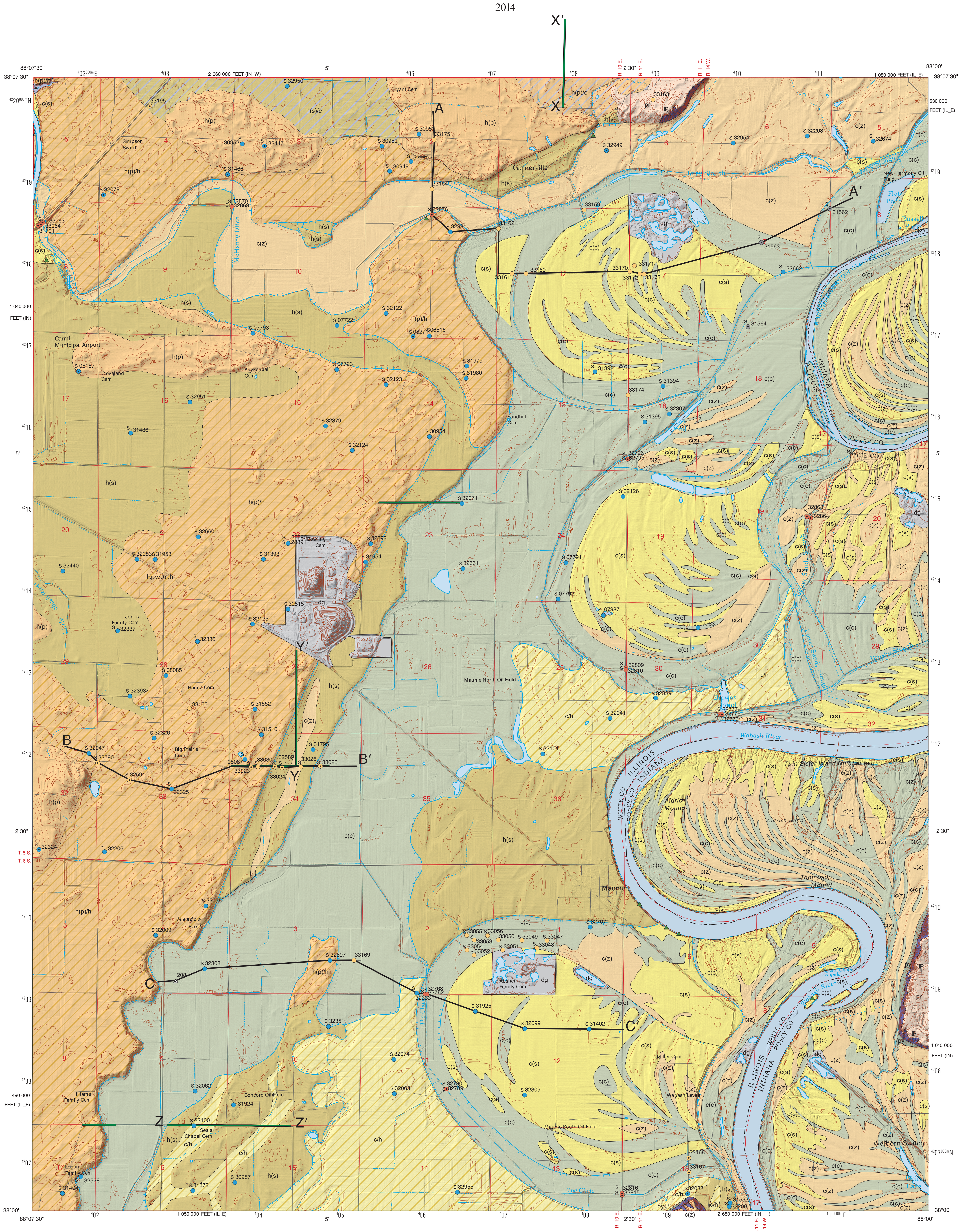
Prairie Research Institute
ILLINOIS STATE GEOLOGICAL SURVEY

