Surficial Geology of Beaver Creek Quadrangle

Bond County, Illinois

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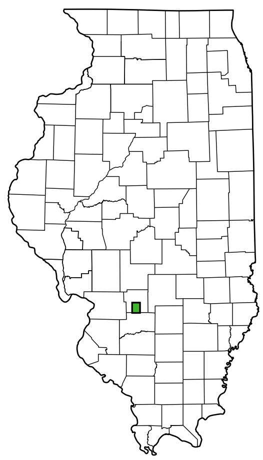

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Introduction

The Beaver Creek 7.5-minute quadrangle is located in the Kaskaskia River Basin and within Bond County, southwestern Illinois (Figs. M1, 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, 2011a,b). The Beaver Creek Quadrangle is the fourth 1:24,000 quadrangle surficial geology mapping project in the middle Kaskaskia Basin region, following mapping of the Stolletown Quadrangle (Grimley and Gemperline 2015), Keyesport Quadrangle (Grimley and Walkowska 2017), and Pleasant Mound Quadrangle (Grimley et al. 2018).

The Beaver Creek Quadrangle is within an area that was entirely covered by glacial ice during the Illinois and pre-Illinois Episodes (Figs. M1 and M2; Hansel and McKay 2010; Curry et al. 2011; Grimley and Phillips 2011a; Grimley et al. 2017). 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). The expansive Illinois Episode glacial ice lobe likely divided into multiple sublobes during its recession, including a sublobe in the Kaskaskia Basin (Figs. M1 and M2) and the Springfield Plain (Webb et al. 2012; Grimley et al. 2017). Various types of glacial hills, including ice-walled channels, kames, and morainal ridges, were formed within the Kaskaskia Basin during an overall recessional phase. This phase included times of glacial surging or streaming (Grimley and Phillips 2011a; Webb et al. 2012), perhaps affected by the subglacial substrate and hydrology, followed by stagnation and ablation (Leighton 1959; Jacobs and Lineback 1969). Based on findings from the Pleasant Mound Quadrangle mapping to the immediate east (Grimley et al. 2018), we now envision that there may have been a late surge of the Springfield Sublobe, southeast into the Kaskaskia River Basin. This interpretation implies that ice marginal landforms of a portion of the Kaskaskia Sublobe were overridden (Fig. M2). During the regional advance and retreat of the pre-Illinois and Illinois Episode glacial ice margins, proglacial outwash (from perhaps multiple sublobes) was deposited in parts of the southwest-trending Kaskaskia River Basin (Grimley and Walkowska 2010). In response to periods of downcutting of the Mississippi River (Curry and Grimley 2006), the Kaskaskia River and its tributaries were incised during middle-late Pleistocene interglacials (Yarmouth and Sangamon Episodes) and during the early Holocene. Glacial ice did not reach the study area during the Wisconsin Episode (late Pleistocene); 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 (McKay 1979; Grimley and Phillips 2011b). The Kaskaskia River valley was likely a minor last-glacial meltwater stream for a relatively short time (from ~25,000 to 22,500 cal years B.P.); thus, it did not serve as a major Wisconsin Episode loess source (Grimley and Phillips 2011a).

Methods

Surficial Map

This surficial geology map is based in part on soil parent material data (Phillips and Goddard 1983), supplemented by data from outcrop studies and stratigraphic test holes obtained for this STATEMAP project, engineering borings from the Illinois Department of Transportation and Bond County Highway Department, and water-well records. Map contacts were also adjusted according to the surface topography, geomorphology, and observed landform–sediment associations.

Locations of subsurface data used for the surficial geology map, cross sections, or landform–sediment associations are shown on the map. All studied outcrops and stratigraphic test holes are shown on the surficial map, as are key engineering, coal, petroleum type, and higher quality water-well borings that were utilized for mapping or for developing the geologic framework. Some of the water-well and oil-gas type borings had sample sets in the ISGS collections that were examined to help verify unit contacts, unit descriptions, and confirm bedrock surface elevations. The locations of many water-well borings were verified by plat books, permit maps, address checking, field confirmations (for water wells only), or a combination of methods. Many other data in this quadrangle, particularly petroleum type borings, are not shown on the map because of poor descriptions of surficial materials or unconfirmed locations. Stratigraphic test core samples were described in detail and samples were analyzed for particle size, clay mineralogy, geochemistry (< 0.25 mm fraction), and magnetic susceptibility (< 2 mm fraction). 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).

