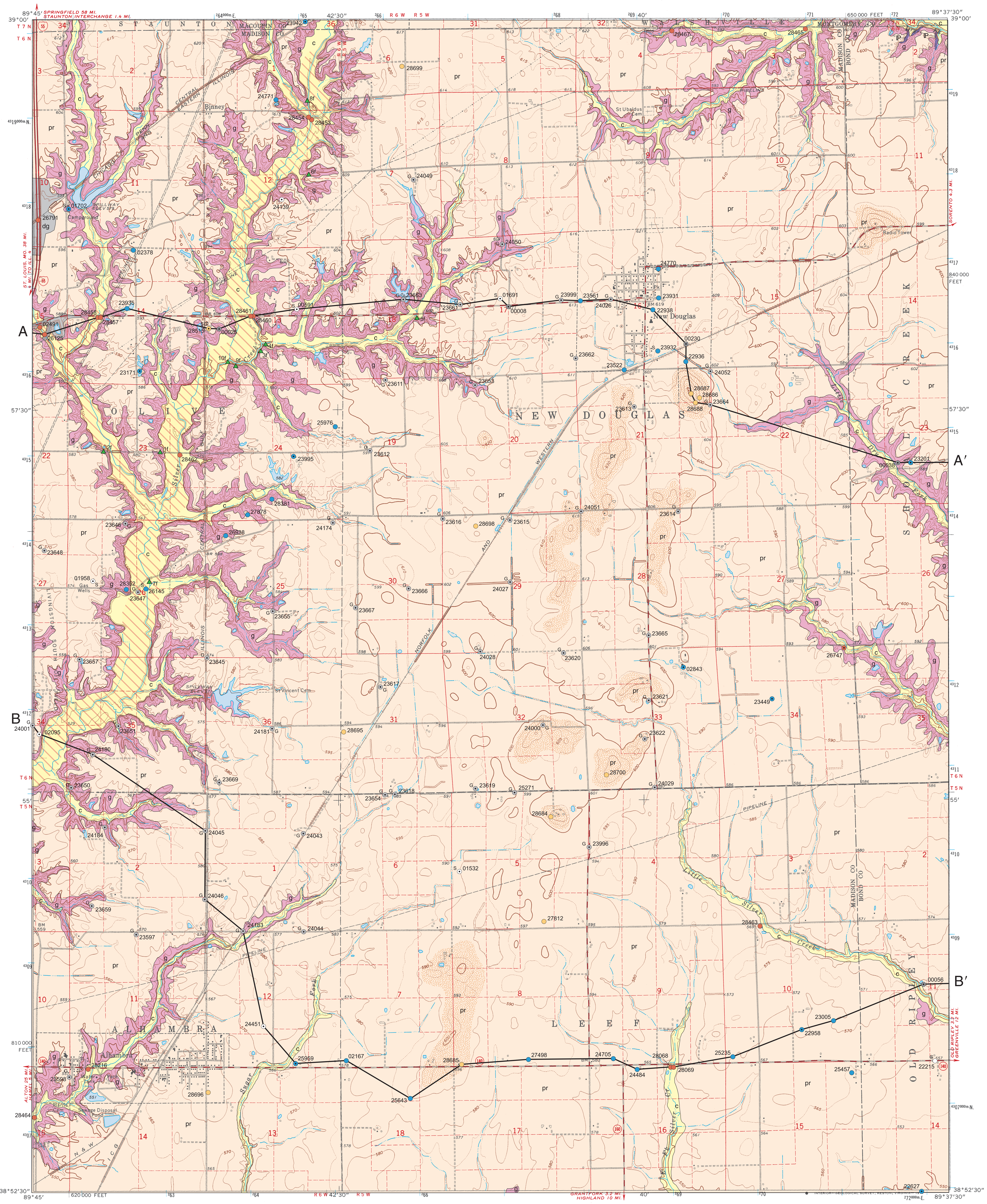
Illinois Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
William W. Shilts, Chief

