SUMMARY REPORT OF THE SURFICIAL GEOLOGIC MAP OF THE SALEM 7.5' QUADRANGLE, HENRY AND LEE COUNTIES, IOWA

Iowa Geological Survey
Open File Map OFM-19-4
June 2019

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Supported in part by the U.S. Geological Survey
Cooperative Agreement Number G18AC00194
National Cooperative Geologic Mapping Program (STATEMAP)
This work was partially supported by a National Science Foundation Award:
Improving Undergraduate STEM Education Grant GP-IMPACT-1600429.

INTRODUCTION

The Salem Quadrangle is located in southeastern Iowa on the Southern Iowa Drift Plain landform region (Prior and Kohrt, 2006). The map area is dominated by loess-mantled till plains in the uplands and glacial outwash and finer-grained alluvial deposits within the Skunk River and its tributaries. Stratigraphically, this area contains Wisconsin age Peoria Formation loess deposits mantling Pre-Illinoian age glacial deposits. Illinoian glacial deposits, which are only present in a small area of southeastern Iowa, are located just to the east of the mapping area. The terminal moraine is between approximately two and three miles to the east of the Salem Quadrangle. The thickness of Quaternary materials varies widely across the quadrangle, generally ranging from 0 to 18 m (0-60 ft) and reaching a maximum thickness of 50 m (165 ft) in a bedrock valley in the northeastern part of the mapping area. Shallow rock areas, as identified on the county soil surveys (Lockridge, 1979; Seaholm, 1985), are located along Sugar Creek as well as the Skunk River and its tributaries including Fish and Bogue creeks.

Mapping the Mount Pleasant and Salem quadrangles is the third phase of a multi-year program to map the surficial and bedrock geology of southeast Iowa. It has been nearly 40 years since Hallberg (1980a,b) established the stratigraphy for the Illinoian and Pre-Illinoian glacial advances in eastern and southeastern Iowa. The majority of the drill cores and outcrops for those studies were to the north and east of the Salem Quadrangle and provide the stratigraphic framework for the mapping area. Additional data available since that time (LIDAR, DEMs, and digital soil surveys) have allowed for the refinement of the Illinoian boundary and greater detail in mapping the valleys. The Lowell and Danville quadrangles were mapped in FY16 (Clark et al., 2017a,b; Tassier-Surine et al., 2017a,b) as well as the Sperry and West Burlington quadrangles in FY17 (Clark et al., 2018a,b; Tassier-Surine, 2018a,b). The only other surficial map of the area consists of the Des Moines 4˚ x 6˚ Quadrangle at a scale of 1:1,000,000 (Hallberg et al., 1991). Several Iowa Geological Survey (IGS) field trip guidebooks outline the Pleistocene, Devonian, and Mississippian stratigraphy (Witzke et al., 2002; Witzke and Tassier-Surine, 2001), but their focus is on the area near Burlington (to the east).

PURPOSE

Detailed geologic mapping in southeast Iowa was completed as part of the IGS's ongoing participation in the United States Geological Survey (USGS) STATEMAP Program. Mapping was completed as part of the IGS Developing Areas and Impaired Watershed mapping initiatives and provides comprehensive surficial and bedrock geologic information. These maps are the basis for further development of derivative datasets and map products for use by local, county and state decision-makers. An increased demand for groundwater resources in the region, new research into the Lower Skunk River watershed, development of additional aggregate resources, and expanding urban areas led to the selection of southeast Iowa as a target for geologic mapping by the Iowa State Mapping Advisory Committee (SMAC). Key societal concerns that can be aided by this mapping project include watershed management, groundwater quantity and quality assessment, flood mitigation, aggregate resource protection, and land use planning and development.

