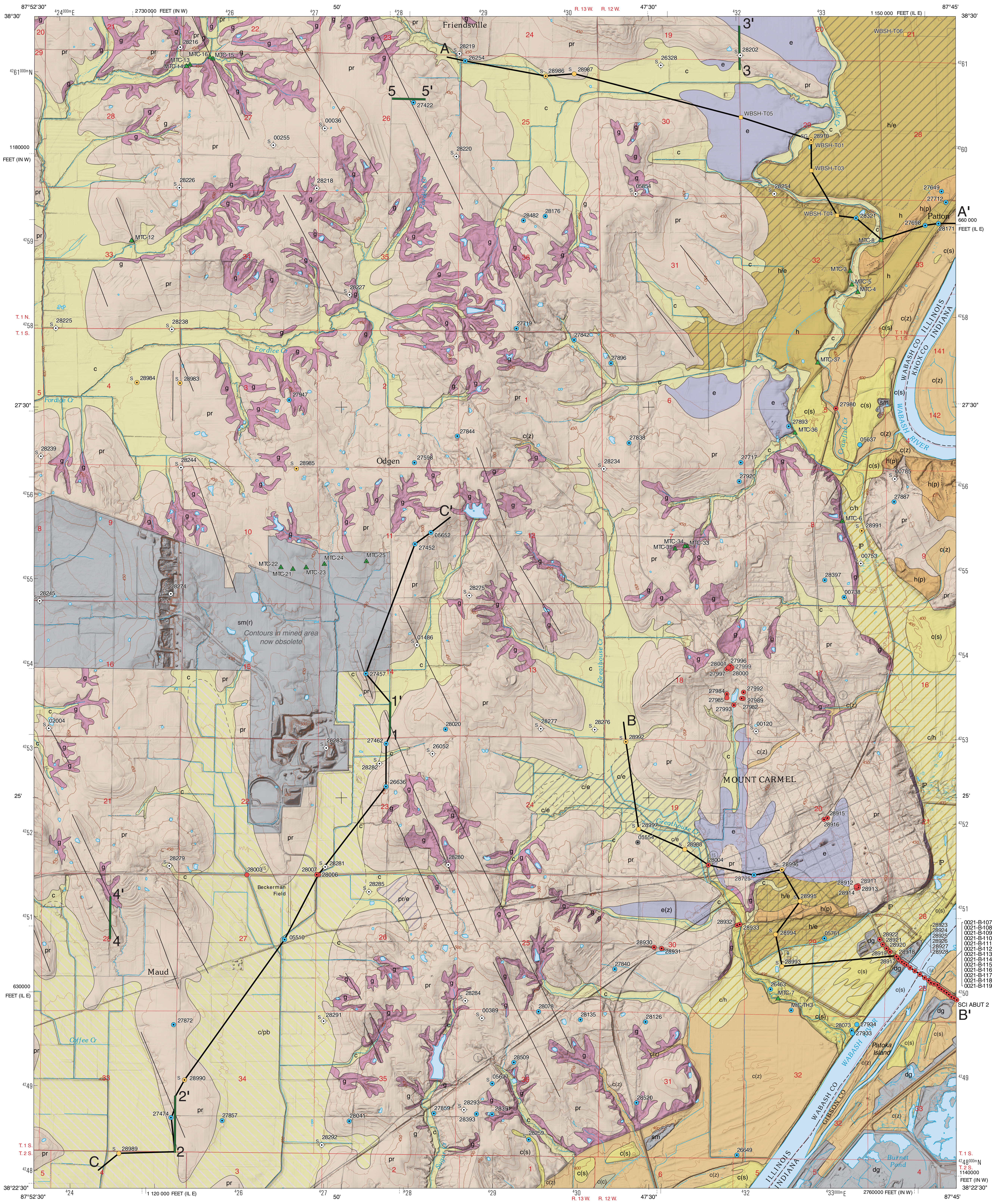
Prairie Research Institute
ILLINOIS STATE GEOLOGICAL SURVEY

Surficial Geology of Mount Carmel Quadrangle
Wabash County, Illinois, and Knox and Gibson Counties, Indiana

