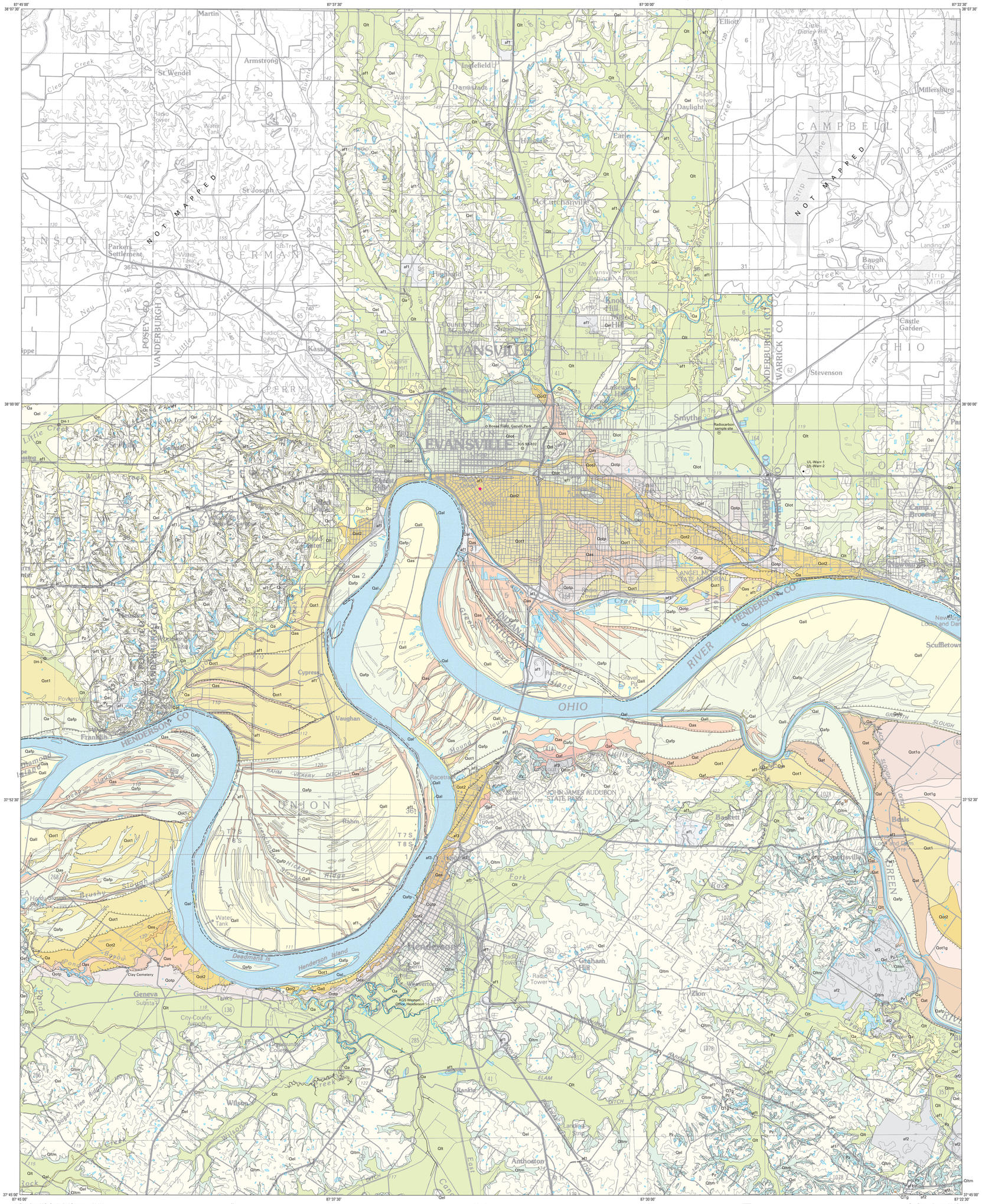
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
INDIANA, KENTUCKY, AND ILLINOIS STATE GEOLOGICAL SURVEYS

