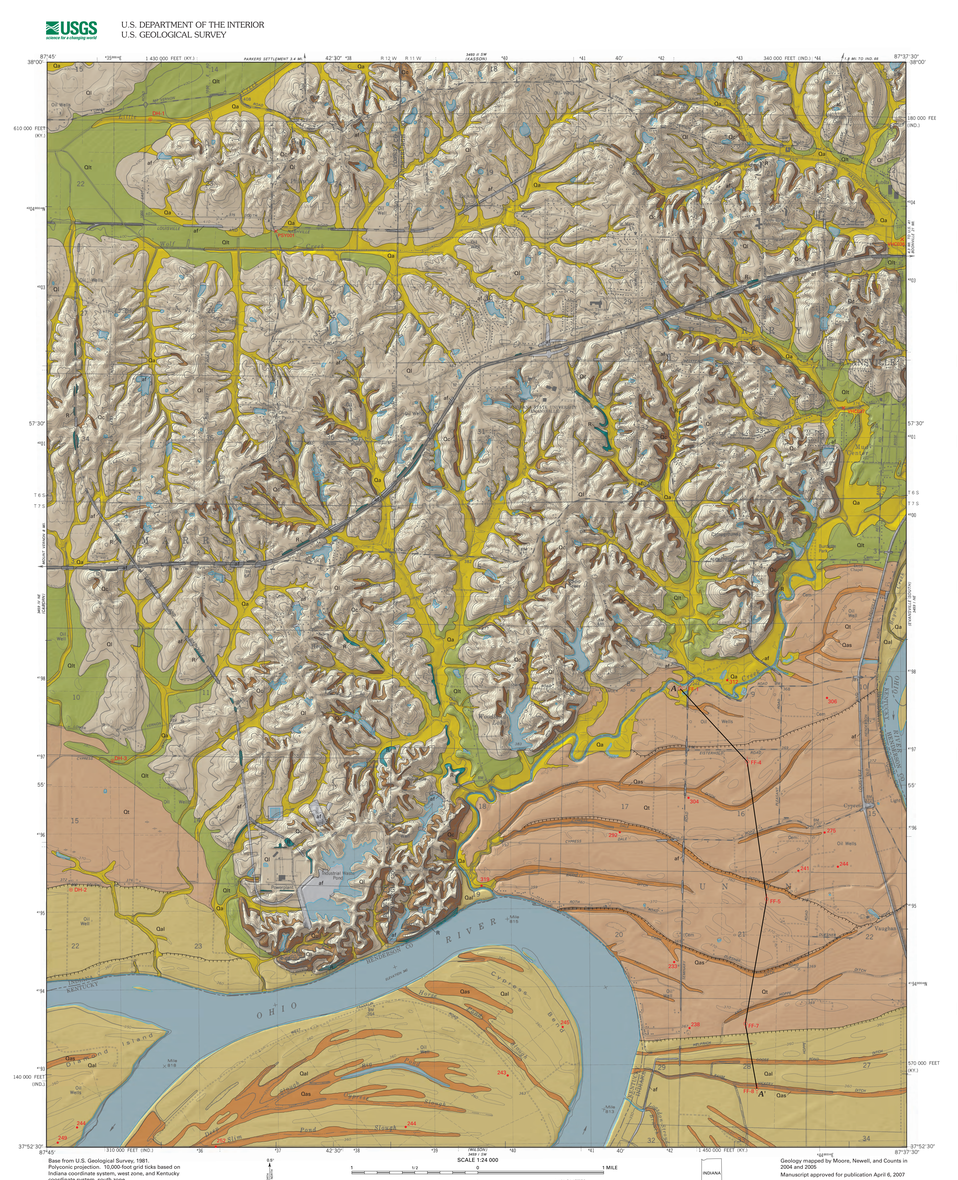
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

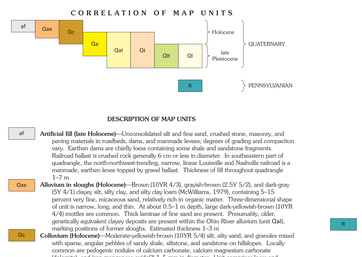
SCIENTIFIC INVESTIGATIONS MAP 2967
Version 1.0



Base from U.S. Geological Survey, 1981.
Polyconic projection. 10,000-foot grid ticks based on Indiana coordinate system, west zone, and Kentucky coordinate system, south zone
1,000-meter Universal Transverse Mercator grid, zone 16.
1927 North American Datum

Geology mapped by Moore, Newell, and Counts in 2004 and 2005
Manuscript approved for publication April 6, 2007

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

af — **Artificial fill (late Holocene)**—Unconsolidated silt and fine sand, crushed stone, masonry, and paving materials in roadbeds, dams, and manmade levees; degrees of grading and compaction vary. Earthen dams are chiefly loess containing some shale and sandstone fragments. Railroad ballast is crushed rock generally 6 cm or less in diameter. In southeastern part of quadrangle, the north-northwest-trending, narrow, linear Louisville and Nashville railroad is a manmade, earthen slope topped by gravel ballast. Thickness of fill throughout quadrangle 1–7 m.