Andrew C. Phillips
2016



QUATERNARY DEPOSITS

Description	Unit	Interpretation
HUDSON EPISODE (~13,000 years before present (B.P.) to today)		
Removed or constructed ground	Disturbed ground: dg	**Excavations associated with State Route 64**
Removed earth	Surface Mine: sm	**Small aggregate pits** exploited channel and outwash gravels, now filled with water
Removed earth with reclaimed ground.	Surface Mine (reclaimed): sm(r)	**Surface coal mine**; most of area on map was removed and is being replaced with farmable ground
Loam, silt loam, and silty clay loam; local basal sand or pebbly sand beds; fine portion typically massive, but locally laminated or thin bedded; graded upwards; brown to yellow-brown; typically leached; as much as 20 feet thick	Cahokia Formation: c; over Henry Formation: c/h; over Equality Formation: c/e; over Petersburg Silt: c/pb	**Alluvium**; Less than 15 feet thick in tributary stream valleys draining bedrock uplands; up to 20 feet thick where mapped as undifferentiated alluvium in Wabash Valley; where lithology of underlying unit is similar, contact is gradational and recognized by buried paleosol
Silty clay loam to silty clay, intercalated with minor loam, massive to weakly stratified; brown to olive brown; leached; as much as 5 feet thick	Cahokia Formation (clayey facies): c(c)	**Backswamp and flooplain lake** deposits
Silt loam to loose silt, massive, may include loamy interbeds, olive brown to gray brown; leached near surface; as much as 10 feet thick	Cahokia Formation (silty facies): c(z)	**Overbank and secondary channel deposits** in Wabash Valley; drapes over relict sandy scroll bar deposits; forms several small terrace flights
Sand, loamy sand, and sandy loam; very fine to coarse; laminated to thick bedded to massive; fine gravel lenses; yellow brown to brown; leached near surface; as much as 25 feet thick	Cahokia Formation (sandy facies): c(s)	**Channel, point bar, and levee deposits** in Wabash Valley, and differentiated in Greathouse Creek; incised into Henry Fm; forms terraces along valley walls
WISCONSIN EPISODE (~55,000–13,000 years B.P.)		
Silt loam to clay loam; upper unit massive with gradational contact, brown to yellow brown; lower unit sandier with granules, massive to crudely bedded, brown to reddish brown, typically leached; upper and lower units as much as 9 feet and 1 foot thick, respectively	Peoria and Roxana Silts: pr; over Equality Formation: pr/e	**Loess;** mapped over all upland surfaces, intercalates with some of the valley fill; locally eroded off some ridges to expose underlying till; lower Roxana Silt is loess intermixed with colluvium
Sand to sandy loam; fine to coarse; thin bedded to massive, silty and fine gravel lenses; brown and light brown to gray; locally leached but typically calcareous; as much as 90 feet thick in Wabash Valley	Henry Formation: h; over Equality Formation: h/e	**Outwash**; buried below Cahokia Fm in Wabash Valley, but may be surficial unit in terraces; formed sediment dams blocking tributary valleys, where prograding delta facies intercalate with slackwater lacustrine facies; scarped by late-glacial and post-glacial floods in Wabash Valley
Fine sand to loamy fine sand and silt loam; thin-bedded to massive, yellow brown to brown; upper portion leached, as much as 15 feet thick	Henry Formation (Parkland facies): h(p)	**Eolian dunes;** formed in sandy deposits close the Wabash Valley, including the outwash dam of Crawfish Creek valley and on Carmel Mound; landforms include parabolic and complex dunes formed by westerly winds; intercalates with loess; formed 22-15 ka.
Silty clay loam to clay, laminated to massive, fossiliferous zones with gastropod and ostracode tests, peaty horizons, generally calcareous; gray to gray brown; as much as 40 feet thick	Equality Formation: e	**Slackwater lake deposits from damming of upland tributary valleys by outwash;** crops out in terraces along Crawfish Creek and as surficial unit in areas of Crawfish Creek and Greathouse Creek valleys; buried by Cahokia Fm or Peoria and Roxana Formations in lower valley fills and terraces; upper elevations at ~415 feet asl.
Sand to silt loam and silty clay loam; bedded to massive; yellow brown to brown; leached to strongly weathered; as much as 20 feet thick	Equality Formation (sandy facies): e(s)	**Alluvium** from upper tributary streams draining uplands into slackwater lakes; derived from till and loess covering uplands; interpreted in boreholes in Crawfish Creek
ILLINOIS EPISODE (~190,000 to 130,000 years B.P.)		
Silt loam to clay; laminated to massive; includes fine sand lenses 1-5 feet thick; olive brown to gray; as much as 30 feet thick	Petersburg Silt (cross sections only): pb	**Lacustrine sediment** in fills of Coffee Creek and portions of Crawfish Creek tributary valleys; found only in boreholes; portions may have been ice-contact, but also may have been slackwater lake fills; includes alluvial facies in upper valley reaches; recognized by paleosol developed in upper portion; upper elevations ~390 feet asl
Sand, gravelly sand, and sandy gravel, medium to poorly sorted; thin bedded; light brown to gray; leached to calcareous; as much as 15 feet thick	Pearl Formation (cross sections only): pl	**Outwash**; found in core in tributary valley fills above or intercalated with Glasford Formation; may include weak B horizon of Sangamon Geosol in upper part
Loam to clay loam diamicton; sand and fine gravel lenses 2-5' thick and 5-20' wide; brown to gray; leached to calcareous; less than 10 feet thick	Glasford Formation: g	**Till with outwash channels;** veneers bedrock hills below Peoria and Roxana Silt Formations, though locally exposed in gullies and stream valley walls; underlies all other units in bedrock valleys; truncated Sangamon Geosol may be developed in upper part.
PENNSYLVANIAN BEDROCK		
Shale, sandstone, limestone, coal	IP	**Shale, sandstone, and limestone** are common outcrop and subcrop. Coal is a less common subcrop.

