridges, and interspersed mixed-facies ridges, has the overall appearance of a large ice-walled distributary fan system that covered ~15 mi^2 and emanated from a several mile long esker system to the north (see “esker fan” on the regional map, Fig. M2). The well-preserved geomorphology seems consistent with stagnant ice melting around the former channels. Thus, this is a classic example of topography inversion, with the lowlands once having ice blocks and the ridges representing the location of former ice-walled channels that deposited coarse-grained glaciofluvial sediments. This particular ice-walled fan system (including Secs. 2–11, 15–16, and 22 in T3N, R2W) would have been a major outlet for meltwater drainage along the central axis of a disintegrating Kaskaskia Sublobe (Fig. M1) during the end of the penultimate glaciation (Illinois Episode). We hypothesize that this ice-walled channel system lasted relatively briefly (a few decades) in the fast-melting stagnant ice as the inflow of ice from the main ice sheet to the northeast was later cut off. The direction of the ice-walled distributary system first south and then southeast toward Carlyle Lake generally follows the gradient of the subglacial or bedrock topography to lower elevations.

In the northwestern part of the quadrangle, the ridges are aligned northeast–southwest. Yet many hills are less sinuous, broader, and gentler in form than classic eskers. In this area, Hagarstown sandy facies was mined in now-abandoned sand and gravel pits (Sec. 32, T4N, R2W; Sec. 6, T3N, R2W). An example of the sandy facies ridge deposit is documented in stratigraphic test boring 23624 in Section 33, T4N, R2W. This 44-ft-deep boring encountered 28 ft of fine-medium sand to coarse gravelly sand (generally coarsening with depth) between 12 and 40 ft depth. Below the 40-ft depth, dense glacial till and weathered shale (inclusions?) prevented further drilling with a PowerProbe drill rig. The upper 12 ft in this boring consists of 6 ft of last glacial loess overlying 6 ft of weathered Hagarstown or Berry Clay Member (clay loam–sandy loam).

(B) Mixed-Lithology Ridges Interlobate ridges or isolated knolls that consist of sorted coarse-grained sediments intermixed with sandy diamicton and fine-grained deposits (till, lake sediment, etc.) are mapped as the mixed facies, Hagarstown Member (Pearl Formation). The mixed facies was coined to capture the lithologic complexity and heterogeneity of the Hagarstown Member in many areas (Grimley 2008). Some small hills mapped as the mixed facies [pl-h(m)] in the Keyesport Quadrangle are of unknown sediment composition and were mapped as the mixed facies if a dominance of sandy or fine-grained material could not be determined with reasonable confidence. Others were documented by drilling, geophysics (Fig. 1A), or water-well logs to have a mixed lithology (stratigraphic test 27185 in Sec. 16, T3N, R2W). Hills mapped as pl-h(m) are distributed throughout the quadrangle and tend to be smaller, rounder-type hills than the sandy facies hills, which tend to be more elongate and steeper. Many of the pl-h(m) hills could be considered kames, presumably a mix of ablation drift, debris flows, and ice-contact glaciofluvial sands. Some of the mixed-lithology hills could be ice-pressed or ice-squeezed hills as were noted in the Stolletown Quadrangle to the west (Grimley and Gemperline 2015), yet none were recognized here based on data thus far. Areas of near-surface mixed-facies Hagarstown are mapped solid reddish brown (pl-h) where the loess cover has been eroded to less than 5 ft thick and are stippled with a mixed pattern [pr/pl-h(m)] where the loess cover is greater than 5 ft.