Qas — **Alluvium in sloughs (Holocene)**—Brown (10YR 4/3), grayish-brown (2.5Y 5/2), and dark-gray (5Y 4/1) clay, silt, silty clay, and silty clay loam (McWilliams, 1979), containing 5–15 percent very fine, manganese sand, relatively high in organic matter. Three-dimensional shape of unit is narrow, long, and thin. At about 0.5–1 m depth, large dark-yellowish-brown (10YR 4/4) mottles are common. Thick laminae of fine sand are present. Presumably, older, buried alluvium of Wabash Valley deposits are present within the Qas alluvium (and older Qal).

Qa — **Creek alluvium and sheetwash alluvium (Holocene and late Pleistocene)**—Underlies creek floodplains. Upper several meters (Holocene) is moderate-yellowish-brown (10YR 5/4) and light-yellowish-brown (10YR 6/4) silt and slightly clayey silt, silty very fine sand, and sandy silt; massive and planar laminated. This part includes silty sheetwash alluvium eroded from nearby loess-covered hills. Near bedrock valley walls, unit grades laterally to silty colluvial aprons (toe slopes of hills) that contain small pieces of shale and sandstone. Locally, unit contains pebble-size bedrock debris transported by creeping down hillslopes. It is eroded locally, exposing meter-scale bedrock outcrops. Although colluvium is present on hillslopes throughout quadrangle, only the steepest (18–25 percent) slopes were mapped because these may be unstable during earthquakes or problematic as building sites. Locally present are as much as 1.5 m of stump and log debris and a hummocky surface. Elsewhere a low-angle hillslope surface, probably at the contact with the underlying bedrock. Thickness 0.5–1.5 m.

Qal — **River floodplain alluvium, levee alluvium, and outwash (Holocene and late Pleistocene)**—Ohio River valley fill, the most voluminous alluvial unit in map area. Unit underlies the river floodplain, of which it forms the bedrock. Almost yearly or once in 2–3 yr. Unit is chiefly lithic quartz sand; yellowish-brown (10YR 5/6) fine-grained sand, silt, and clay grading downward to dark-grayish-brown (2.5YR 4/2) and olive-gray (5Y 4/2) medium- to coarse-grained sand, granules, gravel, and sandy gravel. B and C horizons of a buried soil, developed on a pre-European-settlement land surface, were penetrated at 1.3–2.4 m depth in 9 auger hole DH–2. The buried soil is in brown (10YR 5/3) clayey silt having clay skins, prismatic peds, and yellowish-brown (10YR 5/6) medium mottles, underlain by clayey silt containing abundant $CaCO_3$ concretions 1–2 cm in diameter. Deposits of unit Qal locally include lenses of fine- and medium-grained sand, clay, silty clay, and sandy silty clay, which may have been deposited in meander-scroll swales on a late Pleistocene floodplain (equivalent to Holocene unit Qas). Unit Qal includes, in part, the "South quadrangle jackstraw" of Ray (1979). Elsewhere unit grades laterally to the east-by-east cross bedding in sets 10 cm to 1 m thick, and planar bedding 2–10 cm thick on exposed bedding surfaces at depth. Unit contains gravel lenses composed of chert, dolostone, sandstone, limestone, granitoid rock, dacite, quartzite, and quartz. About 5 percent of sand is coal and dark-gray carbonaceous shale. Thickness is uncertain because of no definite base within the entire fill of the Ohio River valley. Maximum known thickness is at least 35–39.6 m, in shape of buried paleochannel that crosses southeastern part of Franklin quadrangle (Harvey, 1956, p. 75 and plate 5).