SURFICIAL GEOLOGY OF MAUNIE QUADRANGLE
WHITE COUNTY, ILLINOIS, AND POSEY COUNTY, INDIANA

STATEMAP Maunie-SG

Andrew C. Phillips, Olivier Caron, and Timothy H. Larson
2014



QUATERNARY DEPOSITS

Description	Unit	Interpretation
HUDSON EPISODE (~12,000 years before present (B.P.) to today)		
Removed earth, originally sand and gravel, now filled with water; total depth of excavation unknown	Disturbed ground (cross-section only) dg	**Borrow pits** for local aggregate and fill for State Rt. 141
Brown to yellow brown loam, silt loam, and granular loam; massive to irregularly bedded; less than 10 ft thick	Peyton Formation py	**Alluvial fans at the base of slopes and gullies,** mainly derived from loess, outwash, and eroded bedrock
Dominantly brown to yellow-brown loam, silt loam, and siltyclay loam; local basal sand or pebbly sand beds; fine portion typically massive, but locally laminated or thin bedded; graded upwards; weathered; less than 5 feet thick	Cahokia Formation c; over Henry Formation c/h	**Alluvium,** mapped only in ephemeral tributary streams draining bedrock uplands
Brown to gray silty clay loam to silty clay, intercalated with minor loam, massive to stratified, up to 10 ft thick	Cahokia Formation (clayey facies) c(c)	**Overbank, lake, and intercalated stream deposits** in abandoned meander cutoffs, scroll swale deposits, and isolated floodplain ponds and depressions; inset terraces numbered youngest (1) to oldest (4); early post-glacial deposits drape over and are complexed with Henry Formation
Gray brown silt loam to loose silt, massive, may include loamy interbeds, up to 10 ft thick	Cahokia Formation (silty facies) c(z)	**Scroll bar, channel, and near-channel deposits;** inset terraces numbered youngest (1) to oldest (4); early post-glacial deposits drape over and are complexed with Henry Formation
Yellow brown to brown very fine to coarse sand with fine gravel lenses, loamy sand, and sandy loam; laminated to thick bedded or massive, up to 30 ft thick	Cahokia Formation (sandy facies) c(s)	**Channel, point bar, and crevasse splay deposits,** and forming the core of meander scrolls or the upstream portions of scroll bar complexes; inset terraces numbered youngest (1) to oldest (4); early post-glacial deposits drape over and are complexed with Henry Formation, where they do not exceed 5 ft thick
WISCONSIN EPISODE (~55,000–12,000 years B.P.)		
Gray to gray brown silty clay loam to clay, laminated to massive, fossiliferous zones, generally calcareous; up to at least 20 ft thick	Equality Formation e	**Slackwater lake deposits from damming of upland gullies during full glacial valley fill;** crops out in uplands south of New Haven and on south end of Dogtown Hills; upper elevations at 420 ft
Yellow brown to brown very fine sand, sandy silt, and silt loam, upper portion leached of carbonate, up to 15 ft thick	Henry Formation (Parkland facies) h(p)	**Eolian sand dunes reworked from outwash deposits;** mapped on hilltops where it intertongues with the Peoria and Roxana Silts. Base of h(p) in outcrop dated by OSL to 22.88 ± 1.99 ka to 21.67 ± 2.20 ka (ISGS 196, 197); also occurs on Terraces A and B (see text) where it is undifferentiated from sandy and silty facies of the Henry Formation
Brown to olive silty clay to silty clay loam, massive to laminated, grades down to medium sand, upper portion leached of carbonate, up to 10 ft thick	Henry Formation (Parkland facies) over Equality Formation h(p)/e	**Isolated to massed eolian dunes covering slackwater lake sediment** in terrace dominating northwest quadrant and southeast margin of map area, and as delta fan complex grading into high slackwater terrace in extreme northwest corner of map
Dark brown to brown silt loam to silty clay loam, grades down to medium to coarse sand; bedded to massive, upper portion leached of carbonate, up to 8 ft thick	Henry Formation (Parkland facies) over Henry Formation h(p)/h	**Isolated to massed eolian dunes covering delta plain facies of slackwater terrace i**n terrace dominating northwest quadrant and southeast margin of map area, and as delta fan complex grading into high slackwater terrace in extreme northwest corner of map; includes late-glacial dune sand differentiable only by landform
Brown to light brown sand to sandy loam, with fine gravel and gravel lenses, bedded to massive, upper portion leached of carbonate, up to 60 ft thick	Henry Formation (sandy facies) h(s); over Equality Formation h(s)/e	**Sandy facies of outwash i**n terrace dominating northwest quadrant and southeast margin of map area, and as delta fan complex grading into high slackwater terrace in extreme northwest corner of map; includes late-glacial dune sand differentiable only by landform
Brown to gray fine gravel to sandy gravel, bedded to massive, upper portion leached of carbonate, up to 30 ft thick	Henry Formation (gravelly facies) (cross section only) h(g)	**Gravelly facies of outwash, forming the deepest portion of the valley fill and generally buried;** differentiable as a map unit where earth electrical resistivity and closely spaced well log data are available
Brown to yellow brown silt loam, massive; up to 12 ft thick	Peoria and Roxana Silts pr	**Loess;** mapped on top of bedrock hills at New Haven; on top of Dogtown Hill and Little Chain Hill it is intertongues with and is mapped as h(p); may include Teneriffe Silt in lower part
ILLINOIS EPISODE (~190,000 to 130,000 years B.P.)		
Gravelly sand to sandy gravel, weak B horizon of Sangamon Geosol in upper part; leached to calcareous; up to 20 ft thick	Pearl Formation (cross section only) pl	**Outwash;** found in core and sample sets as remnants filling bedrock depressions; root of paleosol in upper portion