SCIENTIFIC INVESTIGATIONS MAP 3069
Pamphlet accompanies map



Base from U.S. Geological Survey, 1:100,000
Evansville, Ind.-Ky., 1991, Princeton, Ind.-Ill., 1986
Projection and 10,000-meter grid, zone 16
Universal Transverse Mercator
1927 North American Datum

APPROXIMATE MEAN DECLINATION, 1991

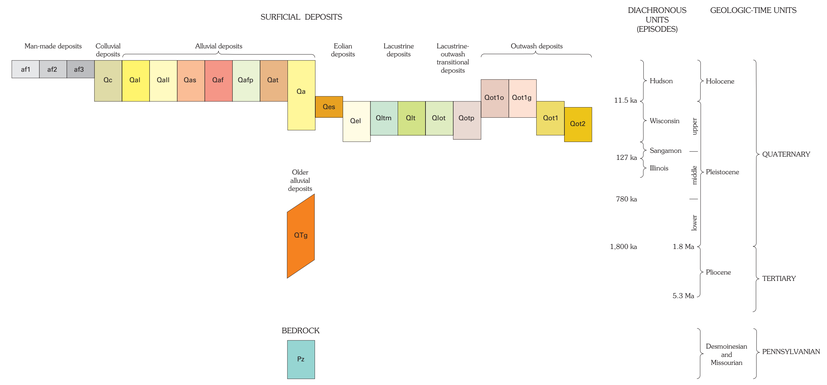
SCALE 1:50 000

CONTOUR INTERVAL 10 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

MAP LOCATION

See figure 1 in pamphlet for sources of geologic mapping

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

[Note: Munsell color designations of deposits appear in the format "brown (10YR 4/3)", for example]

SURFICIAL DEPOSITS

Man-made deposits

af1 — **Artificial fill, engineered (modern)**—Unconsolidated silt and fine sand, crushed stone, masonry, and paving materials used as fill for construction of roads, railroads, buildings, floodwalls, landfills, and other engineered structures. Thickness 0.3–23 ft

af2 — **Artificial fill, mine spoil (modern)**—Disturbed bedrock and regolith produced by strip-mining operations in Kentucky

af3 — **Artificial fill, other (modern)**—Chaotic, unconsolidated material; includes material dredged from creeks to form artificial levees in Kentucky

Colluvial deposits

Qc — **Colluvium (Holocene)**—Relatively thin regolith that mantles steeper hillslopes in bedrock uplands; moderate-yellowish-brown (10YR 5/4) silt, sand, clay, granules, and angular pebble-size fragments of shale, siltstone, and sandstone, and nodules of soil calcium carbonate moved downslope by creep; unsorted; includes slopewashed and gravity-moved loess. Virtually all hillslopes are mantled by some colluvium; practically, only areas of thickest colluvium were mapped, as judged by individual mappers. The nonuniform distribution of the map unit reflects more the differing judgments of the individual mappers than actual quantities of colluvium. Thickness of mapped colluvium 3–9 ft

Alluvial deposits

Qal — **Alluvium, modern (Holocene)**—Silty clay and sandy silt with minor sand and sparse gravel deposited by Ohio River on river banks during and after modern floods and bankfull river stages; during normal river stage, sediment is exposed on river banks; deposits inset into adjacent units. Thickness 10–15 ft

Qall — **Alluvium, natural levee deposits (Holocene)**—Brown (10YR 4/3) and grayish-brown (2.5Y 5/2) sand and silty sand in natural levee ridges along banks of Ohio River. Aerial photograph of surface deposits shows closely spaced lineaments at approximate right angles to river bank; these mark sandy crevasse-splay deposits, scouring flow paths, and overwash deposits formed during recent floods; unit grades into adjacent floodplain deposits (**Qafp**) with no discernible break; unit is sandier than adjacent floodplain deposits. Overlies alluvium (**Qal**) and late Pleistocene outwash (**Qot1**). Thickness 6–10 ft at scarp; thins away from river axis