(3) Illinois Episode Outwash in Terraces and Lowlands Of considerable significance across much of the northern quadrangle (~20% of the map area) are up to 70-ft-thick proglacial sand deposits with some gravel that occur in lowland areas. These deposits occur in the subsurface below Peoria-Roxana loess deposits, Cahokia Formation, or Equality Formation (see cross sections A–A′ and B–B′, for example). This sand and gravelly sand unit is classified as the Mascoutah facies, Pearl Formation (Grimley and Webb 2010) and occurs below high terraces or interridge lowlands that are typically between 455 and 485 ft asl. The Pearl outwash in such terraces can be traced as a Kaskaskia River basin landform–sediment assemblage for several miles up-basin to the northeast (Grimley and Phillips 2015) and down-basin to the southwest (Grimley 2008; Grimley and Phillips 2011; Grimley and Gemperline 2015). This Pearl outwash is considered predominantly Illinois Episode in age, though basal portions could locally include some pre-Illinois Episode fluvial deposits. Portions of the Pearl Formation that occur below the Glasford Formation are classified as the Grigg tongue of the Pearl Formation (Grimley and Webb 2010). Other tongues of the Pearl Formation, where it is intercalated with the Glasford Formation, are unnamed and considered Pearl Formation undivided (pl) in cross sections. The Pearl sand and gravel is typically underlain by Glasford diamicton, Banner Formation, or bedrock (see concealed deposits).

Areas of the loess-covered Illinois Episode terrace with the Mascoutah facies of the Pearl Formation occur mainly on the northwest and east flank of the bedrock surface topographic high in the southwest part of the quadrangle. Terrace areas are mapped with a diagonal, colored line pattern where more than 5 ft of the Pearl Formation is predicted to occur at depth based on available data. In most cases, except below recent alluvium, areas with the Mascoutah facies are overlain by 5 to 15 ft of the finer grained and pedogenically altered Berry Clay Member of the Pearl Formation. An additional 5 to 7 ft of last glacial loess (Peoria and Roxana Silts) covers the Berry Clay Member, such that loose sand deposits are typically 15 to 20 ft below ground surface. The Mascoutah facies (and older tongues of the Pearl Formation) is typically a fine to medium sand, but may coarsen to a coarse, gravelly sand in areas, especially above Glasford Formation. The percentage of gravel can be up to 20% in gravelly beds but is typically <5%.

The Illinois Episode age for the terrace is based on the presence of interglacial soil alteration features (Sangamon Geosol) at the top of the outwash sequence and below loess deposits (Peoria and Roxana Silts). Because of the loess cover as well as accretionary and pedogenically altered material (Berry Clay Member), elevations for the top of the underlying loose sand (with some gravelly beds) in the Stolletown Quadrangle are typically 440 to 460 ft asl; the terrace elevation ranges from 455 to 485 ft asl. The Berry Clay Member generally overlies the Mascoutah facies of the Pearl Formation in the quadrangle, but also locally overlies the Glasford Formation. On the surficial map, the Berry Clay Member was mapped along the gentle eroded slopes of the Illinois Episode terrace where it occurs surficially (<5 ft depth), but Berry Clay was not mapped along slopes where it occurs above Glasford Formation (because they are of similar lithology). The Berry Clay generally contains strong interglacial soil alteration features (Sangamon Geosol) and is buried by Wisconsin Episode loess on uneroded landscapes. The Berry Clay Member is typically a clay loam to sandy loam where the unaltered parent material is more sandy (where it overlies Pearl Formation sand). Although originally classified as an upper member of the Glasford Formation (Willman and Frye 1970), the Berry Clay was more recently classified as a member of the Pearl Formation (Grimley 2008; Grimley and Webb 2010). Some deposition and most alteration of Berry Clay likely occurred during the Sangamon Episode interglacial.

Overall, Pearl Formation outwash in the Keyesport Quadrangle was deposited in advance of the approaching Illinois Episode glacial front, as well as during its retreat. The Mascoutah facies of the Pearl Formation was likely deposited in association with glacial meltwaters emanating from the ice margin when it was receding northeastward within Bond and Fayette Counties (Fig. M2). Specifically, some pulses of glacial meltwater must have originated from ice-walled channel and esker meltwater systems to the northeast in eastern Bond and western Fayette Counties. Ice-walled fan and esker systems have previously been identified in the Vandalia region (Jacobs and Lineback 1969; Grimley and Phillips 2015) and at the Keyesport sand and gravel pit in northeastern Stolletown Quadrangle (Grimley and Phillips 2015; Webb et al. 2012).