PENNSYLVANIAN BEDROCK

Description	Unit	Interpretation
Shale, sandstone, limestone, coal	Pennsylvanian bedrock IP	**Shale and sandstone** are common outcrop and subcrop. Coal is a less common subcrop. Limestone crops out in portions of Little Wabash and Wabash River channels

Data Type

- Outcrop
- Outcrop from field notes (ISGS archives)
- Stratigraphic boring
- Water-well boring
- Engineering boring
- Coal boring

S 26211 — Labels indicate samples (s). Boring and outcrop labels indicate the county number. Dot indicates boring is to bedrock.

- Scarp (may coincide with unit contact)
- Contact
- Inferred contact
- Electrical resistivity profile line
- A—A′ Line of cross section

Note: The county number is a portion of the 12-digit API number on file at the ISGS Geological Records Unit. Most well and boring records are available online from the ISGS Web site. Wells and borings in Indiana are labeled with the Indiana Geological Survey's record numer.

Base map compiled by Illinois State Geological Survey from digital data (2012 US Topo) provided by the United States Geological Survey. Shaded relief and contours derived from 2011 Illinois LiDAR and 2013 Indiana LiDAR.

North American Datum of 1983 (NAD 83)
Projection: Transverse Mercator
10,000-foot ticks: Illinois Coordinate System of 1983, east zone
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 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology based on field work by Andrew C. Phillips, Olivier Caron, Timothy H. Larson, Rebecca A. Alberts, and Alison R. Bruegger, 2013–2014. Core were obtained by the ISGS Drill Team. Dates were determined by Hong Wang at the ISGS Geochronology Laboratory.

Digital cartography by Deette M. Lund, Jennifer E. Carrell, Trisha S. Rentschler, and Alison R. Bruegger, Illinois State Geological Survey. Shaded relief by Donald E. Luman.

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This map has not undergone the formal Illinois Geologic Quadrangle map review process. Whether or when this map will be formally reviewed and published depends on the resources and priorities of the ISGS.

ROAD CLASSIFICATION
Local road — State Route

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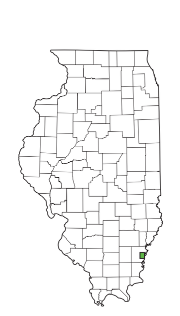

ADJOINING QUADRANGLES
1 Centerville
2 Crossville
3 New Harmony
4 Carmi
5 Solitude
6 New Haven
7 Emma
8 Mount Vernon

3° — TRUE NORTH — MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2014

Introduction

The Maunie 7.5’ Quadrangle includes a portion of the Wabash Valley and surrounding uplands, approximately 23-37.5 river miles upstream of Wabash River confluence with the Ohio River. The City of Carmi, the seat of White County, lies about 2 miles west on the west side of the Little Wabash Valley (LWV). This surficial geologic map is part of a long term project (e.g. Phillips 2013; Phillips and Gemperline 2012; Bryk et al. 2012) along the lower Wabash River valley that comprises the Illinois – Indiana border. River meandering and meander loop cutoffs over the past 130 years have caused the natural boundary to deviate from the political boundary. The mapping results build upon the existing geologic framework and support studies of river processes, seismic hazard, water and aggregate resources, and earth history.