Qas — **Alluvium, active modern floodplain sloughs (Holocene)**—Organic-rich, brown (10YR 4/3), grayish-brown (2.5Y 5/2), and dark-gray (5Y 4/1) clayey silt, silty clay, and clay loam (McWilliams, 1979); includes thick laminae of micaceous, fine sand; uppermost few feet locally colored by common, large, dark-yellowish-brown (10YR 4/4) mottles, indicating frequent fluctuation in level of water table. Unit is in sloughs on floodplain (**Qafp**), on low outwash terrace (**Qot1**), and in a few prominent swales cut into the surfaces of units **Qot2** and **Qlot** in Evansville, Ind. The swales in unit **Qlot** are relict distributary channels of a late Pleistocene delta that prograded into a marginal slackwater lake. These swales contain slough deposits of Holocene age. Estimated thickness 3–10 ft

Qaf — **Alluvium, alluvial fans (Holocene)**—Silt, sand, and gravel; forms fan-shaped, alluvial-colluvial deposits at mouths of small tributary valleys that drain hilly uplands immediately north and west of John James Audubon State Park, Ky., central part of map area; deposited by floods and debris flows. Estimated thickness 3–25 ft

Qafp — **Alluvium, river floodplains (Holocene)**—Yellowish-brown (10YR 5/6) clay, silt, and fine lithic quartz sand, grading downward to dark-grayish-brown (2.5YR 4/2) and olive-gray (5Y 4/2) medium to coarse sand, granules, gravelly sand, and sandy gravel; grain size varies abruptly from place to place. Composition of gravel includes chert, quartzite, sandstone, limestone, coal, and granitoid rocks as seen in man-made pits (numerous small water bodies south of Interstate 164 on map). Upper 6 ft is finer grained, consisting of clayey silt, silty clay, and sandy silt. Surface of unit, formed by repeated flooding, is the lowest, wide, nearly level surface above the Ohio and Green Rivers. Deposit overlies older alluvium (**Qat**), outwash (**Qot1**), or bedrock (**Pz**); contact (line drawn on map to separate units) is apparent in the field, and was drawn at scarp of the next higher terrace. Age of unit may range from modern to as old as 6,500 years. Base of unit is not exposed and is indeterminable in drill holes. Estimated to be 10–15 ft thick or less

Qat — **Alluvium, low terrace (Holocene)**—Silt, sand, and clay deposited by rivers; near Spottsville, Ky. (southeast quadrant of map area), unit forms terrace slightly higher than the adjoining floodplain of the Green River (**Qafp**) and lower than the Ohio River low outwash terrace (**Qot1**) and the lacustrine terrace (**Qlt**); contact with adjacent units varies from sharp to poorly defined and is locally inferred on the basis of topographic expression. Approximately 30 ft thick

Qa — **Creek alluvium and sheetwash alluvium (Holocene and upper Pleistocene)**—Underlies creek floodplains; upper few feet is Holocene in age and is moderate-yellowish-brown (10YR 5/4) and light-yellowish-brown (10YR 6/4) silt and slightly clayey silt, silty very fine quartz sand, and sandy silt; thick bedded to planar laminated. Mostly silty sheetwash alluvium eroded from loess-covered hills. On toe slopes, near bases of hills, unit grades laterally to sandy silt colluvial aprons containing pieces of shale and sandstone. We speculate that most of unit is Holocene (<11,000 years old), but in places unit may be late Pleistocene where it overlies interbedded fine-grained (silt, clay) lake sediment and creek alluvium of late Pleistocene age (approximately 20,000–11,000 years old). Horizontally, the interface with adjacent units varies from sharp to poorly defined; contact on map was drawn where creek floodplain meets the creek-facing escarpment of lacustrine terrace or the bases of bedrock hills. Some streams have been rerouted for land-use purposes; locally, some sediment from these streams has been mechanically redistributed across adjacent fields and is unmappable. Estimated thickness 6–26 ft