SURFICIAL GEOLOGY OF NEW DOUGLAS QUADRANGLE

MADISON AND BOND COUNTIES, ILLINOIS

David A. Grimley
2005

Illinois Preliminary Geologic Map
IPGM New Douglas-SG



QUATERNARY DEPOSITS

Description	Unit	Interpretation
HUDSON EPISODE (~12,000 years before present (B.P.) to today)		
Fill or removed earth; sediment of various types; up to 30 feet thick	Disturbed ground dg	**Man-made fill or excavations;** includes large areas of disturbed sediment or borrow areas such as near interstate highways
Silty clay loam, silt clay, silt loam, and loam; occasional sand and gravel beds; gray to dark brown; massive to well stratified; noncalcareous; up to 25 feet thick	Cahokia Formation c	**Alluvium** (river deposits) in stream valley floodplains; derived from reworking of loess and diamicton from uplands and slopes; includes some historical deposition
WISCONSIN EPISODE (~75,000–12,000 years B.P.)		
Silt to silt loam; yellowish brown to gray to brown; massive to blocky structure; friable; noncalcareous; contains modern soil solum in upper 3 to 5 feet; up to 10 feet thick	Peoria and Roxana Silts pr	**Loess;** includes redeposited loess in sloping areas; the Peoria and Roxana Silts are not easily differentiated due to similar physical properties, alteration, and thinness of units
ILLINOIS EPISODE (~200,000–130,000 years B.P.)		
Mixture of loam, poorly sorted sand, diamicton, and silty clay; may contain zones of well sorted sand and gravel, but distribution is difficult to predict; strong brown to yellowish brown to light olive gray; high variability; soft to moderately stiff; up to 40 feet thick but generally less than 25 feet thick	Hagarstown Member, Pearl Formation (cross sections only) pl-h (stipples on map where buried)	**Ice-contact drift;** upper portion may contain Sangamon Geosol; may include debris flows, inclusions, fractures or faults, and possible buried remnants of eskers or kames; intertongues with Glasford Formation; where unit is buried, contact lines are not shown on map
Sand with some gravel; may include silty or clayey beds; gray to yellowish brown; stratified; moderately to well sorted; up to 25 feet thick	Pearl Formation outwash facies (cross sections only) pl (hachures on map where buried)	**Outwash;** occurs underneath Cahokia Formation in south and southwest flowing valleys (particularly Silver Creek valley); directly overlies Glasford or Banner Formations; where unit is buried, contact lines are not shown on map
Pebbly loam diamicton; contains sand lenses up to 20 feet thick; light olive-brown to dark gray; main portion is generally massive, very stiff to hard, calcareous, and contains 5-10 % pebbles (typically < 2-inch); upper few feet is weathered to brown or yellowish brown, and is softer with more clay (silty clay loam); up to 90 feet thick	Glasford Formation (< 5 feet of loess cover) g	**Till and ice marginal sediment;** upper few feet generally contains Sangamon Geosol solum; upper third often includes some sand and gravel lenses and supraglacial deposits; lower portion is mainly basal till; crops out along steep slopes; covered by up to 5 feet of loess
PRE-ILLINOIS EPISODE (~700,000–450,000 years B.P.)		
Silty clay loam and silty clay; few pebbles; crudely to well stratified; moderately stiff; dark greenish gray to olive gray to dark gray; noncalcareous; up to 15 feet thick	Lierle Clay member, Banner Formation (cross sections only) b-l	**Accretionary sediment;** occurs in shallow depressions with some stream and slope sediment; includes Yarmouth Geosol, sometimes truncated
Pebbly silty clay loam diamicton; contains some sand lenses; olive to olive gray to dark gray; massive to weakly laminated; shale fragments common; moderately stiff to stiff; noncalcareous to calcareous; up to 50 feet thick	Omphghent member, Banner Formation (cross sections only) b-o	**Till and ice marginal sediment;** generally contains evidence of Yarmouth Geosol weathering or oxidation in upper 10 feet; the alteration zone may or may not be truncated
Silty clay, silty clay loam, and clay; greenish gray to olive gray; massive to faintly laminated, moderately stiff; moderately to very moist; noncalcareous; up to 25 feet thick	Canteen member, Banner Formation (cross sections only) b-c	**Mainly fine-grained alluvium and lake sediment;** nonglacial; may contain one or more paleosols; overlies Grover Gravel or bedrock

TERTIARY / EARLY QUATERNARY DEPOSITS

Description	Unit	Interpretation
Iron cemented gravel and sand; poorly sorted with clay coatings and fillings; reddish brown; consists of abundant chert and quartz with some local shale fragments in zones; pebbles are angular and imbricated; rare erratic pebbles of quartzite, jasper and ironstone; up to 15 feet thick	Grover Gravel (cross sections only) QTg	**Alluvium;** nonglacial; may include reworked, resistant Cretaceous and Paleozoic sedimentary rock fragments; overlies Paleozoic bedrock

PRE-TERTIARY (PALEOZOIC) DEPOSITS

Description	Unit	Interpretation
Shale, sandstone, and limestone; may include beds of coal and underclay in subsurface (> 50 feet depth); various colors including olive brown, greenish gray, light gray, bluish gray, and yellow brown; laminated to bedded to massive; noncalcareous to moderately calcareous	Near-surface Pennsylvanian bedrock IP	**Bedrock exposures** or bedrock within 5 feet of land surface; areas shallow to bedrock (Bond Formation) occur in northeastern portion of quadrangle;

Data Type

- 6f Outcrop
- 28516 Stratigraphic boring
- 23935 Water well
- 26125 Engineering boring
- 23661 Coal boring
- 01958 Other boring, including oil and gas
- SG Boring with samples (S) or geophysical log (G); dot indicates to bedrock

Note: Numeric labels indicate the county number, a portion of the 12-digit API number on file at the ISGS Geological Records Unit. Outcrop labels indicate author field number. Online well and boring records are available at the ISGS web site.