Qt — **River terrace deposits (late Pleistocene)**—Dark-brown (10YR 3/3) and dark-yellowish-brown (10YR 4/4), fine- to coarse-grained quartz and subordinate lithic sand, includes lenses of granules and pebbles in lower part. Upper part of unit is silty sand to silt. Up to 9 m depth, is Holocene in age and is mainly fine sandy silt, silt, and clayey silt. This upper part includes some loess, alluvium deposited in swales, and sheetwash alluvium derived from nearby hillslopes. Flooding, probably rarely, below 5–9 m. Lower part of unit, probably was deposited in braided channels by turbid glacial meltwater during and in waning phase of floods. Layers 2–10 m thick are gray (5Y 6/1), 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 by auger (Appendix, DH–3 lithologic log, 25–30 ft and 45–55 ft in depth), and are clay plugs of an oxbow lake deposit and (or) older lacustrine clay that interfingers with adjacent sandy fluvial deposits. Two seconds of CDP data from a lacustrine clay plug in the northeast corner of the quadrangle, which are flat-bottomed valleys. They are headwater tributaries of the Wabash River, 25 km west. In headwater tributaries, surfaces of lake deposits converge with floodplains of creeks making a broad, undissected valley floor (Shaw, 1915). Lacustrine terrace deposits in southwestern part of quadrangle rim the northern, arcuate edge of Ohio River terrace alluvium. Unit is horizontally laminated to very thin bedded, relatively impermeable, and porous; drains to deeply buried hydrogeologic (not gravity influenced) water. Map unit corresponds to slackwater-lake deposits and lacustrine facies of the Atherton Formation (Wayne, 1963, p. 35). Mapped extent in West Franklin quadrangle is less than that depicted on previous maps (Gray and others, 1991). Unit may include small areas of Qlt. Unit probably interfingers with buried lenses and alluvium of the river, as suggested by thin interbeds of sand, silty sand, and sandy silt detected in penetrometer soundings (WK0106 and VH0337 (fig. 3). Similar vertical sequences of clay and silt interbedded with fine sandy levee deposits were sensed in penetrometer soundings under the lake plain east of Evansville (fig. 1) (accessed at URL http://earthquake.usgs.gov/regional/nca/cpt/data/?map=evansville). Upper beds of unit include thin non-glacigenic flood sediments (chiefly silt and clay) of Holocene age. Terraces are flooded locally during major floods, as shown in photographs of the 1937 flood (Willard Library archives). Unit supports high runoff and high water table, is unsatisfactory as septic tank field, and has poor load-bearing characteristics (Gray, 1973). Beds of clay and organic material, sensed by penetrometer soundings (fig. 3), probably formed in oxbow lakes, marshes, ponds, and (or) sloughs. Beds are 0.5 m to many meters thick and commonly surface. Unit is chiefly lamination to as much as 258 m/s in lower sandy ones. Thickness of unit in Wolf Creek valley is about 8.5 m and about 11.5 m in Little Creek valley (northeast part of map). In northeastern part of map area, unit is about 18.5 m thick under Carpenter Creek and 22 m thick under an unnamed tributary to Bopps Creek near Mud Center. Unit is thickest in downstream parts of valleys of tributary creeks to the Ohio River

Ql — **Loess, undifferentiated (late Pleistocene)**—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 microns in diameter) and clayey silt; pink (7.5YR 8/4) on some broken surfaces. Loess continuously covers bedrock hills. Unit is mainly Peoria Silt (Ray, 1963a, b), which, in few places, may overlie remnants of Roxana Silt (25–ka), the Farmdale Silt or Farmdale Loess of previous workers (Hansel and Johnson, 1996). Peoria Silt may overlie Sangamon Geosol formed in older silt or formed on bedrock (perhaps combined with Yarmouth Geosol?). Unit is cohesive; upper part is structureless to platy; massive (no discernible bedding) and stands in high vertical cuts. Vertical fractures are present locally, contains abundant small pores (0.1–0.2 mm in diameter); permeable and well drained. Locally present are blocky, medium soil peds and sparse to common black (N2) iron-manganese oxide nodules 1–10 mm in diameter in discontinuous zones 0.5–1 m thick. Oxidized and leached of calcium carbonate above about 3 m; below 3 m oxidized and unleached (slightly calcareous). Compact, firm, and plastic where moist and clayey. Average proportions of grain size classes of six loess samples from 0 to 9.1 m depth near Newbury, Ind., (Fehrenbacher and others, 1965b) are (in percent): sand 2.9, silt 78.2, clay 18.8. Clay is illite with lesser amounts of expandables (montmorillonite) and kaolinite. Pebbles are rare. Fossils are chiefly terrestrial snails. Loess rests on bedrock at base of unit. Under toe slopes of hills, loess grades laterally to creek alluvium and (or) to colluvium. Thickness of unit ranges from 0 to about 18 m; common thickness is 6–9 m.

At a measured section now obscured by vegetation, Rube and Olson (1978) and Olson and Rube (1979) described a loess section north of Bopps Creek in N1/2 sec. 7, T. 7 S., R. 11 W., about 150 m west of Pleasant Road as follows (top to bottom): Upper bench—sub-unit 4.6 ft (1.3 m) Peoria Silt 11.8 ft (3.6 m). Farmdale Silt 2.3 ft (0.7 m). late Sangamon Geosol >1.3 ft (>0.3 m). Lower bench—sub-unit 4.6 ft (1.3 m) Peoria Silt >20.3 ft (6.0 m). late Sangamon Geosol 6.5 ft (1.9 m) developed on Pennsylvanian shale.