Eolian deposits

Qes — **Dune sand (lower Holocene and upper Pleistocene)**—Very fine to fine lithic quartz sand deposited by wind; small-scale cross bedding; mapped mostly near south bank of Ohio River; locally contains lenses of clayey silt. Base not observed; locally mantled by unmapped loess as thick as 15 ft. Thickness unknown

Qel — **Loess, undifferentiated (upper Pleistocene)**—Silt, clayey silt, and minor fine sand. Brownish-yellow (10YR 6/6), pale-brown (10YR 6/3), yellowish-brown (10YR 5/8), and strong-brown (7.5YR 5/6) quartz and feldspar silt (4–64 micrometers in diameter) and clayey silt; pink (7.5YR 8/6) on fresh surfaces; massive; lacks bedding; loess forms a blanket deposit that covers all hills and uplands north and south of Ohio River in map area; not mapped where thin (3–5 ft), including on lacustrine terraces (**Qlt**) and outwash terraces (**Qot1**, **Qot2**); bulk of this deposit (the Peoria Silt in formal rock-stratigraphic nomenclature) is probably about 22,500–12,000 years old in map area (table 1; Counts and others, 2005; Don McKay, Illinois State Geological Survey, written commun., 2006); two older parts of this unit (Roxana and Loveland Silt) are locally buried by the main body (table 1). For more information about unit in the western Evansville area see Moore and others (2007). Ray (1965, p. 63–68) gave mineralogy and grain-size analyses of loess in the Owensboro, Ky. area, which is probably similar to loess in the Evansville area. Thickness 30–50 ft in Kentucky, 12–25 ft in Indiana; most thicknesses were measured near Ohio River; unit thins gradually away from river

Lacustrine (lake) deposits

Qltm — **Upland marginal lacustrine deposits (upper Pleistocene)**—Clayey silt, silt, and fine sand; a gradational unit between lacustrine terrace deposits (**Qlt**) and loess (**Qel**). Unit includes loess, loess-derived slopewash alluvium, colluvium, lacustrine silt and clay, and lacustrine shoreline deposits; contacts drawn between the flat lake plains and surrounding loess-mantled hills. Mapped only in Kentucky. Thickness estimated from 12 ft to less than 2 ft under toe slopes of adjacent hills

Qlt — **Slackwater deposits, lacustrine terrace (upper Pleistocene)**—Light-yellowish-brown (10YR 5/4), light-gray (10YR 7/1), gray (10YR 5/1), yellow (10YR 8/8), and very pale brown (10YR 7/3) clayey silt, silty clay, and clay deposited in lakes and marshes in tributary stream valleys; generally, thin bed(s) of rounded chert and quartz pebbles at basal contact on bedrock. On land surface, unit forms broad flats and low terraces flanking lower reaches of modern creek floodplains; on map, contact of unit with adjoining fluvial units may be gradational or sharp, and is drawn on escarpments that separate terraces; contacts with eolian and upland units (**Qel**, **Qltm**) are gradational and approximate, and placed at toe slopes of adjoining hills. Poorly exposed **Qlt** unit was sampled by drilling; drilling revealed laminae and thin beds of silt, silty very fine sand, massive organic-rich clay layers, vivianite, woody material, root traces, pakosols, plant debris, snail and bivalve fragments, and bioturbation (fig. 10); unit is relatively impermeable; some layers strongly calcareous. Slackwater lakes formed in creeks behind dams made of rapidly aggrading sand in trunk channels of the Ohio River glacial sluiceway. In northeastern Evansville and Pigeon Creek areas, unit is complexly interfingered with sand, silt, and clay, indicating that natural levees of the sluiceway repeatedly encroached into slackwater environments.