Setting

The quadrangle is centered on the Wabash Valley. The Little Wabash River, a major tributary to the Wabash River, flows through the extreme northwest corner of the quadrangle, but at one time flowed through the valley that is now occupied by McHenry Slough. Four main landform assemblages occur (Fig. 1). First, noses of bedrock, partly covered by a veneer of till and eolian dunes or loess forms the valley walls and isolated hills along the boundary of the quadrangle. Second, a high terrace (elevation 385-390 ft), the Carmi Terrace, fills the mouth of the LWV. It is an assemblage of outwash, deltaic, and slackwater lake sediments. This terrace is bounded by a distinct scarp, the Meadow Bank, that trends from the southwest corner of the quadrangle northeast towards the bedrock nose near the east center or the northern boundary (Fig. 2). Patches of isolated to amalgamated eolian dunes mark the surface. Third, lower terraces at 370-375 and 365-370 ft, respectively, occur east of the Meadow Bank and in the McKinley Slough valley. Together the two terraces comprise the Maumee Terrace, named after late-glacial floods from Glacial Lake Maumee near the headwaters of the Wabash. The surface of the higher of the two terraces is shaped by braid bars formed by outwash. The namesake village of Maunie occupies this level along the banks of the Wabash but within the 100 year floodplain. The lower of the two terraces has been partly to wholly smoothed by Hudson Episode stream activity and flood deposits. Fourth, cut off and existing meanders of the Wabash River fill the eastern half of the quadrangle. The Wabash River Old Channel was cut off before 1840 and is an oxbow lake. Other meanders were cut off earlier in the Hudson Episode and are largely filled in but still flooded during high levels of the Wabash. Several of these terraces are likely correlatable to the 6 allogeomorphic units differentiated by Autin (1996) in the lower Wabash Valley of Indiana.

The Wabash Valley lies within the Wabash Valley Seismic Zone, an area of historic and modern seismicity and associated bedrock faults (Bristol and Treworgy 1979; Woolery 2005; Hermann et al. 2008). The valley may have existed in the Mesozoic and was certainly active during the Quaternary Period. During the Quaternary, Illinois Episode ice advanced to just 3-5 miles south of the Quadrangle boundary (Phillips et al. 2013; Gray 1988). Although remnants of till and possibly other ice-marginal deposits can be found in the valley, most Illinois Episode (~160-130 ka) and possibly older deposits were eroded by later events. Wisconsin Episode (~60-12.5 ka) ice advanced to only ~90 miles north of the quadrangle, but left a legacy of proglacial sediment including outwash, slackwater lake, and wind deposits that at one time filled the valley or blanketed adjacent uplands. Large flood events during the glacial-post glacial transition eroded into portions of the valley fill, and marked the beginning of a meandering phase of the Wabash River. Lateral meander migration and loop cutoff over the past 12.5 ka have left striking scroll bar-meander loop landforms. The 5 major terrace levels mentioned above and several minor terraces indicate distinct downcutting events through the late glacial and post-glacial episodes.

Methods

The surficial geology was analyzed from compilations of boring records archived at the Illinois and Indiana Geological Surveys (ISGS and IGS, respectively), geologic field notes, aerial imagery, and soil surveys (Soil Survey Staff 2008, 2011). Locations of water well, geotechnical boring, and mineral well records were confirmed with the best available data. Most of the mapped locations are likely within 25 ft of their true locations, but the accuracy ranges from 1 to 330 ft. The boring and well inventory is relatively sparse. Although the petroleum well inventory is very dense, none of those wells have useful information about the valley fill and very few identify the bedrock surface accurately. New data were generated by study of sample sets in the ISGS Samples Library, a coring program, geophysical surveys, and interpretation of recent high-resolution elevation data (FEMA 2012, IGS 2014). Shallow explorations were completed with percussion coring to depths of 14 to 44 ft at 17 sites. Meander scroll sequence, oxbow fills, and eolian dunes and their underlying strata were the main targets. Deep explorations to bedrock were completed by wireline methods at two locations, one in the northwest corner of the quadrangle and a second 3.5 mi northwards up the LWV. Total core recovery was 495 ft. The deep explorations targeted fossiliferous slackwater lacustrine sediment and the sedimentary transition from fluvial facies at the slackwater lake mouth into fully lacustrine facies. Three earth electrical resistivity profiles, X–X,′ Y–Y,′ and Z–Z,′ (8 ft nominal electrode spacing) totaling 4 Km in length were obtained across eolian dune, slackwater terrace, and outwash terrace sequences. These profiles add substantially to previous seismic (Heigold and Larson 1994) and resistivity (Larson et al. 2013) studies in the area. Siting resistivity targets was difficult because of the extensive subsurface oil pipeline network in the area.

Interpretation of the core was supported by 84 size analyses on eolian and fluvial sediments using laser scanning, 20 size analyses on lacustrine clays, and 8 clay mineral analysis. Ages of two samples were obtained by AMS ^{14}C assays on conifer needles. Zircon crystals in a granite boulder excavated from Illinois Episode till (Glasford Formation) were dated by U-Pb series methods by the Arizona Laserchron Center.