- Contact
- Inferred contact
- A—A′ Line of cross section

Base map compiled by Illinois State Geological Survey from digital data provided by the United States Geological Survey. Topography by photogrammetric methods from aerial photographs taken 1973. Field checked 1974.

North American Datum of 1927 (NAD 27)
Projection: Transverse Mercator
10,000-foot ticks: Illinois State Plane Coordinate system, west zone (Transverse Mercator)
1,000-meter ticks: Universal Transverse Mercator grid system, zone 16

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

BASE MAP CONTOUR INTERVAL 10 FEET
SUPPLEMENTARY CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Released by the authority of the State of Illinois: 2005

Geology based on field work and data compilation by D. Grimley, 2004–2005.

Digital cartography by J. Carrell, Illinois State Geological Survey.

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

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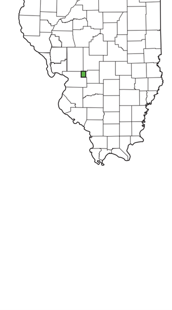

1	2	3
4		5
6	7	8

ADJOINING QUADRANGLES
1 Gillespie South
2 Mount Olive
3 Sorento North
4 Worden
5 Sorento South
6 Marine
7 Grantfork
8 Pocahontas

1°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2005

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

Introduction

The surficial geology map of the New Douglas 7.5' Quadrangle, located in southwestern Illinois about 30 miles northeast of St. Louis, Missouri, provides an important framework for land and groundwater use, engineering assessment, environmental hazards, and geological studies. This study is part of a broader geologic mapping program undertaken by the ISGS in developing areas of the St. Louis Metro East region (Phillips 2004, Grimley 2004).

The New Douglas Quadrangle is located in northeastern Madison County, about 20 to 25 miles northeast of the Mississippi River valley (fig. 1) and the maximum extent of glacial ice during the Illinois and pre-Illinois episodes (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 basin and/or more eastern Great Lakes Region during pre-Illinois episodes (Willman and Frye 1970). Deposits of both glacial episodes have also been reported by McKay (1979), Stohr et al. (1987), and Phillips (2004) within 15 miles of this area. Glacial ice did not reach the study area during the Wisconsin Episode; however, glacial meltwaters from the upper Mississippi River drainage basin deposited outwash throughout the middle Mississippi Valley. This outwash was the source for loess deposits (windblown silt) which blanket the uplands of southwestern Illinois.

Methods

Surficial map
The surficial geology map is based in part upon soil parent material data (Goddard and Sabata 1982, Phillips and Goddard 1983), supplemented by data from outcrops, stratigraphic test holes obtained for this STATEMAP project, engineering borings from Illinois Department of Transportation (IDOT) and Madison County Highway Department, coal borings, and water wells. Map contacts were also adjusted according to the surface topography, geomorphology, and observed landform-sediment associations. Important data points used for the surficial geology map, cross sections, and conceptual framework are shown on the map.

Cross sections
The cross sections portray the deposits as would be seen in a slice through the earth down to bedrock (vertically exaggerated 20x). 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 (IDOT and Madison County Highway Department), coal test borings (many with various geophysical logs), water well records, and oil well records. Units less than 5 feet thick are not shown on the cross sections. Dashed contacts indicate where data is less reliable or not present. The full extent of wells that penetrate deeply into bedrock is not shown.

Surficial Deposits

The surficial deposits can be divided geomorphically into three terrains: (1) upland flats and slopes, containing predominantly glacial and windblown sediments near the surface; (2) upland hills and ridges, containing ice contact sediment; and (3) valleys, containing predominantly postglacial waterlain sediments near the surface. There are also older concealed deposits, whose occurrence and thickness is closely related to the bedrock surface topography (fig. 2). Areas of disturbed ground are mapped in the northwestern portion of the quadrangle, near interstate-55, where removed earth and fill occur.

Upland flats and eroded slopes
Upland flats and eroded slopes comprise about 91% of the quadrangle's area. Uneroded uplands are blanketed by loess (windblown silt) that is underlain by thick glacial till and ice-marginal deposits. The loess (Peoria and Roxana Silts) is 6 to 10 feet thick on uneroded uplands, but is thinner on the many eroded sloping areas (see map and cross sections). During the last glaciation (Wisconsin Episode), silt-size particles from Mississippi Valley meltwater deposits were periodically windswept and carried in dust clouds eastward to vegetated upland areas where particles gradually settled out across the landscape. The loess deposits are typically a silt loam to heavy silt loam where unweathered. In the modern soil solum (generally the upper 3 to 4 feet), the loess is altered to a heavy silt loam or silty clay loam (Goddard and Sabata 1982). The Peoria Silt is the upper and younger loess unit and the Roxana Silt, with a slight pinkish hue, is the lower loess unit (Hansel and Johnson 1996). Because the total loess thickness does not exceed 10 feet, both loess units are slightly to moderately weathered, leached of carbonates, relatively similar in physical properties and thus impractical to map separately.