We estimated from 5 to 6 m of loss in the Ohio River valley in 22–12 ka, slightly younger than a consensus age of 25–11 ka (Wang and others, 2000) based on radiocarbon dated samples from the Mississippi River Valley (Ben Miller, written commun., 2006). Counts and others (2005) dated Peoria Silt, 41 km (26 mi) east-southeast of West Franklin quadrangle near Bon Harbor Hill, Tennessee, luminescence ages of 21.7,650, 12,020, and 11,850 yr B.P. were obtained on samples near the base upward through a 14-m-thick section. The loess section overlies a water-laid sand bed that dated at about (22,000) years B.P., which covers Sangamon Geosol(?) on the underlying bedrock. Loess thickness in West Franklin quadrangle within about 5 km of Ohio River is as much as 7.5 m thick, thinning to <0.7 m more than 3 km north of the river (Fehrenbacher and others, 1965a, p. 568)

R — **Bedrock (Pennsylvanian)**—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; locally fractured, moderately friable claystone. A strong paleosol, probably Sangamon Geosol (compounded with Yarmouth Geosol?), is developed at bedrock surface in places. Sandstone is planar thick bedded, cross bedded, and moderately well cemented. Unit is overlain by loess, alluvium, and colluvium and is sparsely exposed in manmade cuts and stream banks. The Inglefield Sandstone Member of the Patoka Formation is exposed in banks of an unnamed creek near tennis courts at University of Southern Indiana campus (shown on map as Indiana State University slightly north of center of map) (Clark and others, 2002; Inkenbrandt and others, 2005). Well exposed in cliffs at village of West Franklin, Ind., type locality of the Shelburn Limestone Member of the Shelburn Formation, which underlies the Dittney Coal Member and overlies the Busseron Sandstone Member of the Patoka Formation (Shaver and others, 1986). Base of unit covered

Contact

Outcrop scarp—Hachures at base of scarp.

DH-1 Auger hole

FF-1 Test drill hole in unconsolidated deposits—Approximately located

VHC037 Cone penetrometer sounding

312 Well—Approximately located. Number is bedrock altitude in feet above mean sea level

SUBSURFACE DATA AND DEPOSITIONAL ENVIRONMENTS OF THE WATER-TRANSPORTED DEPOSITS

RIVER FLOODPLAIN ALLUVIUM, LEVEE ALLUVIUM, AND OUTWASH (UNIT Qal)

The deepest auger hole, DH–2, penetrated about one-half the entire thickness of river alluvium (see map and Appendix). A more complete characterization of this unit was obtained by Fraser and Fishbaugh (1986) in 14 test holes drilled on a north-south transect in the southeastern part of the West Franklin quadrangle and southeastern part of the Evansville, Ind., and Henderson, Ky., quadrangles in the reach of the transect where alluvium under the Ohio River terrace and floodplain (fig. 4). Fraser and Fishbaugh analyzed grain sizes of about 400 subsurface samples from the 14 holes. Their findings on the river alluvium as follows (p. 5):

"The basic sequence of the alluvial fill consists of mud [silt and clay] at the top passing downward through sandy mud and muddy sand into sand and gravel. Locally, both deposits form in bottomset beds and locally grained sand that in turn overlies interbedded pebbly coarse sand and granular medium-fine sand. The basal part of the sequence consists of highly consolidated mud and pebbly sand that fill in an irregular topography on bedrock.

The deepest alluvial fill that overlies the buried bedrock surface (fig. 4, unit 8) is highly consolidated mud, sand, and gravel, probably of late Sangamonian age. Radiocarbon ages on fossil wood in DH–1 indicate that the lower beds (table 1) accumulated during some of the period of loess deposition, entrained 22–12 ka from thermoluminescence age determinations (Ben Miller, written commun., 2006). Loess accumulation may have covered outcrops, eliminating a bedrock source of sand, granules, and gravel. Although we mapped lacustrine deposits in the valleys of Little Creek and Wolf Creek, we cannot rule out the possibility that the deposits there are, in large part, creek alluvium. The Little Creek bottomland possibly held intermittent shallow lakes owing to damming at the confluence of Big Creek (the trunk stream) with the Wabash River, 25 km west of this quadrangle. If that distance seems too great for back-water flooding of tributary creeks and into the Wabash River valley, it should be noted that in Illinois, beginning at about the same point on the WVO line, slackwater-lake deposits were mapped by previous workers 50 km upstream in the Little Wabash River.

SPECULATIONS ABOUT FLOODS AND SEDIMENTATION RATES
FOLLOWING AN EARTHQUAKE

During the 19th and 20th centuries, humans cleared the forests, drained marshes, channelized drainages, and built flood walls, levees, dams, and locks on the Ohio River. These actions changed the river regime as well as rates of sediment transport from uplands to bottomlands. Structure built on the river altered the normal-pool elevation of the river, possibly increasing the frequency of flooding.