Two electrical resistivity transects were additionally utilized to help with mapping surficial deposits (location of acquired lines indicated on map). A computer-controlled resistivity meter (ABEM Terrameter LS) was used and the survey line was moved in 100 m increments. A two-dimensional resistivity model, approximately 60 m deep, was calculated from the electrical data using a finite element inversion program.

Topographic corrections (using lidar elevation data) were applied to the profiles.

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). Data used for subsurface unit contacts (in approximate order of quality for use in this mapping project) are from studied outcrops, stratigraphic test holes, engineering boring records, water-well records, coal borings, and oil- or gas-boring 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 extend into bedrock is not shown.

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 151 data locations were used in the map and in the 1.5 km buffer area, including 2 outcrops, 36 engineering borings, 47 water type borings, 6 coal borings, 5 electrical resistivity profile estimations, and 54 oil and gas type borings. A bedrock surface was modeled from the 151 data points (coded with bedrock top elevations) utilizing the "Topo to Raster" module in ArcMap 10.5.1 (ESRI) using a vertical standard error of 3 feet and with "drainage enforcement," which attempts to make a hydrologically correct surface. The bedrock surface elevation in the Beaver Creek Quadrangle ranges from about 363 to 472 ft above sea level (~109-feet relief). A drift thickness map (Fig. M4) was created by subtracting an elevation model (grid format) of the bedrock topographic surface from a surface lidar digital elevation model, using a 30-m cell size for the resulting grid file. After converting to polygons, the resulting drift thickness map had some irregular, detailed, or small polygons, some of which were simplified in Figure M4. Drift thickness ranges from 0 (bedrock outcropping in northwestern part of quadrangle) to about 200 ft thick (esker ridge in Sec. 32, T5N, R3W).

Surficial Deposits

The surficial deposits are divided into four landform–sediment associations: (1) uplands/till plains underlain by mainly loess and till deposits (mainly northwestern 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 (mainly in southern part of map) covered by loess; and (4) postglacial river valleys with alluvial sediments. Older concealed deposits (5), associated with a pre-Illinois Episode glaciation, are preserved in some areas as well. Areas of anthropogenically disturbed ground consist mainly of fill associated with highway or railway embankments.

(1) Uplands—till plain

Flat to gently rolling uplands, underlain by mainly loess, paleosol, and till deposits are found mainly in the eastern part of the quadrangle. Because of a more than 5-foot-thick loess cover, many such areas are mapped as Peoria and Roxana Silts, but the loess is directly underlain by weathered accretionary deposits (Berry Clay Member) and glacial till (Glasford Formation) as shown in the cross sections (map sheet 2). Older pre-Illinois Episode glacial units are found below the Glasford Formation in some areas (see Concealed Deposits Section). Pre-Illinois Episode deposits, present in the subsurface only, are preserved mainly in bedrock valleys. Pennsylvanian bedrock units in the area (the Bond and Shelbourne-Patoka Formations) regionally dip gently eastward toward the center of the Illinois Basin (Kolata et al. 2005). Thus, the generally north–south trending bedrock surface high in this quadrangle (Fig. M3) likely reflects the strike of more resistant Pennsylvanian limestone or sandstone units. This 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 northwestern Beaver Creek Quadrangle, along Shoal Creek, about 3 feet of Pennsylvanian mudstone was exposed that is stratified, silty, dense, and micaceous. No other bedrock outcrops were found during this mapping or have been reported in the quadrangle.

Below surficial loess and accretionary deposits, the uplands are mainly underlain by 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 or paleosol parent material within 5 feet of ground surface, mainly the Hickory and Atlas soil series, were mapped in the U.S. Department of Agriculture county soil survey reports (Phillips and Goddard 1983) in many sloping areas of the quadrangle. However, some areas on slopes mapped as Hickory loam or Atlas clay loam soil series may include thin or weathered Pearl Formation outwash or Berry Clay Member (see later section on outwash terrace). However, these units are too thin to map along the slopes at the 1:24,000 scale.