On many sideslopes and ravines, where the loess has been eroded to less than 5 feet, the underlying weathered and unweathered diamicton (a massive, poorly sorted mixture of clay, silt, sand, and gravel), and associated sorted sediment, are mapped as the Glasford Formation. The Glasford, deposited during the Illinois Episode, is predominantly pebbly loam diamicton (interpreted as till) that is interspersed with sand and gravel lenses that can be tens to hundreds of feet wide and up to 20 feet thick. This unit is especially common near the surface in northwestern areas along Silver Creek valley, where postglacial loess erosion has been significant. The Glasford Formation is up to 90 feet thick and occurs nearly everywhere on this quadrangle in the subsurface. Sand and gravel lenses are more common within upper portions of the unit, but it can also be present near the unit base (see cross sections). Based on data from one core (# 28515; Sec. 13, T6N, R6W), the lower portion of the Glasford Formation has a slightly lower illite content than upper portions, perhaps due to more local incorporation of weathered and clay-rich pre-Illinois Episode till. No physical evidence was observed here for two separate Illinois Episode ice advances as has been noted to the east near Vandalia, Illinois (Jacobs and Lineback 1969). Compared to overlying loess deposits, the Glasford Formation is more pebbly, stiff, and dense, and has a lower moisture content (9–15 %) and higher average blow counts (table 1).

In its uppermost portion, the Glasford Formation contains a buried interglacial soil, known as the Sangamon Geosol, that exhibits alteration features such as root pores, fractures, oxidation or color mottling, strong soil structure, clay accumulation, and/or clay skins. Such alteration features, most prevalent in the upper few feet of the Glasford Formation, help to delineate the contact below Wisconsin Episode loess deposits (a thin covering of late Illinois Episode loess is sometimes included in the upper Glasford Formation). The upper 10 feet of Glasford till is generally more weathered, less stiff, and may have a higher water content than the remainder of the unit, which is very stiff to hard (table 1) because it was deposited subglacially under the entire weight of glacial ice.

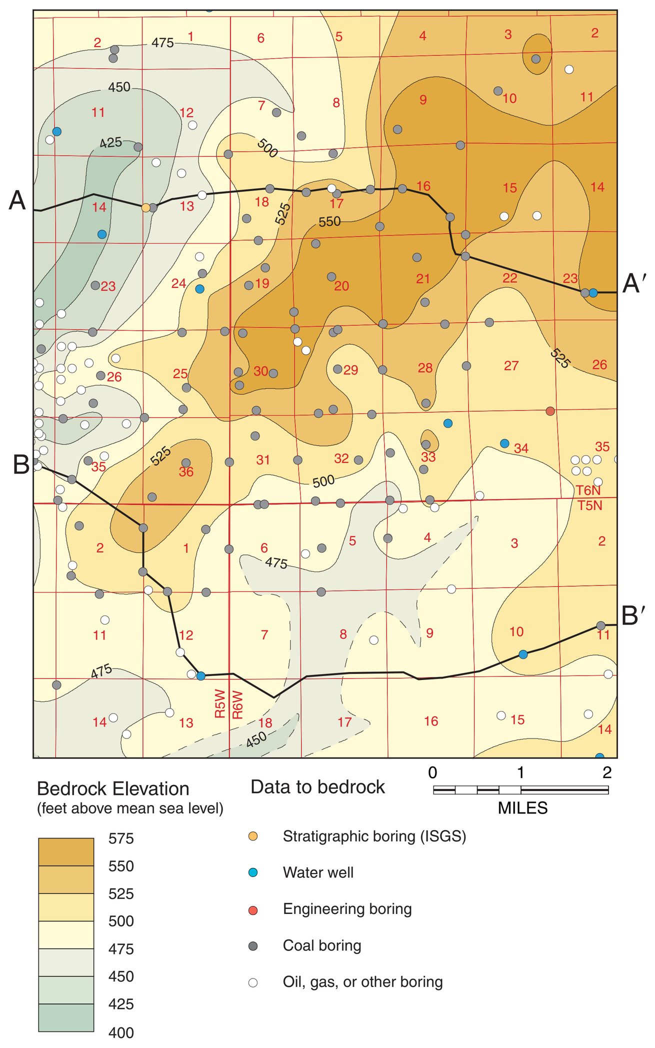

Figure 2 Bedrock topography of the New Douglas Quadrangle. Section boundaries are shown in red and cross section lines are shown in black. Scale is 1:100,000. The bedrock valley in the south-central area is somewhat speculative.

Oxidation (to light olive brown) and fracturing of Glasford diamicton may extend 15 to 25 feet below the unit top before unaltered, uniform gray till is encountered.