Base map compiled by Illinois State Geological Survey from digital data (2015 US Topo) provided by the United States Geological Survey. Shaded relief and contours derived from 2012 LiDAR elevation data.

North American Datum of 1983 (NAD 83)
Projection: Transverse Mercator
10,000-foot ticks: Illinois State Plane Coordinate systems, east zone (Transverse Mercator); Indiana State Plane Coordinate systems, west zone (Transverse Mercator)
1,000-meter ticks: Universal Transverse Mercator grid system, zone 16

Recommended citation:
Phillips, A.C., 2016, Surficial Geology of Mount Carmel Quadrangle, Wabash County, Illinois, and Knox and Gibson Counties, Indiana: Illinois State Geological Survey, USGS-STATEMAP contract report, 2 sheets, 1:24,000

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
NATIONAL GEODETIC VERTICAL DATUM OF 1988

Geology based on field work by A. Phillips, 2015–2016.

Digital cartography by Deette M. Lund and Jennifer E. Carrell, Illinois State Geological Survey.

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program under StateMap award number G15AC00505, 2015. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

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.

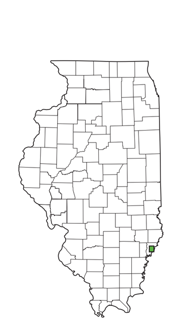
Point Data Type
- Stratigraphic boring
- Water well boring
- Engineering boring
- Coal boring
- Oil and gas boring
- Outcrop
- Outcrop in field notes (ISGS archives)
- Passive Seismic Sounding

Line Data Type
- Contact
- Terrace scarp
- Dune
- Glacial lineament
- 1 — 1′ Electrical resistivity profile line
- A — A′ Line of cross section

SG 26211 Labels indicate samples (s) or geophysical log (G). Boring labels indicate the county number. Outcrop labels indicate geologist's field number. Dot indicates boring or outcrop is to bedrock.

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.

ILLINOIS STATE GEOLOGICAL SURVEY
PRAIRIE RESEARCH INSTITUTE
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Prairie Research Institute
Illinois State Geological Survey
615 East Peabody Drive
Champaign, Illinois 61820-6918
(217) 244-2414
http://www.isgs.illinois.edu



1	2	3
4		5
6	7	8

ADJOINING QUADRANGLES
1 Berryville
2 Lancaster
3 Saint Francisville
4 Bone Gap
5 East Mount Carmel
6 Grayville
7 Keensburg
8 Owensville

