Surficial geology of the Woodstock, IL 7.5 minute Quadrangle, McHenry County, Illinois, scale 1:24,000

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ABSTRACT
The surficial geology of the Woodstock 7.5-minute Quadrangle, which is located in the northwest part of the Chicago-Metropolitan Area, was mapped to better address natural resource issues and better understand local geologic history. In the study area, the population is dependent completely upon groundwater for water supplies, and groundwater withdrawals are expected to increase dramatically in coming decades. The landscape and surficial geologic materials in the Woodstock Quadrangle are a result of numerous glaciations during the Quaternary. Surficial sand and gravel deposits, along with buried outwash deposits from older glacial events, constitute important aquifer and aggregate resources for local residents and industry. The landscape within the Woodstock Quadrangle includes glacial moraines, ice-walled lake plains, kettles, incised valleys, and glacial lacustrine deposits. These landforms, coupled with the thick glacial sediments, record a complicated geologic history associated with glacial processes and paleoclimate change. The surficial geologic map of the Woodstock Quadrangle consists of seven lithostratigraphic units associated with the most recent Wisconsinan glaciations in North America. These geologic units include multiple till deposits, outwash sediments, lacustrine sediments, and modern alluvium and peat deposits. This map provides the base geologic knowledge for planners, decision-makers, and other scientists.

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1. Introduction
McHenry County is one of the fastest growing counties in the Midwest United States. Located 40 miles northwest of Chicago, communities in eastern McHenry County have experienced an explosion of both population and industry. By 2050 water demand for northern Illinois is expected to increase 30–100% (Meyer, Lin, Abrams, & Roadcap, 2013). Currently, groundwater withdrawals slightly exceed 24 MGD. Depending on demand scenarios, those withdrawals could increase between 6 and 43 MGD (Meyer et al., 2013). Thus, there is an urgent need to explore and develop new groundwater resources, which could certainly include the shallow sand and gravel aquifers throughout the county (Thomason & Keefer, 2013). The results of this project will provide a better understanding of the geometry and variability within major surficial geologic units within the Woodstock Quadrangle (Figure 1, Main Map). This will help with developing reliable predictive models of surficial aquifer recharge and groundwater flow systems.

2. Geologic setting
New insights into the geomorphology of McHenry County are developing from high-resolution land surface models that have been generated from light detection and ranging (LIDAR) datasets, and a detailed view of the geomorphology of the Woodstock Quadrangle is a result of these models. Primary landforms in the Woodstock Quadrangle include the regionally extensive Woodstock Moraine and Barlina Moraine, which intersect near the city of Woodstock. The new land surface models have revealed a complex assemblage of stagnant ice features (ice-walled lake plains) overprinted on these moraines. Parts of the Wonder Lake Valley system, which is a complicated network of sub-glacial valleys that were likely later reoccupied by surficial melt water (Curry, Berg, & Vaiden, 1997), are also found along the eastern edge of the Woodstock Quadrangle. The LIDAR land surface models have helped discern terrace levels and glacial meltwater flow paths within the Wonder Lake Valley system and within glacial outwash plains to the north and east of the regional moraines. Furthermore, low-lying, subterranean remnants of glacial lakes or kettles are intermixed with the outwash landscape.

Quaternary deposits cover the vast majority of McHenry County, except for a few creek bed outcrops and quarry exposures in the southwestern part of the county (Curry et al., 1997). These deposits have been generally categorized into the Pre-Illinoian, Illinoian, and Wisconsinan (Figure 2). Most of the modern...
landscape and thickest glacial deposits are derived from the Harvard Sublobe of the Lake Michigan Lobe, which was part of the Laurentide Ice Sheet during the Wisconsinan (Curry et al., 1997).

Pre-Illinoian deposits (>190,000 kya) are largely missing or unidentified in the subsurface throughout the study area (Curry et al., 1997). However, younger deposits of the Illinois Episode (190,000–130,000 kya) are much more ubiquitous. They include the tills of the Glasford and Winnebago formations and associated fluvial deposits of the Pearl Formation. Illinoian deposits occur at land surface along the western edge of McHenry County (Berg, Kempton, Follmer, & McKenna, 1985; Curry et al., 1997). In the Woodstock

Figure 1. Location map of Illinois, McHenry County, and the Woodstock Quadrangle.