Near-surface Pennsylvanian bedrock is mapped only in the most northeastern portion of the map (Sec. 2, T6N, R5W), based on soil survey reports (Phillips and Goddard 1983). However, many areas along the eastern margin of the map and in the vicinity of New Douglas have relatively shallow bedrock (< 50 feet of glacial drift) due to a NE-SW trending buried bedrock high (fig. 2). In many areas of this bedrock high, pre-Illinois episode units have been eroded and thus Illinois Episode till rests directly on the bedrock surface (see cross section A–A′ especially).

Upland hills and ridges
In the central portion of the quadrangle, several ridges and knolls occur in a NNE-SSW alignment, approximately parallel to regional ice flow during the Illinois Episode (generally to the southwest, Grimley et al. 2001). These loess covered ridges are up to 40 feet in relief and cover about 3 % of the quadrangle. These areas, historically termed "ridged-drift", tend to contain a higher proportion of loamy to sandy deposits at depth than surrounding areas and are thus mapped as the Hagarstown Member of Pearl Formation underneath 5 to 10 feet of loess deposits (such areas are stippled). Prior studies of similar features in south-central Illinois have noted significant sand and gravel in some features (Jacobs and Lineback 1969); whereas other ridges contain a high proportion of intermixed diamicton and fine-grained sediment (Phillips 2004). In this mapping area, the Hagarstown Member may be up to 40 feet thick (mostly much thinner) and could include a mixture of irregularly bedded and fractured diamicton, sand, loam, and ice-thrusted inclusions. However, these predictions are based only from a limited number of shallow borings that have been drilled in these ridges. The Hagarstown Member generally overlies Glasford Formation (Willman and Frye 1970), but has been redefined as a member of the Pearl Formation (Killey and Lineback 1983), due to its more close association.

The location of these ridges appears to have a relationship with bedrock topography. In many cases in southwestern Illinois, including here, the ridges appear to initiate near a bedrock high (town of New Douglas area) and then follow the general ice flow direction towards a bedrock valley (south-central area in this quadrangle). The bedrock high in the northeastern portion of the quadrangle may have caused a "weak spot" in the glacial ice that subsequently developed into a subglacial channel and/or crevasse system. As the ice flowed to the SW over this bedrock high (compare ridges to figure 2), small elongated cavities or cracking may have developed underneath or within the ice on the lee side of the bedrock obstacle. The ridged-drift may have formed when ice was in its final melting phase and, in the lee of the bedrock high, an interlobate or reentrant area developed that experienced debris flows and ice contact deposition. The Hagarstown Member includes a considerable amount of debris flow deposits and fractured fine-grained inclusions mixed with sorted sediments. The high variability of material in these ridges suggests an ice-marginal position of deposition during their formation. However, some portion of the ridges and knolls may have had a subglacial origin as well.

Valleys
Valleys occupying about 6% of the quadrangle's area are mainly filled with fine-grained postglacial stream deposits (classified as the Cahokia Formation). The Cahokia Formation is generally 10 to 25 feet thick in Silver Creek valley and 5 to 15 feet thick in the smaller valleys. Although mostly silty clay loam, silt loam and loam in texture, the Cahokia Formation may include layers of fine to medium sand at depth and includes channel sand in modern streams. The Cahokia Formation in Silver Creek Valley and its tributaries is underlain by up to 15 feet of sand with some gravel. These coarse-grained deposits are interpreted as outwash or ice-marginal sorted sediment related to Illinois Episode glaciation and are correlated to the Pearl Formation (Willman and Frye 1970). In Madison County, Pearl sand and gravel is most common in terraces or in the subsurface along south and southwest trending valleys (e.g., Silver Creek valley) that may have served as meltwater outlets for Illinois Episode glacial ice. In boring logs, the Pearl Formation is sometimes difficult to distinguish from Cahokia sand, and thus some areas shown as Pearl Formation on cross sections may include postglacial sands. Sediment in the Cahokia Formation is mostly derived from erosion of loess and till deposits exposed on uplands and sloping areas. The Cahokia Formation may contain buried organic-rich paleosols and layers of historically eroded sediment. Due to periodic flooding during postglacial times, areas mapped as Cahokia Formation generally have relatively youthful modern soil profiles (generally lacking B horizons, Goddard and Sabata 1982) in comparison to upland soil profiles.

Concealed deposits
In most areas of the quadrangle, pre-Illinois episode deposits (classified as the Banner Formation) are preserved below the Glasford Formation and above the Grover Gravel or bedrock (see cross sections). The Banner Formation is divisible into three units (two informal and one formal): a greenish-gray, weakly laminated silty clay with some beds of fine sand (Canteen member; lower unit); a silty clay loam diamicton with sand and gravel bodies (Omphghent member; predominant unit); and a greenish-gray to dark gray, silty clay to silty clay loam with soil development features (Lierle Clay Member; upper unit). These members of the Banner Formation (described below from youngest to oldest) are thickest over a preglacial bedrock valley in the northwest portion of the quadrangle (fig. 2; western part of cross section A–A′) that is now infilled. The Banner Formation is not known to occur within 5 feet of the surface on this quadrangle and so is shown only in cross section. Much of the following information, regarding characteristics of the Banner Formation, is based on continuous core samples from a stratigraphic test hole to bedrock in Section 13, T6N, R6W (county # 28515).