The complex relations among manmade structures and river regime are beyond the scope of this report, and so our conclusions are speculative. Nevertheless, whether or not caused by river engineering, field evidence indicates that the upper 1 or 2 m of silty alluvium in the quadrangle were deposited in historic time. Evidence for recent surficial sediment deposition was seen in a ditch in an agricultural field (NW1/4NE1/4 sec. 23, T. 7 S., R.12 W., elevation 370 ft). There, about 1.5 m of silty alluvium bury A and B soil horizons of a buried soil. The deposit is mapped as river alluvium (unit Qal). Organic matter and fossil seeds penetrated in DH–1 and in DH–2 at 6 m depth, a fragment of a former, stabbed land surface recently buried by silty alluvium.

Flooding and sedimentation possibly were affected by construction of flood walls, levees, dams, locks, and rip-rap at Evansville and upstream. Successive USGS topographic maps of the West Franklin quadrangle, for example, show increases in the river-navigation channel between 1937 and 1957 and between 1957 to 1982 to 1981. This 11-fo me may increase frequency of flooding of the river and tributaries like Bayou Creek, depositing thicker silt and clay layers than in time before engineering.

Engineering structures on the river serve to aid navigation and minimize minor flooding. We do not know which structures, if any, were in place prior to the flood of 1937. That flood (Maxwell, 1938), a 100-yr or even a 500-yr flood, crested at 57.75 ft (Evansville flood gage) on January 31, 1937 (http://www.crh.noaa.gov). Other large floods in 1993 and 1997 followed lock and dam construction. The lower valley saw at least two major floods in the 20th century, even with the existing flood-control structures. Smaller, more frequent floods also have occurred. This was apparent as recently as January 2005, when floodwater inundated much of the river floodplain (set Qal), Bayou Creek floodplain (unit Qa), and low parts of the terrace (unit Qt) south of Bayou Creek. Since the late 1800's more than a dozen Ohio River floods, all lowlanding the 1937 flood) smaller than the 1993 flood, are recorded (Jackson and Vivian, 1997). During this period of record a significant flood occurred each decade on average. When the river floods, thin increments of sediment settle on floodplains of the river and tributary streams (Marshfield, 1938; Ray, 1974, p. 65). Photographs of the 1937 flood (Willard Library archives) show water standing at features identified in the Evansville area on the topographic map at 385 ft above sea level. One of us (Moore) observed water backed up about 2 km in Bayou Creek and its floodplain during a 2003 flood of the Ohio River for details see Vanderburgh County Westside Watershed Project, 2004).

Acceleration of erosion of hillslopes and sedimentation in creek valleys probably resulted from land clearing. Late 18th and early 19th century documents, including those compiled by surveyors of the General Land Survey Office, describe vast, dense hardwood forests on uplands and bottomland marshes in Indiana. Bramble and Miller (1966, p. 547) wrote:

"As seen by early French explorers, the great forests sprawling from the tip of Lake Michigan, far southward to the Ohio River, were a magnificent yet forbidding wilderness of giant hardwoods."

Before settlement, broad marshes or thick forests covered floodplains of the Wabash River and Ohio River (Fuller and Clapp, 1904, p. 10–11; Den Uyl, 1957; Lindsey, 1966; Franklin, 1994). Ridpayu (1872) identified numerous taxa in the dense, diverse vegetation in a Posey County bottomland bayou (pond). Subsequently, the marshes and wetlands were drained, streams were artificially channelized, and forests were almost entirely cleared. Did these changes accelerate erosion of the previously forested hills and alluviate low-lying areas? We assume so and believe that at least 1 m, perhaps 2 m in places, of silt were deposited on creek floodplains and high terraces of the Ohio River in the past 200 yr. The position of farm houses and barns on elevated berms and elevated railroad ways in the southern part of the quadrangle indicates the extent of areas that are frequently flooded. The buried soils in the drainage ditch and in DH–2 mark the position of a stable land surface before the onset of accelerated deposition.

The creek alluvium is estimated to be 5–7 m thick in the northwestern part of the map area and about 7–10 m in the eastern and northeastern part. If the uppermost 2 m was deposited in the 19th and 20th centuries, that is approximately 20 or 25 percent of the total creek alluvium estimated in the map area.

CREEK ALLUVIUM AND SHEETWASH ALLUVIUM (UNIT Qa)