3°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2016

ROAD CLASSIFICATION
State Route
Local road

Introduction

The Mount Carmel 7.5' Quadrangle includes portions of the Wabash Valley and its surrounding uplands. It occurs about 50 river miles upstream of the confluence of the Wabash River with the Ohio River. The confluence of the White River, a major tributary to the Wabash that drains a large portion of western Indiana, occurs just east of the quadrangle boundary. This surficial geologic map is part of a long term project (Phillips et al. 2014; Phillips et al. 2013; Phillips and Gemperline 2012; Bryk et al. 2012) along the lower Wabash River valley that comprises the Illinois-Indiana border. The City of Mount Carmel is the county seat. The surrounding area is rural. The main economic activities are agriculture and petroleum production; a surface coal mine, the Vigo Coal Company mine, terminated extraction operations in 2016. The Quaternary geology depicted here represents a preliminary interpretation of the mapping effort and may be revised with further analysis of the results. The map builds upon the existing geologic framework and supports studies of glacial processes, river processes, seismic hazard, water and aggregate resources, and earth history.

Setting

The Wabash Valley may have existed in the Mesozoic and was certainly an active river valley throughout the Quaternary Period. It lies within the Wabash Valley Seismic Zone. Faulting and downwarping associated with the seismicity (Bristol and Treworgy 1979; Woolery 2005; Hermann et al. 2008) were likely conducive to valley formation. The epicenter of the M5.4 April 2008 Mount Carmel Earthquake, the largest ever recorded in Illinois, was 1 mile west of the quadrangle boundary (Fig. 1, Hermann et al. 2008). The area was covered by ice during the Illinois Episode glaciation, ~160-130 ka. The terminal moraine lies ~20 mi to the SE (Gray 1988). During deglaciation, the Wabash Valley was a major meltwater outlet of the ice sheet and was likely filled with outwash. Erosion during the ensuing Sangamon Episode interglacial, ~130-60 ka, removed much of the sediment from the uplands and valley, exposing bedrock on some of the ridges. Ice advanced to about 60 miles N of Mount Carmel during the Wisconsin Episode, ~60-13 ka. Outwash again filled the valley and dammed tributaries to form slackwater lakes. Dry and windy climate towards the end of the Wisconsin Episode was conducive to the generation of loess and dunes from extensive unvegetated outwash plains; the thickest deposits accumulated on the eastern side of the Wabash Valley. Huge floods cascaded episodically down the Wabash Valley during the glacial-interglacial transition when proglacial lakes burst their dams (Fraser 1993). In the lower valley near Mount Carmel, the floods left deposits in tributary valleys, but also eroded much of the valley fill. The Wabash River began to meander across its floodplain during the Hudson Episode postglacial, ~13 ka – present. The Vigo Coal Company surface coal mine excavated the surface sediment in the west-central portion of the quadrangle. Excavation operations were terminated in 2016 and reclamation operations are expected to be completed in the ensuing year. The Duke Energy plant occupies the Wabash River floodplain in the southeast corner of the quadrangle.

Four landform-sediment assemblages were differentiated within the quadrangle (Fig. 1). First, Bedrock-controlled uplands have rough topography with larger valleys radiating away from a SSE-trending ridge. They are covered by a veneer of till and loess. Erosion has exposed the bedrock in steeper gullys and along portions of the Wabash Valley wall. A knob of bedrock protruding from the valley fill north of Mount Carmel lies partially within the quadrangle. Second, tributary valleys are filled with alluvium in the upper portions. The lower portions of the tributary valleys are characterized by broad and flat plains, which are classed as lacustrine (slackwater) terraces. Outwash sand and some gravel that prograded from the Wabash Valley largely fills the mouths of the valleys, and intercalates with fine lacustrine sediment that underlies the flat plains. The uppermost part of the lacustrine terraces is either alluvium from the larger creeks or mixed lake sediment and loess. Arcuate scarps from Wabash River flows, possibly from late glacial floods, cut the main terrace scarps. Third, eolian dunes derived from the sandy outwash occur near the lacustrine terrace mouths and on top of the bedrock knob east of Mount Carmel. At this writing it is unclear whether they can be correlated to nearby dunes constructed during (~22 ka) or after (~15 ka) loess deposition. Fourth, the Wabash River floodplain features several small alluvial terraces left during downcutting episodes of the Wabash River. The main valley is underlain by outwash, which is buried by channel and point bar sand of the meandering Wabash River. Much of that fluvial scroll bar morphology is subdued by a veneer of fine overbank sediment. A few backswamp lakes were mapped during the first land survey in 1851, but are now mostly sedimented in. Several small pits were dug on the floodplain to mine buried channel or outwash gravels.