In some areas, a greenish gray to dark gray, silty clay to silty clay loam, known as the Lierle Clay Member of the Banner Formation (Willman and Frye 1970) overlies the Omphghent member. The Lierle Clay Member, containing abundant evidence of cumulic soil formation, iron reduction and weathering, is primarily interpreted as depressional deposits that accumulated in wetlands, small ponds, or lowlands. Alteration features, attributed to formation of the Yarmouth Geosol (a buried interglacial soil), include enhanced soil structure, root pores, clay accumulation, and carbonate leaching. Yarmouth Geosol development in the Lierle Clay Member, as well as in the upper Omphghent member, help to delineate the Banner Formation from the Glasford Formation. In some areas, such as in Omphghent township several miles to the west (McKay 1979), a truncated Yarmouth paleosol occurs at the Glasford-Banner contact. Even when the Yarmouth Geosol is partially eroded, deep oxidation and fractures extending into the upper Omphghent member is typically preserved. Such evidence as well as diagnostic physical properties and compositional data (table 1) can aid with correlations of Banner Formation to sites that contain the Yarmouth Geosol.

The Omphghent member, the predominant unit in the Banner Formation, is interpreted mainly as till, ice marginal sediment, and outwash. In comparison to Glasford till, Omphghent till is generally more clayey, less sandy, and not as stiff. Omphghent till also typically has less illite (in clay mineral fraction), less carbonate, a higher moisture content, and slightly higher natural gamma radiation (table 1). In lower, unweathered portions, the Omphghent till contains abundant shale fragments, occasional fossil spruce wood fragments and can have a greenish gray color, similar to the local shale bedrock. Such characteristics likely reflect significant incorporation of shale and clayey bedrock residuum into pre-Illinois episode glacial ice, perhaps the earliest ice advance of the Quaternary Period to cross this area. Included within the Omphghent member of the Banner Formation are lenses of sand and gravel that are typically less than 10 feet thick. The upper, but still relatively unweathered, portion of Omphghent till can sometimes contain more illite, calcite, sand and have higher magnetic susceptibility than the remainder of the unit, perhaps a result of less influence from local shale and residuum. In eastern areas where the Omphghent till locally incorporated carbonate bedrock rather than shale, the entire unit may be somewhat more calcareous and less argillaceous.

The Canteen member of the Banner Formation occurs below the Omphghent member in the deepest portions of the ancestral Silver Creek valley (fig. 2, cross sections), generally below 460 feet. This preglacial bedrock valley loosely follows and is immediately west of present-day Silver Creek valley in the New Douglas Quadrangle. Similar deposits are found in the same bedrock valley immediately to the west, but at slightly lower elevations (Grimley 2004). The Canteen member is mainly fine-grained sediment, but can include sandy zones, particularly just above the bedrock. The uppermost 5 feet of the Canteen member sometimes exhibits a greater degree of soil structure, representing a buried floodplain soil. The Canteen member is interpreted as preglacial Quaternary alluvium and lake sediment because it lacks glacial erratics and is noncalcareous. Some of this unit might represent slackwater lake deposits related to early Quaternary glaciations in the upper Mississippi drainage basin.

In places below the Canteen Member, an indurated conglomerate-breccia occurs that ranges from a thin lag of a few pebbles to up to 10 feet thick. The composition of these pebbles is mainly chemically resistant fragments of rounded to angular chert (yellow brown to brown), quartz, quartzite, ironstone and perhaps jasper, but sometimes includes angular local shale fragments. This unit is correlated to the Grover Gravel (Rubey 1952, Willman and Frye 1970). Physical characteristics, imbrication, and primary occurrence in bedrock valleys suggests an alluvial/colluvial origin. As a result of containing iron-rich stones and cement as well as perhaps Lake Superior province pebbles, the natural gamma radiation and magnetic susceptibility are generally much higher in the Grover Gravel than in the overlying Canteen Member or underlying bedrock (typically shale). The age of this unit is in question but is thought to be late Tertiary or early Quaternary, similar to the Mounds Gravel in southern Illinois (Willman and Frye 1970). The unit contains many resistant chert clasts from Paleozoic bedrock but also may have some clasts reworked from upland Cretaceous deposits such as the Hadley Gravel in western Illinois or the Windrow Formation in the upper Mississippi Valley (Andrews 1958).