Important Findings

- Bedrock crops out in the steepest valley walls and in short reaches of the bed of the Wabash River. The valley walls descend steeply to the broad and very gently sloped floor of the Wabash Bedrock Valley (Fig. 2). The well control is very sparse, but resistivity profiling indicates there may be as much as 30-35 ft of relief within the valley, consistent with the bedrock knobs that protrude from the valley fill (Section Z-Z’).
- Evidence of Illinois Episode glaciation is sparse, but supports the idea that the episode was geologically similar to the Wisconsin Episode. Windows of till were found in outcrop in gullies on the flanks of the valley walls but the observations are not large enough to be mappable within this quadrangle. The root of paleosols, recognized in core by carbonate leaching, were developed in outwash ([pl]; borings 33026, 31395) and lake sediment ([t]; 33175) and indicate substantial filling of the valley followed by erosion.
- Zircons from a granite boulder excavated from Illinois Episode till were dated by U-Pb series methods by the Arizona Laserchron Center. The 1139.7±12.8 Ma age is consistent with a date from a cobble obtained from Illinois Episode outwash [pl] 125 Km to the northwest, and suggest provenance in the Grenville Province.
- Conifer needles obtained from slackwater lacustrine sediment [e] at outcrop MNE-6 were dated at 45000±1500 RCYBP (ISGS A3146), and confirmed the onset of aggradation in the Wabash Valley by outwash during Wisconsin Episode ice sheet advance. The outwash was sourced from both the Lake Michigan and Huron-Erie glacial lobes (Fraser 1993). Early deposits ranged from coarse to fine gravel [h(g)] and less than 50 ft thick, whereas later deposits were mainly coarse sand [h(s)].
- An age of 14215±40 RCYBP (which calibrates to 14,493 ± 90 ka, ISGS A3149) was determined on wood fragments obtained from a lacustrine interval at a depth of 8.5 ft in an archived stratigraphic core (boring 33025). The age supports ages from immediately adjacent sediment of 17.3 ± 0.1 (underlying sandy outwash [h(s)]) and 10.0 ± 0.1 (overlying silty alluvium [c(z)]) previously determined by optically stimulated luminescence (OSL) methods. The ages imply that outwash accumulated until at least 14.5 ka and that incision of the terrace was complete by 10 ka.
- The Carmi Terrace was constructed by damming of the mouth of the LWV by outwash, to form a slackwater lake behind it. As aggradation continued, the outwash prograded up the valley as a delta. Fine sediment, sourced both from local remobilization of Illinois Episode deposits and from meltwater inputs in the headwaters. The sandy deltaic facies [h(s)] dominate the subsurface south of McHenry Slough, whereas fine-grained lacustrine facies [e] are found interfingering with the deltaic facies north of McHenry Slough. Similar deposits were found filling the Bonpas Creek valley, 10 miles to the north (Phillips and Gemperline 2012).
- Eolian dunes [h(p)] formed from local the sandy surficial deltaic sediments at 22-23 ka during the glacial maximum (Phillips et al. 2013; Larson et al. 2014). Dunes are found both on the Carmi Terrace as well as on Maumee Terrace deposits and amalgamated on the west (downwind) sides of bedrock uplands (Fig. 2), but it is not known at this time if they are the same age. Preliminary lab work was completed for OSL dates on paired samples from the cored eolian dune/outwash assemblages obtained for this project, but equipment breakdown meant that the ages could not be determined by the time of this publication. If the dunes prove to all have similar ages then the correlation of the Maumee Terrace with Glacial Lake Maumee outburst floods is questionable.
- Loess [pr] is only found as a mappable unit on top of bedrock highs. It is thin (< 10 ft) on the west side of the valley, but reaches >10 ft on the east within this quadrangle. Lenses of loess occur in low spots between dunes on the Carmi Terrace
- During the early Hudson Episode, at about 10 ka (see above), the valley fill was at or near the level of the Maumee Terrace. At this time it appears that the Little Wabash River still flowed through McHenry Slough. That stream and other small creeks partly reworked the Maumee Terrace surface, recognized as very low relief channels and a large swath across the center of the quadrangle. Resistivity line Z-Z’ imaged the channels as less than 20 ft thick (also cross section B-B’). The meanders of one of those streams scalloped the southern end of the Meadow Bank.
- Abandoned meander loops and their point bars are readily apparent as cross-cutting landforms in LiDAR maps, but are separated by only subtle terracing. The oxbow lakes are filled with 5-15 ft of fossiliferous clay to clay loam [c(c)] over <25 ft of channel sands [c(s)]. The age of each cutoff and the duration of infilling is not known, but may be constrained by dating of fossil remains in core obtained for this project.
- No additional sandblows or other paleoseismic features were identified in this project so add to the neotectonic database (Munson and Munson 1996), in part because field studies were significantly inhibited by high water levels.
- Although the deposits in the main valley support small aggregate operations, gravel, found in meandering channel bed and lower point bar facies, is mostly fine and buried by 5-10 m of sand or finer sediment. The sand and fine gravel appear to support extensive irrigation. The irrigation well array is continually densifying. No water level monitoring that could be used to assess the impacts of growth is occurring, however.