Methods

The surficial geology was analyzed from compilations of boring records archived at the Illinois and Indiana State Geological Surveys (ISGS and IGS, respectively) and the Illinois State Water Survey, unpublished geologic field notes, aerial imagery, and soil surveys (Soil Survey Staff 2015a, 2015b, 2015c). Fifty-eight new geotechnical borings from the Illinois Department of Transportation were added to the database. Locations of water well, geotechnical boring, and mineral boring records were confirmed with the best available data. Most of the geotechnical boring locations are likely within 50 ft of their true locations, whereas the accuracy of most water well locations ranges from 25 to 330 ft. The petroleum well inventory is very dense and presumably well-located, but few of those records have useful information about the valley fill or identify the bedrock surface accurately. Some of the petroleum wells do, however, have sample sets that include Quaternary units. New data were generated by study of 56 sample sets in the ISGS Samples Library, a coring program, geophysical surveys, and interpretation of recent high-resolution elevation data (FEMA 2012), and 36 outcrop descriptions. Shallow explorations were completed with percussion coring to depths of 12 to 49 feet at 15 sites, targeting tributary valley fills, terrace assemblages, and loess thickness. One 75-foot deep exploration of a slackwater terrace to bedrock was completed by wireline coring and logged for natural gamma radiation. Interpretation of the core was supported by logging for volumetric magnetic susceptibility, size analyses of 50 samples by laser diffraction, elemental analysis of 60 samples by Energy Dispersive XRF, and 6 clay mineral analyses by XRD. Ages of 8 samples were obtained by AMS ^{14}C assays on wood fragments, and ages of two samples by luminescence methods. Five earth electrical resistivity profiles (8 feet nominal electrode spacing) totaling 1.5 miles in length were obtained. Siting resistivity targets was challenging because of the extensive buried pipelines and other infrastructure. Bedrock soundings by the passive seismic method were made in 8 locations.

Key Findings

Bedrock Uplands

Bedrock supports the ridged uplands. Strong lineation trending SSE and pervasive across the landscape is interpreted as subglacially eroded ridges (Fig. 1). Lineation is evident in overall upland valley orientations, as narrow ridges on uplands and protruding from the valley fill, and as alignments of isolated features. The lineation extends across the Wabash Valley towards the Illinois Episode terminal moraine in Indiana. Although previous researchers had mapped alignment of some ridges (D. McKay, unpublished GIS data), the extent of the lineation could not have been appreciated before the availability of lidar elevation data in 2011. No exposures of lineament interiors were found, although many of the most striking features occur beyond the quadrangle boundary and the generally weak, uniform shale, sandstone, and coal bedrock with shallow dip provides little obvious structural control. Imaging of two of the lineaments by earth electrical resistivity suggested that those landforms were developed largely in the till rather than mainly bedrock sculpting. The origin of this landform class will continue to be researched.

Illinois Episode Units

The bedrock surface in the uplands is buried by less than 10 feet of loess of the Peoria-Roxana Silts over less than 10 feet of till of the Glasford Formation. Exposures along the highwall of the Vigo Coal Company, Inc. surface mine revealed glacifluvial channels 6 feet high and 20 feet wide at the Glasford Formation-bedrock interface and filled with sandy gravel. Outwash of the Pearl Formation associated with the till occurs in lower portions of tributary valley fills (cross sections A-A′ and B-B′). The Pearl Formation is more extensively mappable than it was during previous investigations in the lower Wabash Valley. Similarly, Illinois Episode lacustrine sediment, Petersburg Formation, has not yet been described from this area, although it was regularly encountered during mapping projects in southwest Illinois (Grimley and Phillips 2015).