Figure 2. Correlation diagram of Quaternary sediment units present in McHenry County (Modified from Curry et al., 1997).
Quadrangle, Illinoisan deposits are completely buried by younger sediments. The Sangamon Interglacial followed the Illinoisan from about 130,000–55,000 years ago (Curry et al., 1997). It is marked largely by the Sangamon geosol, which is found quite commonly in the subsurface throughout McHenry County (Hansel & Johnson, 1996). It is often overlain directly by an early Wisconsinan organic silt called the Robein Silt (55,000–25,000 kya). Collectively, in the Woodstock Quadrangle, these interglacial sediments are commonly preserved beneath the Woodstock Moraine, but they are often eroded and missing within the Wonderland Lake Valley system and its tributaries to the west.

The Harvard Sublobe advanced and retreated through McHenry County at least three times during the Wisconsinan. The Marengo Phase (25,000–23,500 kya) of the Wisconsinan deposited the Tiskilwa Formation throughout the study area, and that formation constitutes the prominent Marengo Moraine in western McHenry County. The Ashmore Tongue of the Henry Formation is the associated outwash deposit, and it is a primary confined aquifer throughout the study area. Subsequently, the Livingston Phase (17,500 kya) of the Harvard Sublobe re-advanced and deposited the fine-grained Yorkville Member of the Lemont Formation. Deposition and preservation of these deposits are limited largely to the south-central portion of McHenry County but form parts of the Huntley and Barlina Moraines. The northern extent of these deposits occur in the subsurface within the Woodstock Quadrangle. The Livingston Phase then retreated back east to what is presently the Chain-O-Lakes Lowland (Curry et al., 1997). The last advance of the Harvard Sublobe into McHenry County was the Woodstock Phase, which buried younger sediments and formed the Woodstock Moraine from northwest to southeast across the county. The Haeger Member, which is a sandy-loam diamicton, constitutes the Woodstock Moraine, and the Beverly Tongue of the Henry Formation is the associated coarse-grained outwash. Deposits of the Woodstock Phase and the associated morphology dominate the landscape of the Woodstock Quadrangle.

3. Previous work

Studies of Quaternary deposits in McHenry County date back to the 1940s. Previous investigations have focused on sand and gravel resources (Anderson & Block, 1962; Specht & Westerman, 1976), regional stratigraphy (Berg et al., 1985), groundwater resources (Curry et al., 1997; Meyer, 1998), and glacial history (Curry & Yansa, 2004). Previous surficial mapping projects in McHenry County have been motivated by planning and natural resources incentives. These study areas include the Fox Lake Quadrangle (Thomason & Barnhardt, 2008), Barrington Quadrangle (Thomason & Barnhardt, 2007), Richmond Quadrangle (Stravers, Kulczycki, & Glowiak, 2003b), McHenry Quadrangle (Stravers, Kulczycki, & Glowiak, 2003a), Huntley Quadrangle (Curry & Thomason, 2012), Marengo North Quadrangle (Stravers, Johnson, & Ekberg, 2006), and Hebron Quadrangle (Carlock, Malone, & Thomason, 2010). Carlock, Thomason, Malone, and Peterson (2016) constructed a 3D model of the Pearl-Ashmore Aquifer in northern McHenry County.

4. Methodology and software

Several surficial datasets and field observations were used together to develop this geologic map. These included Natural Resources Conservation Service (NRCS) soils polygons, water-well records, borehole data, field observations at exposures, surface-elevation datasets, and previously completed maps by Berg (1994) and Curry et al. (1997). The NRCS soils polygons, and their associate parent material texture data, provided the base data for this geologic map. Soil scientists also utilize aerial photography to trace boundaries between various soil types. Soils at a depth of 6 ft are likely more closely related to parent material within the last 24 k years within the Woodstock Quadrangle. Thus, generalizations of similar soil units were used to estimate contacts between geologic units. The geologic contacts were then further modified to conform to the detailed morphology of the LIDAR land surface model. Canvas 15 was used to make the geologic map, text, and explanation. The Canvas layers were inserted into the interactive PDF of the topographic base map.