Fossil wood, algae stems, beetle elytra (wing coverings), and aquatic-obligate (water-loving) snails collected from auger hole DH-1 (see map, northwest corner of West Franklin quadrangle) gave ages of about 16,950–11,120 radiocarbon years B.P. (Moore and others, 2007). The ostracode *Cyclocypris ovum* (Rick Forester, USGS, written commun., 2006), collected from an auger hole, indicates shallow water and aquatic vegetation in settings that include littoral zones of fresh-water lakes, sluggish streams, oxbow ponds, wetlands, and springs. An age of 20,880±80 radiocarbon years B.P. (SGS radiocarbon laboratory no. A0629) was obtained on wood collected from a trench, 14 ft deep, east of Evansville (see location on map, UTM coordinates lat 37.99105°N., long 87.47139°W., WGS84 datum, Ron Counts, KGS, written commun., 2008). An age of 33,100±590 radiocarbon years B.P. (SGS radiocarbon laboratory no. 3313) was obtained on wood from Indiana Geological Survey auger hole 93-102 (Woodfield, 1998, p. 52), 52 ft deep in deltaic-lacustrine sediments near Pigeon Creek (see symbol in north-central part of map area). This date falls in the Athens Subepisode of the Wisconsin Episode (Johnson and others, 1997); thus, the estimated age of the unit mapped in Evansville area is 34,000–11,000 radiocarbon years B.P. Similarly, sediment of slackwater lakes accumulated before and during this time in the Mississippi River valley near East St. Louis, Ill., from about 44,000 to 17,000 radiocarbon years B.P. (Curry and Grimley, 2006).

Thickness of unit in map area varies in drill holes and cone penetrometer soundings; maximum thickness known is 92 ft, drilled near Little Pigeon Creek (Woodfield, 1998, p. 16). Thickness of unit is about 30 ft in Wolf Creek valley and about 37 ft in DH-1 in Little Creek valley (both valleys in northwest corner of map area). Unit is 61 ft thick under Carpenter Creek and 72 ft thick under an unnamed tributary to Bayou Creek near Mud Center, Ind. Generally, unit thickens downstream in tributary valleys

Lacustrine-outwash transitional deposits

Qlot — **Lacustrine and outwash terrace deposits (upper Pleistocene)**—Moderate-yellowish-brown (10YR 5/4) silt, clayey silt, and interlayered silty clay, and sparse fine sand. Sand beds increase in thickness (but generally are <2ft in. thick), grain size, and number toward the axis of the Ohio River valley. Away from the axis, unit is predominantly gray (10YR 5/1), massive to very thin bedded silt, slightly clayey, and sandy silt (silt loam in soil texture; nomenclature figs. 10, 11), locally interbedded with laminae of very silty clay. This poorly exposed deposit was sampled by drilling; unit is relatively impermeable, is capped by loess, and may include thin layers of loess. Includes some paleolevee deposits that make high landforms (about 6 ft above surrounding land) at margin of main body of unit; also includes outliers that were islands formed by development of slightly inset outwash terrace alluvium (**Qot2**). Unit is a facies transition between high-energy outwash and low-energy lake depositional environments. Unit underlies an east-west belt where glacial sluiceway floods repeatedly flowed away from channels, splaying out from breaks in natural levees into adjacent shallow slackwater lake basins. Upper part of deposit is locally inset by Holocene creek alluvium and, in places, deposit interfingers with loess. Unit may be as thick as 72 ft

Qotp — **Paleolevee deposits on outwash terrace (upper Pleistocene)**—Brown (10YR 4/3) and grayish-brown (2.5Y 5/2) sand and silty fine sand in paleolevee ridges and overwash deposits on high parts of outwash terrace. Typically adjoins upper limit of a terrace-bounding scarp. Paleolevee and associated fluvial scarp were formed by channels of the ancestral Ohio River glacial sluiceway that cut the fluvial surface inset to a given scarp and paleolevee. Generally 10–20 ft thick at scarp margin; thins away from river axis