Wabash Valley

Under the Wabash Valley floodplain southeast of Mount Carmel, a bedrock shelf is buried by 30-50 feet of glacifluvial and meandering stream sediment (cross section B-B′). Although pervasive sand and gravel of the Henry Formation in the Wabash Valley is a potential aquifer, it is suitable only for small sources because it is relatively thin and shallowly-buried. Existing municipal wells are located along the bank of the Wabash River at the very edge of the main bedrock valley, which reaches a local maximum depth of 120 feet deep (290 feet above sea level (asl)) at the east of cross section B-B′ (see also Gray 1982).

Slackwater Terraces

It has long been recognized regionally that the Wabash Valley was a meltwater outlet for several glacial episodes (Fraser 1993). During each episode, outwash filled the main valley and dammed tributary valleys to form slackwater or proglacial lakes, which in turn filled with lacustrine sediment. Horizons with weak soil development and concentrations of plant matter are evidence of episodic drainage. Sediment was also sourced in the small upland basins and was deposited as alluvium prograding from the heads of the valleys. However, pre-Wisconsin Episode deposits were thought to be largely eroded (Phillips and Gemperline 2012; Phillips et al. 2013; Phillips et al. 2015). Core obtained for this project were the first to demonstrate significant preservation of Illinois Episode sediment filling tributary valleys.

The Crawfish Creek valley fill preserves possibly two episodes of slackwater lake sedimentation, based on study of core MTC-C2 (28910, cross section A-A′). Ice completely filled the valley during part of the Illinois Episode. Upon retreat of that glacier, outwash (Pearl Formation) was deposited. A 2-foot-thick bed of till (Glasford Formation), either from ice readvance or collapse of the roof of a subglacial tunnel, demonstrates that the outwash was ice-contact, and that the lower valley fill is indeed from the Illinois Episode. On top of the till, proglacial lacustrine sediment accumulated. Ostracod species preserved in the sediment indicate that the lakes were shallow, likely controlled by the accumulation rate of outwash in the main valley. The lake bed reached a maximum elevation of 390 feet asl. The upper portion of this lacustrine sequence is well weathered, with preservation of an organic-rich A horizon that provided finite ^{14}C dates of ~54 ka, evidence of weathering during the Sangamon Interglacial Episode. A second phase of slackwater deposition occurred during the Wisconsin Episode. Wood fragments from lacustrine clays yielded dates of 32-25 ka (calibrated). Outwash from the Wabash Valley prograded up into the Crawfish Creek valley. The maximum level of outwash accumulation was 415 feet asl.

Acknowledgements

I thank the several landowners who graciously allowed access to their property, especially where drilling was involved. Colleen Kensler at the Wabash County Soil and Water Conservation District was invaluable for making local contacts. The City of Mount Carmel was strongly supportive, and Alex Messamore at the Vigo Coal Company, Inc. was as accommodating as he could be. The ISGS drill team worked diligently to obtain complete core, and Tim Larson and his crew overcame challenging field conditions during geophysical profiling. Olivier Caron and Kisa Mwakanyamale helped some outcrop study. Steven Zhang assisted with drilling and sample description. Deette Lund and Jennifer Carrell constructed the cartography. This map was made possible by the USGS National Cooperative Geologic Mapping Program under StateMap award number G15AC00505, 2015.

References Cited

Bristol, H. M., and J. D. Treworgy (1979). The Wabash Valley Fault System in Southeastern Illinois Circular 509, Illinois State Geological Survey, Champaign, Illinois, 19 pp.

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.

Grimley, D.A. and A.C. Phillips, 2015, Ridges, mounds, and valleys: Glacial-interglacial history of the Kaskaskia Basin, southwestern Illinois: 55th Midwest Friends of the Pleistocene 2011 Field Conference, Illinois State Geological Survey, Guidebook 41, 124 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.

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, 2015a, Soil Survey Geographic (SSURGO) database for Gibson County, Indiana: USDA Natural Resources Conservation Service, Fort Worth, Texas, on line data downloaded from http://Soil-DataMart.nrcs.usda.gov on 09/09/2015.

Soil Survey Staff, 2015b, Soil Survey Geographic (SSURGO) database for Knox County, Indiana: USDA Natural Resources Conservation Service, Fort Worth, Texas, on line data downloaded from http://Soil-DataMart.nrcs.usda.gov on 09/09/2015.