Water-well records provided additional context for interpreting surficial materials. The Illinois State Geological Survey’s Geological Records Unit had compiled and digitized over 1500 water-well records within the quadrangle. Unfortunately, the water-well records often lacked accurate locations, so they were used largely in a general mapping context. Nonetheless, the uppermost (~5 ft) description of those water-well logs were compared to the soils descriptions in a geologic context, and more than 400 various soils descriptions were standardized to better conform to stratigraphic unit descriptions (Hansel & Johnson, 1996). Well-log records were also standardized to 33 descriptions. When coupled with the soils data, the water-well records helped to increase the accuracy of the surficial geologic map.

In addition to water-well records and soils polygons, a few high-quality geologic cores and downhole geophysical logs helped with the overall interpretation of the regional geologic framework. Within the Woodstock Quadrangle, three 2-in diameter cores were collected to bedrock (>150 ft). These cores provided the best available data to interpret the local geology. Wire-line geophysical logs were also collected from
these three holes, and they provided additional insight into the vertical succession of geologic materials.

5. Results and conclusions

The surficial geologic map of the Woodstock 7.5-minute Quadrangle contains seven lithostratigraphic units based on Hansel and Johnson (1996) unit descriptions. In stratigraphic order from oldest to youngest, they are the Tiskilwa Formation, Yorkville Member, Equality Formation, Henry Formation, Haeger Member, Cahokia Formation, and Grayslake Peat.

Within the quadrangle, the Tiskilwa Formation is located in the western half of the southwest quadrant and is exposed across less than 5% of land surface. The Tiskilwa occurs throughout the County at depth and ranges from 0 to over 300 ft thick. The unit thickens to the west, reaching a maximum thickness of over 300 ft at the Marengo moraine. The Tiskilwa is described as a pinkish-brown, massive diamicton.

The Yorkville Member is present at land surface in the southwest quadrant of the Quadrangle. Most exposures of the Yorkville Member are in the Huntley and Barlina moraines, which are often draped by deposits of ice-walled lake plains (Curry et al., 1997). The Yorkville is a fine-grained, gray, massive diamicton that is dominated by carbonate rock fragments.

The Henry Formation within the Woodstock Quadrangle is located on the east-central portion of the quadrangle and accounts for approximately 20% of surface materials. The unit is predominantly exposed at land surface and pinches out to the southwest. Within the quadrangle, this unit locally scoured the Yorkville Member, because runoff was restricted by the Barlina Moraine to the south west. Henry Formation sediments were generally deposited as braided outwash sediments constrained by the Barlina Moraine to the southwest and the ice margin to the north and northeast.

The Haeger Member is located in the northern half of the Quadrangle and comprises approximately 40% of surface materials. The Haeger Member is a cobbly, sandy-loam diamicton with discontinuous silty to sandy lenses and occasional gravel lenses (Curry et al., 1997).

The Equality Formation is found throughout the Woodstock Quadrangle where meltwater waters collected in the final phases of glacial retreat. Lake sediments account for approximately 10% of surface materials, although they are usually thin (<5 ft thick) and discontinuous. In the quadrangle, most of the Equality Formation is located in broad surficial lowlands. The Equality consists largely of fine-grained lacustrine deposits.

Holocene deposits are common in modern river valleys within the Woodstock Quadrangle. The Cahokia Formation, which is mostly alluvial silt, sand and gravel, is present in modern stream channels throughout the quadrangle in relatively linear geometries and accounts for approximately 5% of surface materials. The Grayslake Peat is composed of organic peat and much that occurs in swampy areas and kettles. Lastly, areas of ‘Disturbed’ land are indicated on the map, and represent surface materials in excess of 5 m that were relocated or removed.

Software

Canvas 15 was used to make the geologic map, text, and explanation.