Exposures of Glasford till in the quadrangle, below loess and Berry Clay Member, were observed at several outcrops, such as in cutbanks along Shoal Creek (e.g., outcrops 23709, 23710, 23714), Beaver Creek (outcrop 23762) and Little Beaver Creek (outcrops 23763, 23765). In the outcrops along Shoal Creek, it is not uncommon to have 4 to 8 feet of stratified gravelly sandy loam to loamy sand (Pearl Formation) overlying the till, but below the loess. Otherwise, the Glasford till is directly overlain by last glacial loess and contains a paleosol (Sangamon Geosol) developed in its upper portion. Compared with overlying loess and any accretionary deposits, the Glasford till is considerably more pebbly, more dense, has a lower moisture content (~9–13%), and has a greater unconfined compressive strength (Q_u; Table 1). An upper till unit of the Glasford Formation in some stratigraphic and engineering test holes is correlated to the Vandalia Member, based on its physical and chemical properties (Jacobs and Lineback 1969; Willman and Frye 1970; Hartline 1981). A lower till unit of the Glasford Formation, that is slightly finer grained, less sandy, and less illitic, is correlative with the Smithboro Member (Jacobs and Lineback 1969; Hartline 1981; Grimley and Gemperline 2015). Both the Vandalia and Smithboro Members of the Glasford Formation were observed at outcrop 23715 (Sec.25, T5N, R4W), where the Smithboro till was finer-grained (silty clay loam diamicton), less calcareous, softer (1.5 to 3.5 tsf), and had more wood fragments. In contrast, the Vandalia till was harder (4.5 tsf), more calcareous, and had fewer wood fragments. At this particular exposure, the Vandalia Member had contorted sand lenses within the unit. Tectonized and contorted sand lenses were also noted within the Vandalia Member in the Pleasant Mound Quadrangle to the east (Grimley et al. 2018). In the Beaver Creek Quadrangle, relatively unaltered till of the Vandalia Member has about 55–72% illite in the clay mineral fraction and has a loam texture with about 11–22% clay (<2 µm), 36–50% silt, and 30–49% sand (Table 1). In comparison, till classified as the Smithboro Member has about 45–55% illite in the clay mineral fraction (with 20–40% expandable clay minerals). The Smithboro facies is more silty (>50%) than the Vandalia Member and generally has more than 20% clay and less than 30% sand (Table 1). The Smithboro Member also has a lower gravel content (generally <4%) than the Vandalia Member (typically 4 to 10% gravel). Finally, the Smithboro facies can have a slight organic aroma, and has more silty inclusions and small fragments of conifer wood. Overall, the characteristics of the Smithboro facies likely reflect glacial incorporation of proglacial palustrine, loessal, paleosol, and lacustrine sediments. Sand and gravel lenses or channels within the Glasford Formation occur locally on uplands.

Strong alteration features are prominent in the upper 4 to 6 feet of the Glasford Formation (where not buried by other Illinois Episode deposits), including root traces, fractures, carbonate leaching, oxidation or color mottling, strong soil structure, clay accumulation, clay skins, or their combination. 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 feet or more into the Glasford till (or diamicton) in some areas. The upper 5 to 10 feet of the Glasford Formation, where uneroded, is generally more weathered (related to the Sangamon Geosol), is leached of carbonates, has a higher water content, has a higher proportion of sand or silt lenses, and is less stiff than the majority of the unit.

Surficial loess deposits (Peoria and Roxana Silts combined) are typically about 6 ft thick where uneroded, with thinner deposits on steeper eroded slopes. The loess deposits cover Illinois Episode deposits (Glasford or Pearl Formations) are shown on the surficial map where ~5 feet or thicker. The loess was deposited during the last glaciation (Wisconsin Episode) when mainly silt-sized 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. Loess deposits are typically a silt loam where unweathered, but in the modern soil solum (about the upper 4 feet), they are altered to a heavy silt loam or silty clay loam. The Peoria Silt is the upper, younger loess unit and is contained mostly within the modern soil solum. The Roxana Silt, typically with a slight pinkish or darker brown hue in other areas, is the lower loess unit (Hansel and Johnson 1996) but is not easily distinguishable in the field as it has been pedogenically mixed with Peoria Silt above (modern soil profile) and/or with Sangamon or Illinois Episode deposits below (upper Sangamon Geosol). Both loess units in this quadrangle are slightly to moderately weathered, leached of carbonates, and relatively similar in physical properties (Table 1); thus, they have not been differentiated for mapping purposes.