References Cited

Autin, W.J., 1996, Alluvial stratigraphy of the Martinsville Formation in the Wabash and White River Valleys: in Munson, P.J., and C.A. Munson, Paleoliquefaction evidence for recurrent strong earthquakes since 20,000 years BP in the Wabash Valley area of Indiana: Contract Report for Grant No. 14-08-0001-G2117, USGS National Earthquake Hazards Reduction Program, 137 p.

Bryk, A., A.C. Phillips, E. Prokocki, and J.M. Best, 2012, Surficial Geology of Wabash Island Quadrangle, Gallatin County, Illinois: University of Illinois, USGS-EDMAP contract report, 2 sheets, 1:24,000.

FEMA, 2012, Terrain, Wabash, Illinois: FEMA CASE 12-05-0809S [LiDAR elevation model], Federal Emergency Management Agency, Washington, D.C., digital data obtained from the Illinois Height Modernization Program (http://www.isgs.uiuc.edu/nsdihome/webdocs/ilhmp/) on 7/31/2012.

Fraser, G. S., 1993, Sedimentology and history of late Wisconsin allu¬viation of the Wabash Valley: Special Report 56, Indiana Geological Survey, Bloomington, 18 p.

Gray, H.H., 1982, Map of Indiana showing topography of the bedrock surface: Indiana Geological Survey Miscellaneous Map 36.

Gray, H. H., 1988, Map of southern Indiana showing geomorphic features relevant to ice marginal relict drainage: in Gray, H. H., 1989, Relict drainageways associated with the glacial boundary in southern Indiana: Indiana Geological Survey Special Report 45, 9 p.

Heigold, P. C., and T. H. Larson, 1994, Geophysical investigations of possible recent ground deformation and neotectonism in White County, Illinois: Illinois State Geological Survey Open File Series 1994-5, 24 p.

Hermann, R.B., M. Whithers, and H. Benz, 2008, The April 2008 Illinois Earthquake an ANSS Monitoring Success: Seismological Research Letters, v. 79, p. 830-843.

Indiana Office of Information Technology, 2013, Posey County, IndianaMap Framework Data [LiDAR elevation model]: IN 2013 Statewide West IMG DEM, downloadable from www.indianamap.org.

Larson, T.H., A.C. Phillips, and S. Elrick, 2014: Paleoseismic Investigation of the Meadow Bank Lineament in the Wabash Valley Seismic Zone: Final Technical Report, USGS Grant G12AP20045, 94 p.

Munson, P.J., and C.A. Munson, 1996, Paleoliquefaction evidence for recurrent strong earthquakes since 20,000 years BP in the Wabash Val¬ley area of Indiana: Contract Report for Grant No. 14-08-0001-G2117, USGS National Earthquake Hazards Reduction Program, 137 p.

Phillips, A.C., and J.M. Gemperline, 2012, Surficial Geology of Grayville Quadrangle, Edwards, Wabash, and White Counties, Illinois: Illinois State Geological Survey, USGS-STATEMAP contract report, 2 sheets, 1:24,000.

Phillips, A.C., and J.M. Gemperline, T.H. Larson, and O. Caron, 2013, Surficial Geology of Emma Quadrangle, Gallatin and White Counties, Illinois, and Posey County, Indiana: Illinois State Geological Survey, USGS-STATEMAP contract report, 2 sheets, 1:24,000.

Soil Survey Staff, 2008, Soil Survey Geographic (SSURGO) database for White County, Illinois: USDA Natural Resources Conservation Service, Fort Worth, Texas, on line data downloaded from http://Soil-DataMart.nrcs.usda.gov on 8/12/2012.

Soil Survey Staff, 2011, Soil Survey Geographic (SSURGO) database for Posey County, Indiana: USDA Natural Resources Conservation Service, Fort Worth, Texas, on line data downloaded from http://Soil-DataMart.nrcs.usda.gov on 11/08/2011.

Woolery, E.W., 2005, Geophysical and Geological Evidence of Neotectonic Deformation along the Hovey Lake Fault, Lower Wabash Valley Fault System, Central United States: Bulletin of the Seismological Society of America, v. 95, p. 1193-1201.