Outwash deposits

Qot1o — **Alluvium, reworked outwash, Ohio River scrollwork terrace (Holocene and upper Pleistocene)**—Fine to coarse sand and rounded gravel clasts, with local lenses of silt and clay; pebble and cobble composition is chert, quartzite, sandstone, siltstone, igneous and metamorphic rocks, limestone, and coal; lithologically similar to adjacent outwash terraces; surface of outwash terrace is mantled by alluvial silty sand and sandy silt sculpted into a scrollwork topography. This unit was originally outwash (**Qot1**, **Qot2**) deposited by the aggrading, braided glacial Ohio River sluiceway. Later, channels of the postglacial, meandering Ohio River eroded and redeposited (reworked) outwash to a depth of about 30 ft, thereby sculpting scrollwork (see "Glossary") patterns now evident on satellite imagery. Unit exposed only at east-central edge of map area. Thickness 30–45 ft

Qot1g — **Alluvium, reworked outwash, Green River scrollwork terrace (Holocene and upper Pleistocene)**—Fine to coarse sand and gravel, with local lenses of silt and clay; gravel includes chert, quartzite, sandstone, siltstone, limestone, and coal; similar in composition to adjacent outwash terraces. This unit was originally outwash (**Qot1**, **Qot2**) deposited by the aggrading, braided Ohio River glacial sluiceways. Subsequently, that outwash was reworked by the Green River. Surface of unit is mantled by silty sand and sandy silt that was shaped into scrollwork topography by point-bar building currents of the meandering Green River; unit overlies older outwash deposits (**Qot1**, **Qot2**). Thickness 30–45 ft

Qot1 — **Alluvium, outwash, low terrace (upper Pleistocene)**—Dark-brown (10YR 3/3) and dark-yellowish-brown (10YR 4/4), fine- to coarse-grained quartz and subordinate lithic sand, and gravel, with local lenses of silt and clay; gravel includes rounded pebbles and cobbles of chert, quartzite, sandstone, siltstone, igneous and metamorphic rocks, limestone, dolostone, and coal; lithologically similar to high outwash terrace (**Qot2**). Unit exposed in pits in Evansville South quadrangle (SE1/4SW1/4 sec. 3, T. 7 S., R. 10 W.) is mostly sand and lesser amounts of pebbles and cobbles. Surface is mantled with silty sand and sandy silt, which may include loess; unit forms a well-developed, low-relief terrace 370–378 ft above sea level. Unit was deposited as glacial outwash and overlies and cuts into older outwash deposits (**Qot2**). Layers 1–6 ft thick of olive-gray (5Y 4/2), light-blue (5B 7/6), and very dark gray (10YR 3/1) plastic and sticky clay ("blue clay" or "blue mud" as described by water-well drillers) were penetrated in auger hole DH-3 in West Franklin quadrangle (west edge of map area; Moore and others, 2007). These clay layers are interpreted to be plugs of an oxbow lake deposit and (or) slackwater-lake clay that interfinger with sandy outwash. At site DH-3, the upper 10 ft of sediment is slackwater lake deposits; below, hole penetrates mostly outwash of unit **Qot1**. Contact on map is sharp; drawn at scarp of next higher terrace or upland. Unit floods occasionally. About 30–45 ft thick