(2) Glacial Ridges and Knolls

Areas of Illinois Episode glacial ridges and knolls in the Beaver Creek Quadrangle consist of two mapped types: (A) sandy ridges—esker-type ridges, fans, or other hills with coarse-grained material, predominantly glaciofluvial sand and gravel (mapped as the sandy facies, Hagarstown Member, Pearl Formation); (B) mixed lithology ridges—ridges composed of intercalated sorted sediment (mainly sand) and diamicton (together mapped as the mixed facies, Hagarstown Member, Pearl Formation). Both ridge–sediment associations are blanketed by about 6 feet of Wisconsin Episode loess deposits, below which the Sangamon Geosol has developed into the upper portion of these Illinois Episode glacial deposits. The various ice-contact glacial hills are generally consistent with the idea of ice stagnation in the region (Leighton 1959, Jacobs and Lineback 1969), which resulted in kames, eskers, and ice-walled distributary fan systems (Grimley and Phillips 2011a). Electrical resistivity surveys acquired for this project, in conjunction with subsurface drilling, aided differentiation of mixed and sandy glacial ridge deposits in the Beaver Creek Quadrangle, and in differentiating both Hagarstown Member deposits from the denser and generally less sandy Glasford Formation till units.

(A) Sandy Ridges Prior studies in southern Illinois have noted significant sand and gravel in glacial ridges of the

Table 1 Values shown in table indicate typical ranges of the various physical and chemical properties within typical materials for each geological unit in the Beaver Creek Quadrangle. Data for Illinois Episode units are from relatively unaltered portions (below the Sangamon Geosol solum). Data for the Vandalia and Smithboro facies are mainly from subglacial till units (supraglacial or melt-out till has higher water contents, is softer, and more variable in texture and composition).

	Geotechnical properties[1]			Particle Size and Compositional Data[2]						
Unit	w (%)	Q_u (tons/ft^2)	N	sand	silt	clay	Clay mineralogy	Carbonate (field test)	MgO mass % (< 250 µm fraction)	MS
Cahokia Formation	18–28 (6)	0.3–1.4 (6)	3–10 (6)	silt loam to silty clay loam to loamy sand			ND[3]	Mainly noncalcareous	ND	ND
Peoria and Roxana Silts	18–23 (5)	0.75–2.5 (5)	ND	50–71	17–30	17–25	30–71% expandables 15–25% illite	Noncalcareous	0.6–0.9	8–90
Berry Clay Member, Pearl (or Glasford) Fm.	17–25 (5)	1.5–3.0 (5)	ND	silty clay loam to sandy clay loam			23-60% illite (typically high expandables)	Noncalcareous	0.8–1.1	3–60
Hagarstown Member (sandy facies), Pearl Fm	10–25 (2)	<0.25–1.5 (2)	ND	58–92	4–32	4–21	63–75% illite	Leached to calcareous	0.7–4.1	15–80
Hagarstown Member (mixed facies), Pearl Fm	18–30 (1)	< 0.25–3.0 (2)	ND	2–75	6–20	4–25	62-80% illite (sparse data)	Leached to calcareous	0.9–3.5	9–80
Mascoutah facies, Pearl Fm. (outwash)	20-24 (2)	<0.25–1.5 (3)	13–48 (3)	70–90	4–10	9–19	35–60% illite	Leached to calcareous	ND	ND
Glasford Formation (Vandalia facies)	9–15 (10)	3.0–6.2 (10)	16–52 (10)	30–49	36–50	11–22	55–72% illite (Vandalia facies)	Calcareous (where unaltered)	2.0–4.1	5–30
Glasford Formation (Smithboro facies)	16–21 (3)	1.75–4.0 (3)	10–45 (3)	50– 52	22–25	20–23	45–55% illite (Smithboro facies)	Calcareous	1.5–2.3	ND
Grigg tongue, Pearl Fm. (outwash)	ND	ND	13–30 (2)	fine sand to gravelly sand			ND	Calcareous	ND	ND
Petersburg Silt	ND	ND	ND	silt to silt loam			ND	Weakly to moderately calcareous	1.1–1.3 (sparse data)	ND
Lierle Clay Member, Banner Formation	18–20 (1)	3.4–3.6 (1)	24–26 (1)	silty clay loam to silty clay			ND	Noncalcareous	1.1–1.4 (sparse data)	ND
Banner Formation (till)	19–23 (2)	3.3–5.5 (2)	14–30 (2)	silt loam to clay loam diamicton			ND	Weakly to moderately calcareous	1.3–2.7	ND
Pennsylvanian bedrock	ND	>4.5	>50	shale, siltstone, mudstone, sandstone, limestone			55% illite (43% kaolinite-chlorite, 2% smectite); mudstone sample	None to very high (in limestone)	~ 1.7	ND