This unit is mainly silt interbedded, interlaminated, and intermixed with scarce laminae and thin beds of very fine grained and fine-grained sand. The unit is poorly exposed and the base is covered. Auger holes penetrated light-olive-brown and light-yellowish-brown silt in the upper few meters before entering deeper, similar deposits, presumably of lacustrine origin. Bedding is thin to very thin, and is commonly laminated. Whereas the upper several meters of the alluvium is certainly Holocene in age, the contact with the buried pre-Holocene alluvium or lacustrine sediment cannot be located with certainty. Many workers consider the creek alluvium to be in erosional contact with lacustrine deposits (unit Qlt), especially in the lower reaches of the tributaries. This relation may be true in places, but from a conceptual-hydrologic viewpoint, the creek alluvium and lacustrine deposits were not readily distinguishable in the field. Both have similar grain size and bedding, and similar fossils could exist in both. Accordingly, both deposits form in bottomset beds and low-energy environments, excepting high-energy flood events. Previous workers mapped the deposits of Little Creek and Wolf Creek as slackwater-lake deposits (Wayne, 1958; Gray and others, 1991) and stream alluvium (Gray, 1969), illustrating ambivalence in interpretation. Peat, abundant wood, and scarcity of granules or pebbles at the base of the fill in Little Creek valley (lithologic log DH–1, Appendix) suggest a marsh, swamp, pond, or lake depositional environment. Radiocarbon ages on fossil wood in DH–1 indicate that the lower beds (table 1) accumulated during some of the period of loess deposition, entrained 22–12 ka from thermoluminescence age determinations (Ben Miller, written commun., 2006). Loess accumulation may have covered outcrops, eliminating a bedrock source of sand, granules, and gravel. Although we mapped the lacustrine deposits in the valleys of Little Creek and Wolf Creek, we cannot rule out the possibility that the deposits there are, in large part, creek alluvium. The Little Creek bottomland possibly held intermittent shallow lakes owing to damming at the confluence of Big Creek (the trunk stream) with the Wabash River, 25 km west of this quadrangle. If that distance seems too great for back-water flooding of tributary creeks and into the Wabash River valley, it should be noted that in Illinois, beginning at about the same point on the WVO line, slackwater-lake deposits were mapped by previous workers 50 km upstream in the Little Wabash River.

RIVER TERRACE ALLUVIUM (UNIT Qt)

A dramatic change in thickness exists near the southwest edge of the quadrangle and due north of DH–3. At the Koehnen Winery and Vineyard, a sinter well was drilled before our study and struck bedrock at 13 ft 4 in depth (Mr. Koehnen, oral commun., 2005). The well is not more than 60 m from the map and is located 100 m south of the Lower Mount Vernon Road. About 200 m south of this point, we augered DH–3, 57 ft (17 m) into alluvium under the Ohio River terrace and did not encounter bedrock. An older water well penetrated 115 ft (35 m) of alluvium (Geological Survey iLith database) 1.6 km south of DH–3 (on Botched Road). This abrupt thickening of alluvium south of Lower Mount Vernon Road and the east-west edge of the mapped unit indicates that the ancestral Ohio River deepened the buried bedrock surface along a northward-trending meander bend. Near the southwest edge of the map, shoe increases in the penetrometer resistance between the upland unit (Ql) and unit Qt and Qt reveals the old meander.

The terrace alluvium was deposited during the Wisconsin Episode (perhaps Athens Subepisode) braided-channel aggradational river phase. Subsequently, a meandering channel of the Holocene Ohio River has cut slightly below the Pleistocene valley floor. Also related to the Holocene river are the terrace escarpments at the terrace, eroding and redeposition the uppermost few meters of terrace alluvium. DH–3 penetrates the interfingering 1993 and 1997 Holocene flood deposits and the Pleistocene terrace deposits. Evidence for the thick clay layers sampled in the auger hole are slackwater lake or oxbow lake in origin. Maximum thickness of unit Qt is about 28 m (last hole FF–5, cross section **A**–**A**'), assuming the lower and upper fine meters of alluvium in the test hole were deposited before and after, respectively, the main body.

LACUSTRINE TERRACE DEPOSIT (UNIT Qlt)

Terrace landforms exist in all lower reaches of tributary valleys except those of Wolf and Little Creeks (northwestern part of quadrangle). The terraces are 3–6 m higher than the creek floodplains. Deposits under terraces appear to be lacustrine because they are horizontally laminated clay and silt. Also they are located adjacent to the Ohio River terrace and floodplain at an elevation that is fitting with the interpretation of former slackwater lakes. Estimated thicknesses of the unit (8.5–22 m) reflect depths where penetrometer soundings encountered resistant rock. Laterally, the presumed lacustrine deposit probably interfingers with river terrace alluvium (fig. 5, unit Qt), owing to damming and back-flooding of tributary creeks by aggradation of outwash in the sluiceway valley (Ohio River valley). Possibly, the lakes alternated with swamps, mudflats, or marshes through time. Shaw (1915, p. 147) characterized the deposits of extinct lakes in southern Illinois and western Kentucky as mainly clay, greenish gray to purple gray, and of medium plasticity to "gumbo" (highly plastic). He noted that certain deposits in southwestern Indiana differ from such plastic clay in that they are yellowish and soft when dry, whereas the lacustrine clay is greenish and hard when dry. Whether Shaw examined the lacustrine terrace deposits in the West Franklin quadrangle is not known.