Disclosure statement

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References

Anderson, R. C., & Block, D. A. (1962). Sand and gravel resources of McHenry County. Illinois State Geological Survey, Circular 336, 15 p.

Berg, R. C. (1994). Geologic aspects of a groundwater protection needs assessment for Woodstock. IL: A Case Study: Illinois State Geological Survey, Environmental Geology 146, p. 38.

Berg, R. C., Kempton, J. P., Follmer, L. R., & McKenna, D. R. (1985). Illinoian and Wisconsinan stratigraphy and environments in northern Illinois: The Altonian revised: Midwest Friends of the Pleistocene 32nd Annual Field Conference Guidebook. Illinois State Geological Survey Field Trip Guidebook 16, 177.

Carlock, D. C., Thomason, J. F., Malone, D. H., & Peterson, E. W. (2016). Stratigraphy and extent of the pearl-ashmore aquifer. McHenry County, IL, USA, World Journal of Environmental Engineering, 4, 6–16.

Carlock, D. R., Malone, D. H., & Thomason, J. F. (2010). Geologic map of the Hebron quadrangle. McHenry County: Illinois State Geological Survey, EDMAP.

Curry, B. B., Berg, R. C., & Vaiden, R. C. (1997). Geologic mapping for environmental planning. McHenry County: Illinois State Geological Survey Circular, 559, 44 p.

Curry, B. B., & Thomason, J. F. (2012). Surficial geology of the Huntley quadrangle. McHenry and Kane Counties: Illinois State Geological Survey, STATEMAP.

Curry, B. B., & Yansa, C. H. (2004). Evidence for stagnation of the Harvard sublobe (Lake Michigan Lobe) in northeastern Illinois, U.S.A., from 24000 to 17600 BP and Subsequent Tundra-Like Ice-Marginal Paleoenvironments from 17600 to 15700 BP. Géographie physique et Quaternaire, 58, 305–321.

Hansel, A. K., & Johnson, H. W. (1996). Wedron and Mason groups: Lithostratigraphic reclassification of deposits of the Wisconsin episode. Lake Michigan Lobe Area: Illinois State Geological Survey, Bulletin, 104, 64 p.
Meyer, S. C. (1998). *Ground-water studies for environmental planning*. McHenry County: Illinois Department of Natural Resources, Illinois State Water Survey: Hydrology Division, Contract Report 630, 141 p.

Meyer, S. C., Lin, Y.-F., Abrams, D. B., & Roadcap, G. (2013). *Groundwater simulation modeling and potentiometric surface mapping*. McHenry County, Illinois State Water Survey Contract Report 2013-06, 224 pp.

Specht, S. A., & Westerman, A. A. (1976). *Geology for planning in McHenry County*: Illinois State Geological Survey, Open File Series 1976–3. Scanlon, Bridget R., and Cook, Peter G., 2002, Theme issue on groundwater recharge. *Hydrogeology Journal*, 10, 3–4. doi:10.1007/s10040-001-0175-3

Stravers, J., Johnson, B., and Ekberg, D. (2006). *Geologic map of the Marengo south quadrangle*. Illinois State Geological Survey, EDMAP Series.

Stravers, J., Kulczycki, & Glowiak, E. (2003a). *Geologic map of the McHenry quadrangle*. Illinois State Geological Survey, EDMAP.

Stravers, J., Kulczycki, & Glowiak, E. (2003b). *Geologic map of the Richmond quadrangle*. Illinois State Geological Survey, EDMAP.

Thomason, J. F., & Barnhardt, M. L. (2007). *Surficial geology of the Barrington Quadrangle, McHenry, Cook and Kane Counties, Illinois*. Illinois State Geological Survey, Statemap.

Thomason, J. F., & Barnhardt, M. L. (2008). *Surficial geology of the Fox Lake Quadrangle, McHenry and Lake counties, Illinois and Kenosha County, Wisconsin*. Illinois State Geological Survey, CGLGMC Fox Lake-SG.

Thomason, J. F., & Keefer, D. A. (2013). *3-D geologic mapping in McHenry County, Illinois*. Illinois State Geological Survey Contract Report.