[1]Geotechnical properties are based on tens of measurements (total for all units) from ~15 engineering (bridge) borings and 5 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). Shallow depths, where sediment was not saturated, were not used for water content data. Number in parentheses after geotechnical properties indicates number of cores/borings used for data; each core may have one or more depths with data.

[2]Particle size, clay mineralogy, and %MgO are based on a dataset (~50 samples) from 5 stratigraphic borings, 10 outcrops and 3 sample sets. 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 Scintag X–ray diffractometer. MgO mass % was measured by X-ray fluorescence. MS, mass-based magnetic susceptibility (x10^{-8} m^3/kg) from tens of measurements in the laboratory on 5 stratigraphic borings and 4 outcrops using a Bartington MS2 meter and MS2B attachment.

[3]ND, no data available.

Vandalia region (Jacobs and Lineback 1969) and southwestward (Grimley and Phillips 2011a; Grimley and Gemperline 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 2010), a unit similar in concept to the original definition of the Hagarstown Member (Willman and Frye 1970; Killey and Lineback 1983). In the Beaver Creek Quadrangle, glacial hills mapped as pl-h(s) are found mainly in the western and southeastern part of the quadrangle and may have up to 120 feet of overall sandy material below the loess cover and Sangamon paleosol (Fig. M5, cross section A–A′). Areas mapped pl-h(s) are boldly stippled with a reddish brown color in areas where the loess cover is greater than 5 feet. The upper 5 to 8 feet of Hagarstown Member, below the loess, is typically altered to a clay loam to sandy loam and contains pedogenic alteration features, such as clay skins and root traces that formed during interglacial soil development (attributed to the Sangamon Geosol). This buried weathered zone is distinctly reddish-brown where present in well drained areas, as observed in stratigraphic test borings into the glacial ridges (23753, 23754).

In the northwestern part of the quadrangle, a significant ridge containing sandy Hagarstown deposits is 50 to 75 feet in relief above the surrounding plain and is about 1.0 to 1.5 km wide. The material composition and shape of this ridges is consistent with an esker or ice-walled channel system. This particular esker (or ice-walled channel) system would have been a significant outlet for meltwater drainage into the Kaskaskia Basin during glacial recession of an ancestral Lake Michigan Lobe (Figs. M1, M2) towards the end of the penultimate glaciation (Illinois Episode). In addition to stratigraphic test holes and water well logs, two electrical resistivity transects (Fig. M5) confirm the presence of thick sandy material (high resistivity) in the prominent ridge in the northwest part of the quadrangle. Particularly high resistivity occurs in dry gravelly sand which was encountered in a stratigraphic test hole on the crest of the ridge. Lower resistivities on the eastern side of the ridge imply more fine-grained material (loess, paleosol, lacustrine) or till. A smaller ridge, which appears to be a subglacial distributary channel, also contains sandy material but of lesser thickness.

(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 2010). Some small hills mapped as the mixed facies [pl-h(m)] in the Beaver Creek 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, or water-well logs or sample sets to have a mixed lithology, including a stratigraphic tests hole in Sec. 19, T4N, R3W (county no. 23752). A core from this test hole encountered a mixture of diamicton, lacustrine silts, and gravelly sand between 10 and 33 feet depth, with Vandalia till below. Hills mapped as pl-h(m) are distributed throughout the quadrangle and tend to be rounder type hills (circular in cross section) than the sandy facies hills; however, there are exceptions. 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 southwest (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 (m)] 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 feet.