Soil Survey Staff, 2015c, Soil Survey Geographic (SSURGO) database for Wabash County, Illinois: USDA Natural Resources Conservation Service, Fort Worth, Texas, on line data downloaded from http://Soil-DataMart.nrcs.usda.gov on 09/25/2015.

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

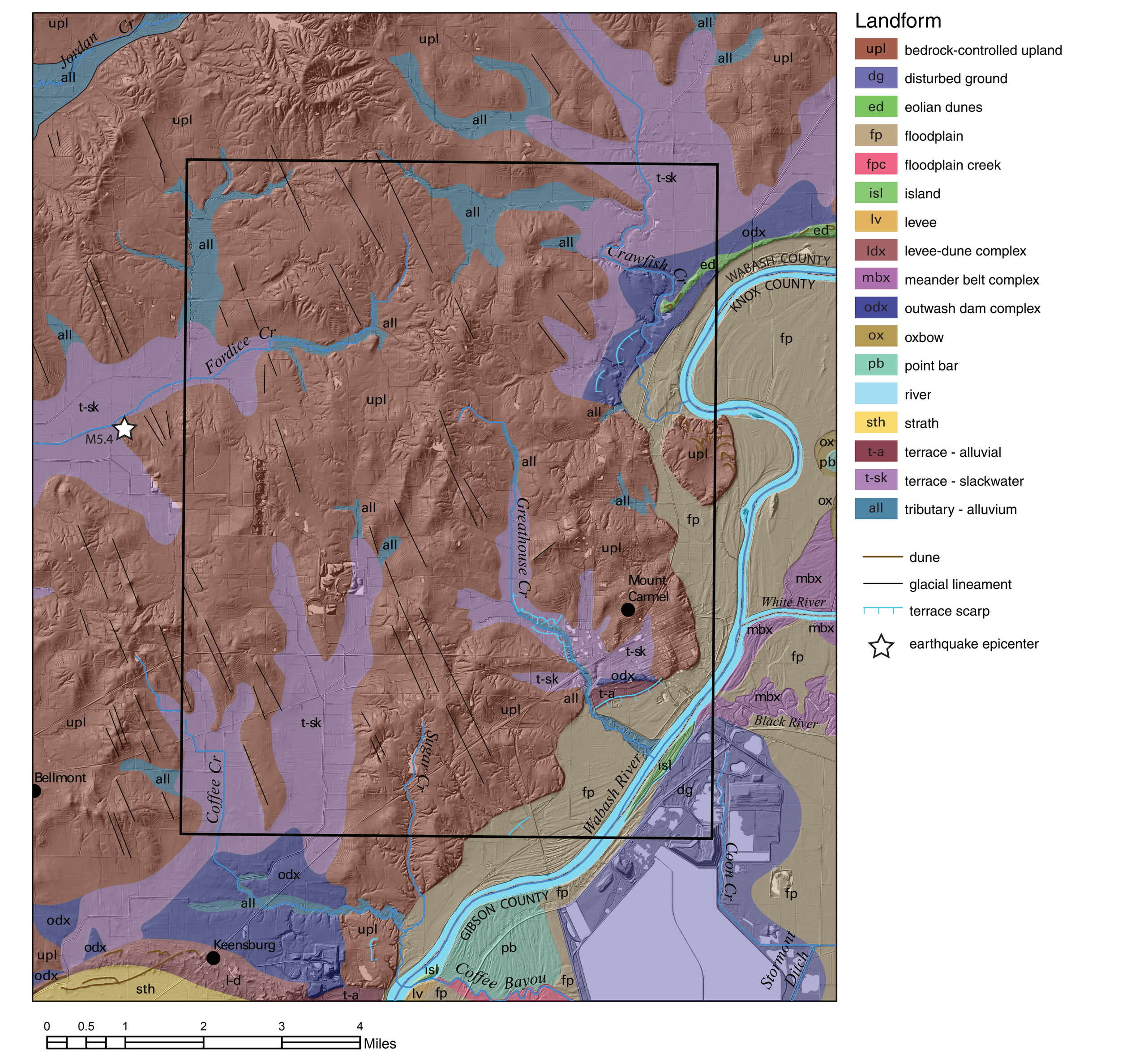


Figure 1 Geomorphic map of Mount Carmel area.