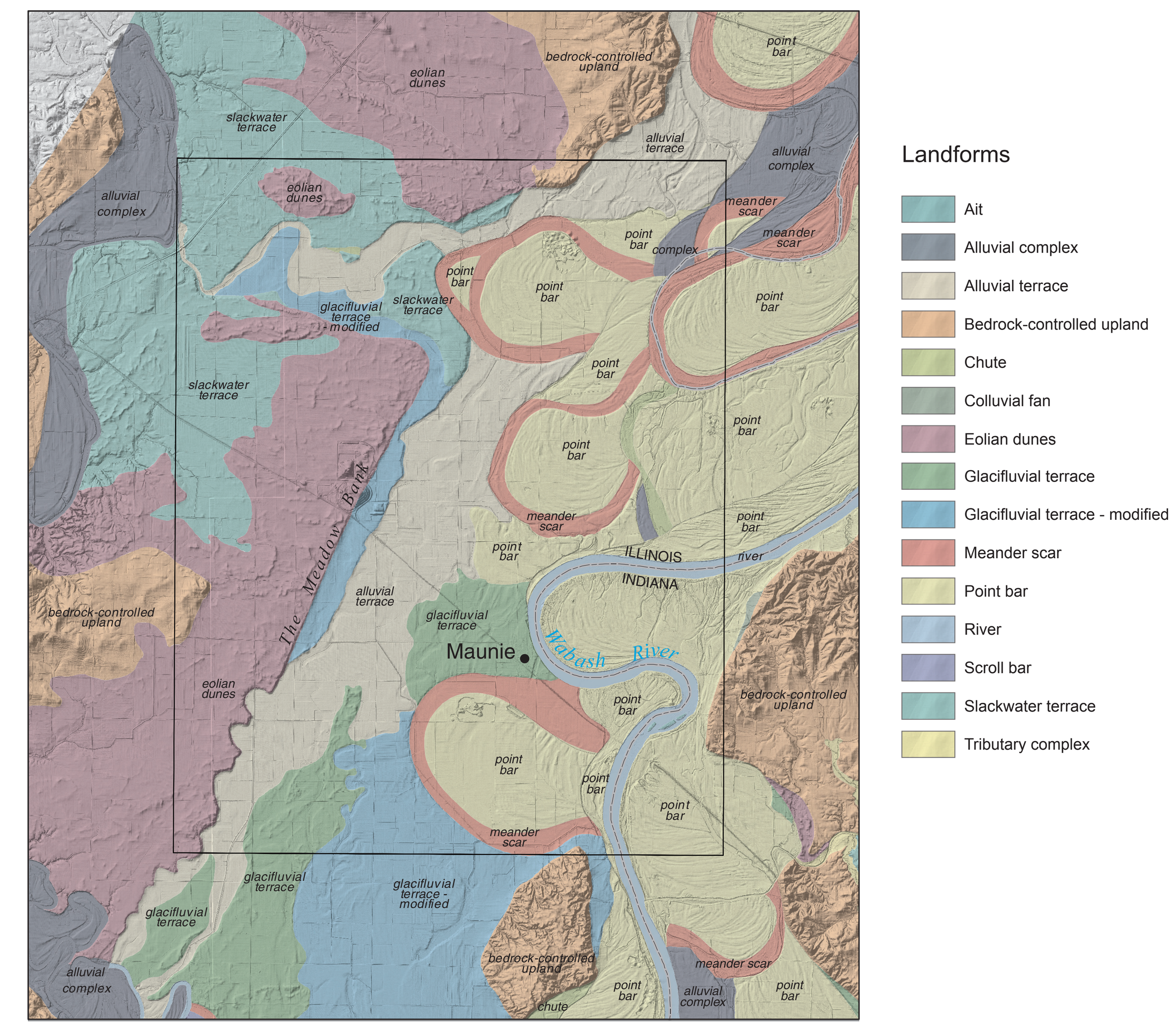

Figure 2 Landform assemblages were visually differentiated from ~4 ft pixel LiDAR topographic data (FEMA 2012; Indiana Office of Information Technology 2013). Bedrock-controlled uplands form the valley walls and protrude as isolated hills from the valley fill. The Carmi Terrace is separated from lower Pleistocene and Holocene terraces to the remarkably straight Meadow Bank, a 10-30 ft high scarp trending southwest-northeast across the quadrangle. Isolated eolian dunes and dune swarms formed by northwesterly winds accentuate the eastern margin of the Carmi Terrace. Lower Pleistocene terraces were partly reworked by early Holocene streams. Several episodes of late Holocene meander cutoff and downcutting are evident from cross-cutting relationships and subtle terrace levels. The Wabash River is actively meandering.