(3) Illinois Episode Outwash in Terraces and Lowlands
Across some of the southern and western parts of the quadrangle are proglacial sand deposits, with some gravel, up to 30 ft thick and distributed in terraces, lowlands and outwash fans. Glaciofluvial deposits within these landforms occur in the subsurface below Peoria-Roxana loess and the Berry Clay Member, including the Sangamon Geosol, or locally below Cahokia alluvium (see cross sections). This proglacial, Illinois Episode, sand and gravelly sand unit is classified as the Mascoutah facies, Pearl Formation (Grimley and Webb 2010). The Mascoutah facies is typically a fine to medium sand, but may also contain beds of gravelly coarse sand. Where the Mascoutah facies is within the alteration zone of the Sangamon Geosol, it can range from sandy loam to loamy sand to clay loam.

Mascoutah facies outwash (Pearl Formation), in the Beaver Creek Quadrangle, occurs multiple terrace in different parts of the quadrangle that are associated with different valley meltwater systems. In the southeastern part of the map, the Pearl Formation is found below about 480 ft asl, on the edge of a regional terrace that can be traced for about 50 miles to the southwest within the Kaskaskia River Basin (Grimley 2010; Grimley and Phillips 2011a, 2011b; Grimley and Gemperline 2015). An Illinois Episode age for the terraces are 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).

Outwash in terraces are typically underlain by Glasford diamicton. Portions of the Pearl Formation, similar in lithology to the Mascoutah facies, that occur below the Glasford Formation are classified as the Grigg tongue of the Pearl Formation (Grimley and Webb 2010). Sand and gravelly sand in the Grigg tongue is preserved in some areas within the buried bedrock valleys (cross section A–A′). The Grigg tongue is up to 25 ft thick, based on a described sample set associated with a water-well borings. This glaciofluvial deposit likely records the first advance of the southwest-flowing Illinois Episode ice front into the ancestral Kaskaskia Basin.

In most cases, except below recent alluvium, areas with the Mascoutah facies are overlain by 5 to 15 feet of the finer grained and pedogenically altered Berry Clay Member of the Pearl Formation. An additional 5 to 6 feet of last glacial loess (Peoria and Roxana Silts) covers the Berry Clay Member, such that loose sand deposits are typically 13 to 20 feet below ground surface. Thus, terraces and fans are mainly mapped as loess on the surficial geologic map, but is portrayed with a diagonal colored line pattern where more than 5 feet of the Pearl Formation is predicted to occur at depth based on available data. In a few lowland areas that feed into the main terrace area, a dashed diagonal line pattern is indicated; in such areas, the Pearl Formation is suspected in the subsurface, but we have lower confidence in its presence (based on electrical resistivity transects, water well descriptions, or geomorphic interpretations rather than direct viewing of samples). Some of these low confidence areas may alternatively have a sandy facies of Glasford Formation till or may contain thin deposits of Pearl Formation. New stratigraphic test holes are needed to confirm its presence and characteristics.

The Berry Clay Member generally overlies the Mascoutah facies of the Pearl Formation in the quadrangle, but can also overlie the Glasford Formation. The Berry Clay typically contains strong interglacial soil alteration features (Sangamon Geosol) and is buried by Wisconsin Episode loess. 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 2010; 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 Beaver Creek Quadrangle was deposited in advance of the approaching Illinois Episode glacial front (Grigg tongue), as well as during ice margin recession (Mascoutah facies). The Mascoutah facies of the Pearl Formation would have been deposited in association with glacial meltwaters emanating from the ice margin when it was receding. Some pulses of glacial meltwater likely originated from ice-walled channel and esker meltwater systems that fed into the proglacial meltwater systems (Fig. M2). Glacial meltwaters may have been associated with the Kaskaskia Sublobe or with a late surge of glacial ice to the southeast (and later ablation) by the Springfield Sublobe (Grimley et al. 2018).