Uppermost bedrock consists predominantly of Pennsylvanian shale, siltstone, limestone, and sandstone. The predominant bedrock lithology below Quaternary deposits is shale and limestone, with beds of coal at depth in some areas. About 15% of the quadrangle's area has been undermined for coal (Chenoweth and Borino 2002), but no active coal mines exist today.

Economic Resources

Sand and gravel
Currently, sand and gravel in the New Douglas Quadrangle is not being mined. Any usable sand and gravel reserves would likely be minor and limited to portions of areas mapped as Hagarstown Member of Pearl Formation (below 5 to 10 feet of loess deposits). However, most sand and gravel in this unit is poorly sorted, intermixed with diamicton, limited in thickness, and unpredictable in its dimensions.

Groundwater
Groundwater is extensively used for household, public, and industrial water supplies. Sand and gravel lenses in the Glasford and Pearl Formations, including the Hagarstown Member, comprise the most significant Quaternary aquifers in the quadrangle (see stippled areas of cross sections). Due to their limited thickness and extent, these aquifers are typically only suitable for relatively low yield water wells. In many upland areas, sand and gravel bodies within the upper Glasford Formation are utilized for low yield household water supply in large diameter bored wells. The dense, lower portion of Glasford till is often drilled into for use as a natural storage area for well water. Sand and gravel lenses in the Banner Formation are relatively uncommon. Since the Grover Gravel has a significant filling of secondary iron cementation and is limited in thickness, this unit is unsuitable as a significant aquifer.

Environmental Hazards

Groundwater contamination
Surface contaminants pose a potential threat to groundwater supplies in near-surface aquifers that are not overlain by a confining (clay-rich, unfractured) unit. Shallow sand and gravel aquifers exposed at the surface are most vulnerable to agricultural or industrial contaminants. Confining units, such as clay-rich till or lake deposits, can serve to protect aquifers (Berg 2001). The potential for groundwater contamination depends on the thickness and character of fine-grained alluvium, loess, or till deposits that cover the aquifer. Groundwater from deeper aquifers near the base of the Glasford Formation or within the Banner Formation would generally have a lower contamination potential than more shallow aquifers because of protection by the entire thickness of the very stiff and dense Glasford till. Field studies of hydraulic conductivity at a nearby waste disposal site at Wilsonville, Illinois (Herzog and Morse 1990) have shown that the lower portion of Glasford Formation (more dense, uniform, and unfractured) can be much less permeable than the upper portion (more fractured and with more sand lenses). The buried Pearl Formation aquifer in Silver Creek valley is only somewhat protected by the relatively thin but mainly fine-grained Cahokia Formation.

Subsidence
Approximately 15% of the quadrangle's area was mined underground for coal between 1891 and 1964 (Chenoweth and Borino 2002). Mined-out areas are predominantly in the northwestern portion of the quadrangle. Coal, 3 to 8 feet thick, was mined from the Herrin (No. 6) Coal Member of the Carbondale Formation and was extracted by the room and pillar method at depths of about 287 to 325 feet below ground surface. Land subsidence in mined-out areas can be a serious potential problem for developers and construction projects (Treworgy and Hindman 1991).