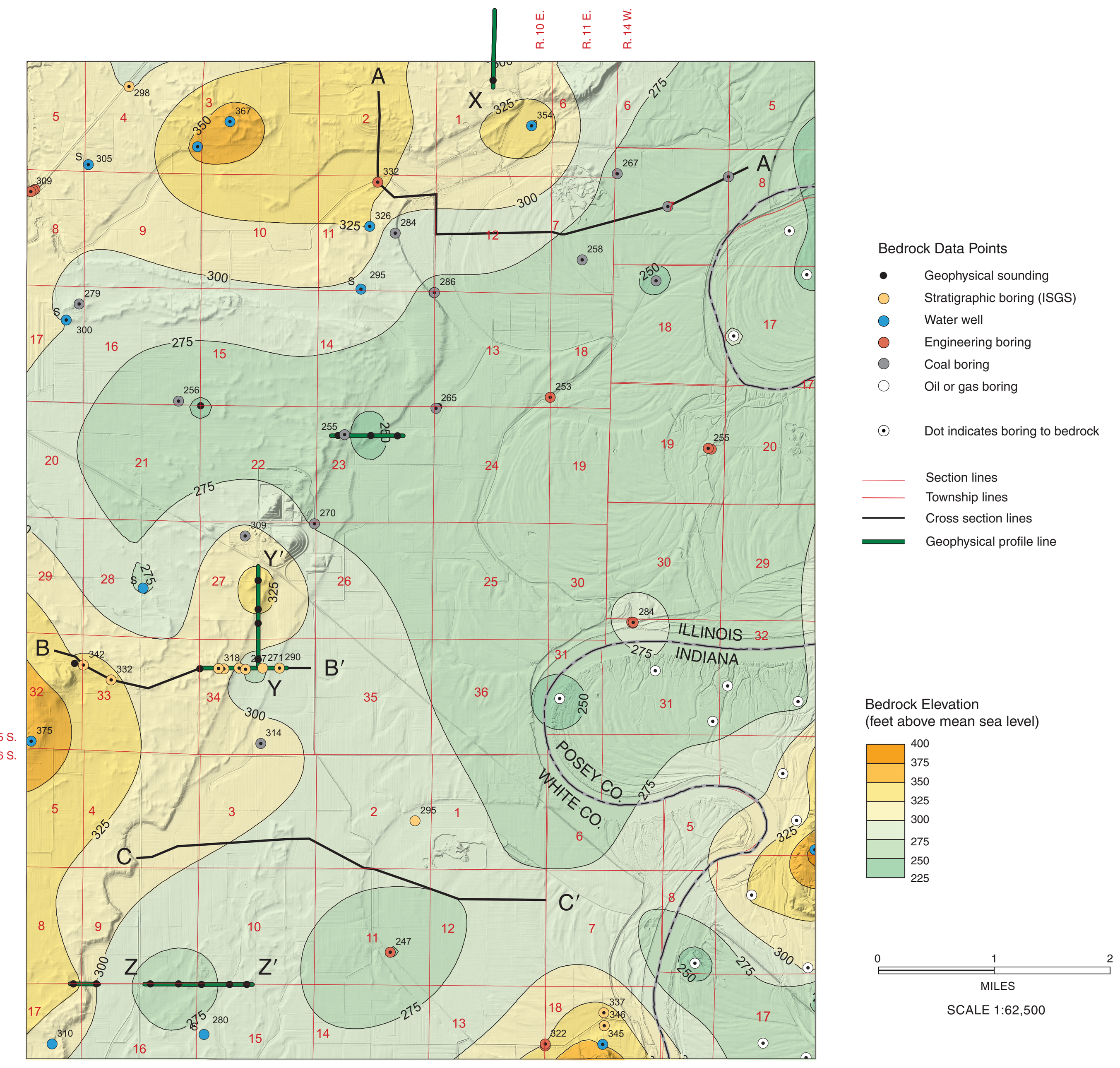

Figure 1 The bedrock topography of Maunie Quadrangle was constructed from boring, geophysical, and outcrop data from ISGS and IGS records. It is shown here with a surficial hillshade map for reference. Source data included a 1-2 mile buffer, not shown, beyond the quadrangle boundary. Some of water wells used did not penetrate through bedrock, but standard practice in the area is to advance to refusal on bedrock, which is sometimes indicated on the well logs (S. Scates, pers. com., 2013). The total depth of these wells were included as synthetic data. Data were exceptionally sparse in the center of the map area. IGS data were digitized from workmaps of the Gray (1982). They largely include petroleum well and boring data that may have not accurately identified the bedrock interface as indicated by polygons supported by single points. Bedrock crops out in the steepest valley walls. Scale 1:100,000.