(4) Postglacial River Valleys

Postglacial (Holocene) stream deposits in Shoal Creek, Beaver Creek, Little Beaver Creek, and other unnamed creek valleys are mapped as Cahokia Formation and consist mainly of fine-grained (silt loam) material that is weakly stratified and soft. The Cahokia Formation can also include zones of sandy loam or beds of fine sand, particularly near the basal contact of the unit above older glacial sediments. The Cahokia Formation may be up to 25 ft thick in the alluvium of Shoal Creek Valley. The Cahokia alluvium is generally 5 to 20 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 (Phillips and Goddard 1983).

(5) Concealed Deposits (pre-Illinois Episode)

Below the loess and Illinois Episode glacial deposits, various pre-Illinois Episode deposits (classified as the Banner Formation) are preserved (see cross sections). Deposits of the pre-Illinois Episode Banner Formation (diamicton, sand, gravel, and silt) occur only in the subsurface in the Beaver Creek Quadrangle. Interglacial soil development (Yarmouth Geosol), where preserved within the uppermost Banner Formation, is the primary basis to distinguish Banner Formation sediments from Illinois Episode deposits in the Pearl and Glasford Formations (Willman and Frye 1970; Curry et al. 2011). Several engineering borings or sample sets in the quadrangle have been interpreted to contain an interglacial paleosol in an accretionary deposit, classified as the Lierle Clay Member of the Banner Formation (Willman and Frye 1970). This deposit is typically a dark greenish gray to light olive brown silty clay loam to silty clay, is mainly noncalcareous, has pedogenic characteristics of a gleyed interglacial paleosol (Yarmouth Geosol), and contains only rare pebbles. The paleosol was documented in sample sets such as water well borings 00898 and 22836 in eastern cross section A-A′. A few engineering borings and water well descriptions make note of a greenish-grey clay, which we interpret to be the Lierle Clay (and top of pre-Illinois Episode deposits), typically at elevations between about 390 and 450 ft asl. Below the Lierle Clay Member, a pre-Illinois Episode deposits may include diamicton (mainly till), silt, or sand and gravel. Such deposits are classified as the Banner Formation (Willman and Frye 1970; Hansel and McKay 2010). Water wells borings and sample sets suggest that deposits of the Banner Formation may be as much as 60 ft thick, particularly in bedrock lowlands (cross section B-B′). This unit is mostly diamicton but locally includes beds of sand and gravel outwash in either the upper or lower part of the unit.

In many areas of the quadrangle, the Banner Formation deposits from pre-Illinois Episode glaciation were removed by erosion of highlands during the succeeding interglacial (Yarmouth Episode) or during the ensuing Illinois Episode glacial advance. Thus, the Banner Formation preserved today, mainly in bedrock lowlands, is a remnant of a once extensive covering of pre-Illinois Episode deposits, that were considerably eroded during later geologic events.

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. The Mascoutah facies (Pearl Formation) varies from very fine and fine sand to gravelly coarse sand (in some beds). However, gravelly zones are limited and the modal texture is probably fine to medium sand. The most economic sand and gravel deposits are within the Hagarstown Member sandy facies, with the thickest deposits (perhaps as much as 100 feet) occurring in the northwestern part of the quadrangle (cross section A-A′). The Hagarstown sandy facies may have zones of cemented sand and may include localized beds of diamicton or silt. 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 (Grimley and Phillips 2011a; Webb et al. 2012). 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 mostly 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 also not desirable because of its general occurrence below 80 to 100 feet 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. Saturated sand and gravel in the Pearl Formation (including Hagarstown Member, Mascoutah facies, and Grigg tongue), sand lenses in the Glasford Formation and, to a lesser extent, the Banner Formation, constitute the predominant glacial aquifer materials in the Beaver Creek Quadrangle. Known sand and gravel lenses are stippled in the cross sections. Wells used for household water supply are typically screened in one of these units. Surface water resources, such as the Kaskaskia River, are also utilized in the region. At some sites, 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 feet of fine-grained loess (Peoria and Roxana Silts), accretionary sediments (Berry Clay Member), or clayey Sangamon Geosol profile (altered into upper Pearl Formation), but in some areas along the valley edges and ravines, the upper 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, such as ancient sand blows, in outcrops along the Kaskaskia River, 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 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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