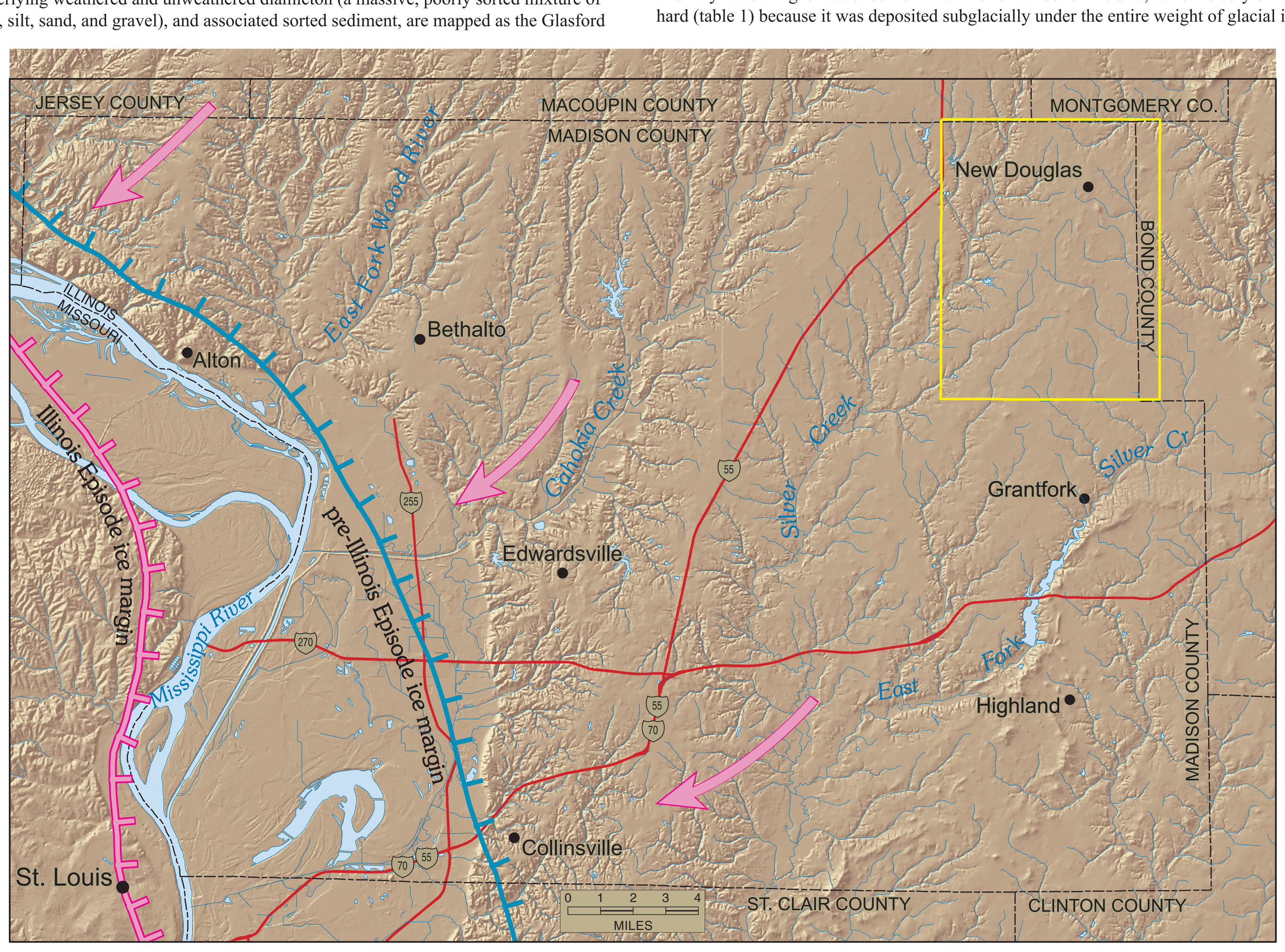

Figure 1 Shaded relief map of the St. Louis Metro East area (northern portion). The New Douglas Quadrangle is outlined in yellow. The quadrangle lies within the ice margins of both the Illinois and pre-Illinois episode glaciations. Arrows indicate the direction of ice flow for the Illinois Episode glaciation.

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

	Geotechnical Properties[1]			Particle Size Data[2]				Geophysical Data[3]	
	w (%)	Q_u (tons/ft^2)	N	Sand (%)	Silt (%)	Clay (%)	Clay Mineralogy	Natural Gamma	MS
Cahokia Fm.	17–31	0.1–1.5	1–10		variable texture		ND[4]	variable	ND
Peoria and Roxana Silts	20–32	1.1– 2.1	5–10	2–15	55–83	17–35	mod. - high expandables	mod.	15–55
Pearl Fm.	14–24	ND[4]	3–86		generally > 50 % sand; some gravel		ND	low	ND
Glasford Fm.[5]	8–19	2.0–8.3	10–45	45–55	22–32	18–28	65–75% illite	mod.-high	10–35
Lierle Clay M.	19–29	2.0–3.5	ND	20–30	25–35	35–45	mod. - high expandables	high	10–20
Omphghent m.[5]	14–21	1.5–5.7	11–30	25–35	30–35	30–40	44–54% illite	high	20–40
Canteen m.	18–21	1.5–4.5	ND	10–40	40–50	17–42	26–36% illite (high kaolinite)	mod. to high	8–15
Grover Gravel	ND	ND	ND	ND	ND	ND	ND	high	35–100
Shale bedrock	8–17	3.5 to > 4.5	50–100	ND	ND	ND	ND	very high	2–5

[1]Geotechnical Properties: based on hundreds of measurements (total for all units) from ~ 25 engineering (bridge) borings and 1 stratigraphic boring 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)

[2]Particle Size and Mineralogy: based on a more limited dataset (~ 20 samples) from 1 stratigraphic boring and 2 outcrops in the NW portion of the quadrangle
sand = % > 63 μm; silt = % 4–63 μm; clay = % < 4 μm (proportions in the < 2 mm fraction)
Clay mineralogy = proportions of expandables, illite, and kaolinite/chlorite (in < 4 μm clay mineral fraction); these calculations using Scintag diffractometer calculations indicate about ¼ more than previous results by H.D. Glass with General Electric X-ray diffractometer

[3]Geophysical Data:
Natural gamma = relative intensity of natural gamma radiation (data from one stratigraphic boring and 55 coal borings)
MS = magnetic susceptibility (x 10^{-5} SI units) (data from one stratigraphic boring)

[4]ND = no data available

[5]Properties for Glasford Fm. and Omphghent m. are mainly for calcareous till (excludes sand and gravel lenses and strongly weathered zones); weathered upper portions can be less stiff, more clayey, and have higher water contents.

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