Shaw (1915) and subsequent workers interpreted slackwater lacustrine deposits in Illinois and Kentucky to result from damming and ponding of tributary streams near their mouths by rapid build-up of valley train in the Ohio River valley late Pleistocene time. Ray (1965, p. 41–46) described in detail the process and resulting deposits near Owensboro, Ky. Slackwater-lake deposits in tributary creeks in the lower Ohio River valley are widely accepted and are suggested by the presence of bay-mouth bars or lakeshore-line features at the Tennessee River–Ohio River confluence (Finch and others, 1964, p. C130–C133) and 105 km east-northeast of Paducah, Ky. (Shaw, 1915, p. 147). Such features were not seen in the West Franklin quadrangle.

Nonetheless, a slackwater-lake origin for this unit in the West Franklin and Evansville South quadrangles is plausible, based on a radiocarbon age and sedimentary structures in the unit. An age of 33,100±350 radiocarbon yr B.P. (Woodfield, 1998, p. 52) on wood buried in lake sediments near Little Pigeon Creek (32 km east of the West Franklin quadrangle) is in the Athens Subepisode of the Wisconsin Episode (Johnson and others, 1997). In the same area, Erik Foale (Indiana Geological Survey, oral commun., 2006) observed pedologic features (cutans, blocky structure, rooting, mottling, and *Edaphichium*—earthworm burrows) in several intervals of 22 m of a drill core of laminated silt and clay. He interpreted these features to record marsh or mudflat environments that alternated with laminated silt and clay of lake and stream paleoenvironments.

Samples of the deposits under Little Creek and a penetrometer sounding of deposits under the valley of Wolf Creek suggest a lacustrine origin. Analyses of the samples in some depth intervals do not exclude a marshy, swamp, pond, or lake depositional environment. The cores, in the northwest corner of the quadrangle, are headwater tributaries to the Wabash River (26 km west). In the valley of Little Creek, fossil wood collected from DH–1 at 21 ft (6 m) depth and at 35 ft (10.5 m) was radiocarbon dated. An aquatic snail shell belonging to Family Hydrobiidae (Saxon Sharpe, Desert Research Institute, oral commun., 2005) was collected at 35 ft (10.5 m) and dated. The dates (table 1; John McGeehin, USGS, written commun., 2005) indicate Michigan Subepisode for the basal sediments and Hudson Episode (Johnson and others, 1997) for the approximate upper half of the deposit. Abundant, white, fossil gastropod shells freshwater snails were collected at 20–21 ft (6–6.1 m) depth. The shells are high spired, 3–6 mm long, basal width ~3 mm, and resemble *Amnicola* gelida Baker, holotype from Morris, Ill., illustrated in Baker, 1928, Plate VI, fig. 19). A. gelida is common in late glacial lacustrine mat deposits in Ohio (Baker, 1928) and was present in 12 ka mat deposited in cool waters of a small lake or pond (Gooding and Ogden, 1965, p. 10).

Table 1. Radiocarbon ages of fossil wood collected in creek alluvium (unit Qa) in auger hole DH–1 of the West Franklin quadrangle.

Laboratory number[1]	Sample ID and depth	Material	$\delta^{13}C$[2]	^{14}C age (yr B.P.)[3]	Dated on
WW5128	DH-1 20-21 ft	Wood	-25	11,120±40	01/18/05
WW5130	DH-1 35 ft	Wood	-25	16,650±50	01/18/05
WW5138	DH-1 35 ft	Shell	0	16,950±45	02/07/2005

[1]Samples sent processed at the ^{14}C laboratory of the U.S. Geological Survey in Reston, Va. The WW number is the laboratory identification for a sample for the USGS ^{14}C laboratory.
[2]Values reported for $\delta^{13}C$ are the assumed values according to Stuiver and Polach (1977) when given without decimal places. Values measured for the material itself are given with a single decimal place.
[3]Determined at the Center for Accelerator Mass Spectrometry, CAMS, Lawrence Livermore National Laboratory, Livermore, Calif. The quoted age is in radiocarbon years B.P., using the Libby half-life of 5,568 yr.

Depositional environments of the sediment under Little Creek are suggested by fossils collected from DH–1. *Carduelepyrum guttatum* Baker, 1928) is an endemic, a small crustacean found among a bivalve shell of calcite, and was collected at 21 ft (6.1 m) depth. Rick Forester (USGS, written commun., 2006); Forester and others, 2005) identified the ostracode *Candona* sp. as a freshwater, cool-water species. This ostracode commonly lives in shallow water, often amongst aquatic vegetation, in settings where ground-water/surface-water interchange occurs. *Physa integra* Haldeman, a gastropod, is a fresh-water snail, also found in shallow, oxbow ponds, wetlands, and springs. It has also been found in vernal recharge ponds among the prairie pothole wetlands in the upper Midwest. The biogeographic distribution of *C. sanctipauli* is that in the U.S.A. (http://www.kent.edu/nanode/) indicates it prefers cool to cold climates, including high elevation sites in the west. The gray (10YR 5/1) laminated silt and clayey silt at 20–21 ft (6–6.1 m) also contained *Carduelepyrum* (green algal) stems, mites, beetle elytra, a lot of woody debris, plant stems, and a small fe rotti clam. Charophytes, like *C. oosum*, commonly live in settings with ground-water/surface-water interchange (Collectively these fossils imply that these sediments were deposited in a shallow pond, or intermittent lake.