(4) Postglacial River Valleys

Postglacial (Holocene) stream deposits in Flat Branch, Allen Branch, Coles Creek, and other unnamed creek valleys constitute only about 3% of the mapped surficial areas of the quadrangle, yet a significant amount of postglacial alluvium also occurs in parts of the Kaskaskia Valley that are submerged underneath Lake Carlyle. These stream deposits, mapped as Cahokia Formation, consist mainly of fine-grained (silt loam) material that is weakly stratified and can include loamy zones or beds of fine sand. The Cahokia Formation is typically up to 25 ft thick in the alluvium of the Kaskaskia Valley under Lake Carlyle and tends to be <10 ft thick in the smaller tributary valleys. The alluvial sediment consists mainly of reworked loess, till, and outwash that was eroded along ravines, slopes, and river banks and redeposited. Because of periodic flooding during postglacial times, areas mapped as the Cahokia Formation (undivided) have relatively youthful modern soil profiles that generally lack B horizons (Hamilton 2002). In lower areas of tributaries and under Carlyle Lake, the uppermost Cahokia Formation may now include some thickness of post-1960s slackwater lake sediment, but it is impractical to delineate.

(5) Concealed Deposits (Buried Bedrock Valley Fills)

In a bedrock valley that trends through the eastern part of the quadrangle (Fig. M3), early Illinois Episode proglacial and ice-contact deposits (Grigg tongue, Pearl Formation), and various pre-Illinois Episode deposits (classified as the Banner Formation) are preserved (see cross sections). This buried bedrock channel or valley (here termed the ancient Kaskaskia Bedrock Valley after Horberg 1950; Hansel and McKay 2010) experienced numerous periods of meltwater, alluvial, and glacial sedimentation during the Illinois and pre-Illinois Episodes, and is an area of relatively thick glacial drift, generally 60 to 145 ft thick (Fig. M4).

Sand and gravelly sand in the Grigg tongue are mainly preserved in the southeastern Keyesport Quadrangle (cross sections C–C′ and D–D′). This glaciofluvial deposit likely records the first advance of the southwest-flowing Illinois Episode ice front into the Kaskaskia Valley. Ultimately, this deposit was mainly buried by glacial till deposits. The Grigg tongue is up to 55 ft thick and consists of interbeds of fine sand, medium to coarse sand, and gravelly coarse sand, based on stratigraphic test hole 27189 and water-well description 26624. The lower part of the unit tends to be more gravelly (up to 30%), but the finer and coarse sand tend to occur in sedimentary packages that likely reflect a shifting braided bar fluvial system. The considerable thickness of the Grigg tongue is likely a result of the ancestral Kaskaskia

Valley having been oriented parallel to and draining away from the southwest ice-flow direction such that it became a sediment accumulation zone. The axis of the ancestral Kaskaskia Valley, prior to Illinois Episode glaciation, was centered on the east side of present-day Carlyle Lake (Fig. M3 and cross sections).

Deposits of the pre-Illinois Episode Banner Formation (diamicton, sand, gravel, and silt) occur only in the subsurface in the Keyesport Quadrangle, and their exact identification is questionable, despite the regional context that pre-Illinois Episode glaciers nearly certainly crossed this area (Hansel and McKay 2010; Grimley and Phillips 2015). Interglacial soil development (Yarmouth Geosol), where preserved within the uppermost Banner Formation, is the primary basis for distinguishing these sediments from Illinois Episode deposits (Willman and Frye 1970). However, a clear Yarmouth Geosol was not found in the few deep stratigraphic test holes drilled west of Carlyle Lake. The mapping of Banner Formation, mainly in the Kaskaskia Bedrock Valley (e.g., cross sections B–B′and D–D′), is mainly based on sample sets from water-well or oil-well drilling in the mid-20th century, prior to the Kaskaskia River impoundment that formed Carlyle Lake. The sample sets indicate a loamy to silty diamicton or loamy sand below Pearl Formation that is distinguished from Illinois Episode deposits by a lower carbonate content and contrasting color. The low elevation of the Banner Formation (~340 to 390 ft asl) is consistent with that found in the Stolletown Quadrangle (Grimley and Gemperline 2015). Any Banner deposits in this infilled valley are remnants. In most areas, Banner Formation deposits from pre-Illinois Episode glaciation were removed by stream incision and erosion during the succeeding interglacial (Yarmouth Episode) or the Illinois Episode glacial advance.