Qot2 — **Alluvium, outwash, high terrace (upper Pleistocene)**—Fine- to coarse-grained quartz and lithic sand, and gravel, with local lenses and beds of silt and clay; gravel includes chert, quartzite, sandstone, siltstone, granitoid rocks, other igneous and metamorphic rocks, limestone, and coal; the granitoid and other igneous and metamorphic rocks have a Canadian Shield provenance. Surface of unit mantled by eolian and alluvial silty sand and sandy silt and forms the highest terraces in Ohio River valley; most of surface is above the historic flood zone although low parts of surface were flooded in 1937 (fig. 4); deposits are the highest known valley fill made of valley train; main body of unit, below 10–15 ft depth, is believed deposited in braided channels by glacial meltwater. Includes some interbeds, 1–6 ft thick, of olive-gray (5Y 4/2), dark-gray (10YR 3/1), and light-blue (5B 7/6), very plastic and sticky clay ("blue clay" or "blue mud" as described by water-well drillers). Overlies bedrock (**Pz**) or older alluvial deposits (not mapped); sharp contact drawn at scarp of adjoining terrace or upland. Age interpreted to be Wisconsin Episode. As much as 170 ft thick

Older alluvial deposits

QTg — **Upland gravel (Pliocene-Pleistocene)**—Gravel and medium to coarse sand, rounded pebbles include quartz, brown patinated chert, and silicified fossils; locally cemented by iron oxide; unit is buried by loess and rarely exposed on uplands; small exposures are present west and north of Spottsville, Ky. (southeastern part of map area) and in southern part of Spottsville quadrangle. Unit is remnant of fluvial gravel-capped terraces, possibly correlative to the Luce Gravel of Ray (1965). Previous workers identified gravelly deposits in the Mississippi Valley region, similar in age and geomorphic position, variously named Lafayette Gravel, Mounds Gravel, Orange Sand, Lagrange Formation, Upland Gravel, Citronelle Formation, or the Upland Complex (Autin and others, 1991, p. 554). Base covered; thickness estimated less than 25 ft

BEDROCK

Pz — **Bedrock (Paleozoic, Pennsylvanian)**—Shale, sandstone, coal, limestone, and overlying, thin, poorly sorted regolith; includes areas of loess thinner than 3–5 ft. Very pale brown (10YR 7/4) and yellow (10YR 7/6) silty, micaceous shale. Pale-yellow (2.5Y 7/4) and light-gray (2.5Y 7/2), clayey, silty, fine- to medium-grained sandstone; hackly fractured, moderately fissile claystone. The Inglefield Sandstone Member of the Patoka Formation is exposed in an unnamed creek near tennis courts at University of Southern Indiana campus (approximately 5.2 mi west of downtown Evansville) (Clark and others, 2002; Inkenbrandt and others, 2005). The type locality of the West Franklin Limestone Member of the Shelburn Formation is conspicuously exposed in high cliffs at West Franklin, Ind. (west-central part of map area); the West Franklin Member underlies the Ditney Coal Member and Inglefield Sandstone Member of the Patoka Formation (Shaver and others, 1986)

Contact

Erosional scarp—Hachures at base of scarp

Clay Cemetery — **Wireline drill core site**—Showing Illinois State Geological Survey well name

DH-1 — **Auger hole**—Showing hole number

Radiocarbon sample site—Fossil wood sample from trench

UL-Warr-1 — **Rock quarry overburden exposure**—Showing OSL loess sample number

Location of figure 5

Giddings probe core samples of paleolevee deposits on outwash terrace (Qotp), Clay Cemetery, 1 mi northwest of Geneva, Ky.

Young wind-deposited silt or loess (4) overlies older wind-deposited silt (3) east of Evansville, Ind. (location on geologic map marked as rock quarry exposure). Regolith (2) overlies Pennsylvanian shale (1). Samples from unit 3 (UL-Warr-1) and unit 4 (UL-Warr-2) gave optical stimulated luminescence ages of >100 ± 15 ka and 18.3 ± 0.28 ka, respectively (see table 1, pamphlet). Unit 3 probably is the Loveland Silt with the Sangamon Geosol developed in it. Unit 4 is the Peoria Silt, which mantles hills in map area.

SURFICIAL GEOLOGIC MAP OF THE EVANSVILLE, INDIANA, AND HENDERSON, KENTUCKY, AREA

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