At Wolf Creek, a penetrometer sounding sensed 8.5 m of thinly bedded clay, silt, clay, clayey silt, and organic material, and in the basal 2 m, this beds of sand to silty sand (see PSY001 on map and fig. 3). The predominantly fine grained deposit and connection to Little Creek suggest deposition environments similar to those described above. The penetrometer measured shear-wave velocities of 188–258 m/s.

CREEK ALLUVIUM AND SHEETWASH ALLUVIUM (UNIT Qa)

This unit is mainly silt interbedded, interlaminated, and intermixed with scarce laminae and thin beds of very fine grained and fine-grained sand. The unit is poorly exposed and the base is covered. Auger holes penetrated light-olive-brown and light-yellowish-brown silt in the upper few meters before entering deeper, similar deposits, presumably of lacustrine origin. Bedding is thin to very thin, and is commonly laminated. Whereas the upper several meters of the alluvium is certainly Holocene in age, the contact with the buried pre-Holocene alluvium or lacustrine sediment cannot be located with certainty. Many workers consider the creek alluvium to be in erosional contact with lacustrine deposits (unit Qlt), especially in the lower reaches of the tributaries. This relation may be true in places, but from a conceptual-hydrologic viewpoint, the creek alluvium and lacustrine deposits were not readily distinguishable in the field. Both have similar grain size and bedding, and similar fossils could exist in both. Accordingly, both deposits form in bottomset beds and low-energy environments, excepting high-energy flood events. Previous workers mapped the deposits of Little Creek and Wolf Creek as slackwater-lake deposits (Wayne, 1958; Gray and others, 1991) and stream alluvium (Gray, 1969), illustrating ambivalence in interpretation. Peat, abundant wood, and scarcity of granules or pebbles at the base of the fill in Little Creek valley (lithologic log DH–1, Appendix) suggest a marsh, swamp, pond, or lake depositional environment. The cores, in the northwest corner of the quadrangle, are

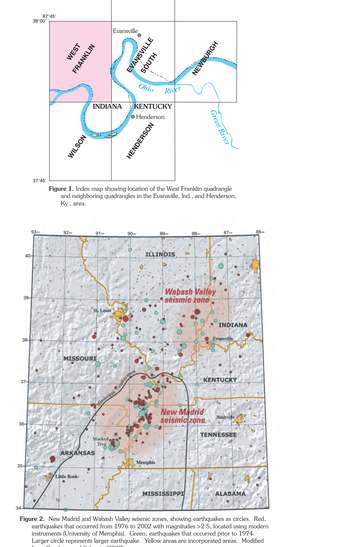


Figure 1. Index map showing location of the West Franklin quadrangle and neighboring quadrangles in the Evansville, Ind., and Henderson, Ky., area.

Figure 2. New Madrid and Wabash Valley seismic zones, showing earthquakes as circles. Red, earthquakes that occurred from 1976 to 2002 with magnitudes >2.5, located using modern instruments (Lawrence Livermore National Laboratory). Green, earthquakes that occurred prior to 1974. Larger circle represents larger earthquake. Yellow areas are incorporated areas. Modified from Gomberg and Schweig (2002).

Figure 3. Locations and grain-size classification data of three cone-penetrometer soundings in the West Franklin quadrangle.

Figure 4. Section crossing terrace and floodplain of Ohio River in southeastern part of West Franklin quadrangle, showing architecture of alluvial fill in valley. The numbers 10–12,000 and 3,980 in the figure are archeological and conventional radiocarbon ages, respectively, in yr B.P. (Fraser and Fishbaugh, 1986, p. 13). Dashed lines separate the fill, from top to bottom, interpreted to be Holocene, Wisconsin Episode, and pre-Wisconsin(?) Episode in age. Figure modified from Fraser and Fishbaugh (1986, figure 14), redrawn at 1:24,000 map scale for this report.

Figure 5. Sketch showing spatial relation of map units and interpreted ages. The upper couple of meters of unit Qt has been reworked in Holocene time (not depicted).

SURFICIAL GEOLOGIC MAP OF THE WEST FRANKLIN QUADRANGLE, VANDERBURGH AND POSEY COUNTIES, INDIANA, AND HENDERSON COUNTY, KENTUCKY

By
David W. Moore, Wayne L. Newell, Ronald C. Counts, Gordon S. Fraser, David A. Fishbaugh, and Theodore R. Brandt
2007

SUMMARY OF CHARACTERISTICS OF THE SURFICIAL DEPOS