Economic Resources

Sand and Gravel
Economically minable deposits in the quadrangle may include sand with some gravel in the Pearl Formation, particularly in the sandy facies of the Hagarstown Member and the Mascoutah facies. The Mascoutah facies (Pearl Formation) varies from very fine and fine sand to coarse and very coarse sand with 20 to 30% gravel. However, the gravelly zones are limited and the modal texture is probably medium sand. The most economic sand and gravel deposits are probably within the Hagarstown Member sandy facies (pl-h(s)), yet its mapping is speculative in some areas because of limited data. The Hagarstown sandy facies has been mined extensively at the Keyesport sand and gravel pit in the Stolletown Quadrangle (Grimley and Gemperline 2015), which includes esker or ice-walled channel deposits (Webb et al. 2012; Grimley and Phillips 2015). Confined glacial meltwater streams in subglacial or ice-walled glacial meltwater streams can lead to higher velocity outflows and coarser grained sediment in comparison with the mostly proglacial outwash in the Mascoutah facies.

The mixed facies of the Hagarstown Member, Pearl Formation is likely not a reliable source for construction aggregate because of its variability and lack of continuous coarse sand and gravel. The Griggs tongue of the Pearl Formation is less desirable because of its occurrence below as much as 65 ft of finer grained deposits, including stiff and dense Glasford diamicton, which would have to be removed. Additional boreholes or geophysical tests would be necessary for site-specific projects to determine the economic viability of the various resources.

Groundwater
Groundwater is extensively used for household, public, and industrial water supplies in southwestern Illinois. Surface water resources such as the Kaskaskia River and bedrock aquifers are also utilized in the region. Yet saturated sand and gravel in the Pearl Formation (including the Hagarstown Member, Mascoutah facies, and Griggs tongue) or, to a much lesser extent, the Banner Formation constitute the predominant glacial aquifer materials in the Keyesport Quadrangle. Known sand and gravel lenses are stippled in the cross sections. Aquifer material in the Pearl Formation (Mascoutah facies) and the Griggs tongue of the Pearl Formation is extensive. Wells used for household water supply are typically screened in one of the facies or members of the Pearl Formation. Some areas in the bedrock-controlled, thin drift of the western Keyesport Quadrangle do not have an adequate water supply in unconsolidated surficial materials because of a lack of sand and gravel bodies. In such areas, bedrock aquifers (if available) are locally utilized for water supply, such as groundwater in Pennsylvanian sandstones.

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). The potential for groundwater contamination depends on the thickness and character of fine-grained alluvium, loess, or till deposits that overlie an aquifer, in addition to land use. Because of lateral and three-dimensional groundwater flow, the position of a site in the overall groundwater flow system also needs to be considered. Groundwater in near-surface sand and gravel units in the quadrangle (e.g., various facies of Pearl Formation) is most vulnerable to agricultural, surface mining, or industrial contaminants. Deeply buried glacial aquifers, such as the Grigg tongue of the Pearl Formation or aquifers within the Banner Formation, generally have a lower contamination potential than more shallow aquifers if groundwater is protected by a considerable thickness of unfractured, clay-rich till or clayey lake sediments. Aquifer material in the Pearl Formation (outwash facies) is typically protected only by about 8 to 15 ft of fine-grained loess, accretionary sediments (Peoria and Roxana Silts), or clayey Sangamon Geosol profile (altered into upper Pearl Formation), but in some

areas along the valley edges and ravines, the Pearl Formation may be exposed, providing a more direct path to any surface contaminants.

Seismic Hazards

Near-surface, fine sand in the Pearl and Cahokia Formations is potentially liquefiable where materials are saturated (below the water table) and subjected to strong ground shaking. Tuttle (2005) identified paleoliquefaction features in outcrops along the Kaskaskia River, as well as at 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 in Illinois with loose sand, disturbed ground (fill), and soft clay (Bauer 1999). Areas with near-surface Cahokia Formation sand and clay or some areas of fill (disturbed ground) may be especially susceptible to seismic shaking because they are relatively soft and unconsolidated and have low density. These conditions amplify earthquake ground motions.

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