Bedrock mapping efforts were successful in subdividing the Mississippian Augusta Group used by Witzke and others (2010) into the Warsaw, Keokuk, and Burlington formations and in better identifying Pennsylvanian outliers. Quaternary mapping efforts focused on better delineation and characterization of the glacial deposits, gaining an understanding of the nature of the Skunk River alluvial system and terrace deposits, confirming loess thickness in the region, and delineating areas of shallow bedrock. The map area includes the Skunk River, which carried outwash from the Wisconsin age Des Moines Lobe glacial advance. Prior to the recent mapping, little information was available regarding the nature and thickness of sand and gravel deposits in the Skunk River. Mapping has helped to further delineate alluvial terraces, as well as identify and characterize sand and gravel resources associated with glacial outwash. Combining the bedrock and surficial map information is allowing stakeholders to address key questions related to shallow rock areas, groundwater protection, water supply concerns, and aggregate resource potential and protection.

QUATERNARY HISTORY AND REGIONAL SETTING

The glacial history of Iowa began more than two million years ago, as at least seven episodes of Pre-Illinoian glaciation occurred between approximately 2.6 and 0.5 million years ago (Boellstorff, 1978a,b; Hallberg, 1980a). Early researchers believed there were only two episodes of Pre-Illinoian glaciation in Iowa. Later regional studies determined that at least seven episodes of Pre-Illinoian glaciation had occurred and led to the abandonment of the classic glacial and interglacial terminology: Kansan, Aftonian and Nebraskan (Boellstorff, 1978a,b; Hallberg, 1980a, 1986). Hallberg (1980a,b, 1986) undertook a regional scale project in east-central Iowa that involved detailed outcrop and subsurface investigations, including extensive laboratory work and synthesis of previous studies. Hallberg’s study marked a shift from the use of time-stratigraphic terms and resulted in the development of a lithostratigraphic framework for Pre-Illinoian till. In east-central Iowa, Hallberg formally classified the units into two formations on the basis of differences in clay mineralogy: the Alburnett Formation (several undifferentiated members) and the younger Wolf Creek Formation (including the Winthrop, Aurora and Hickory Hills members). Both formations are composed predominantly of till deposits, but other materials are present. Paleosols are formed in the upper part of these till units.

A limited area of southeastern Iowa was glaciated during the Illinois Episode, around 190,000 to 130,000 years ago (Curry et al., 2011). These deposits are to the east of the mapping area, but the valley configuration and alluvial deposits may have been influenced by the Illinoian glacial advance. Following the Illinoian glaciation, this area underwent landscape development and erosion until deposition of the Wisconsin Episode loess began. The Pre-Illinoian till is only exposed in drainages and relatively steep sideslopes.

In eastern Iowa, the highly eroded and dissected Illinoian and Pre-Illinoian upland and older terraces are mantled by two Wisconsin loesses. The older Pisgah Formation is thin and includes loess and related slope sediments that have been altered by colluvial hillslope processes. The unit is characterized by the presence of a weakly developed soil recognized as the Farmdale Geosol. It is not uncommon to see the Farmdale developed throughout the Pisgah Formation and into the underlying older Sangamon Paleosol. The Pisgah loess was most likely deposited on the eastern Iowa landscape from 30,000 to 24,000 years ago (Bettis, 1989) and is typically buried by Peoria Formation loess. The Peoria Formation loess accumulated on stable landsurfaces in eastern Iowa from 25,000 to 21,000 years ago. Peoria Formation eolian materials mantle the upland till units and are present on the Wisconsin outwash terraces. On the uplands, the Peoria Formation is a uniform silt loam; in the valleys the silt commonly grades downward to fine sand. The loess deposits in the mapping area are relatively thin, generally less than 4 meters (12 ft).

The Skunk River deposited coarse sand and gravel associated with glacial outwash (Noah Creek Formation) of the Des Moines Lobe during the Wisconsin Episode. Based on the alluvial framework established by Esling (1984), three terrace assemblages can be identified: the Early and Late Phase high terraces, and Low Terrace deposits. The high terraces are characterized by the presence of Peoria and Pisgah formation sediments overlying alluvium, with or without the intervening Sangamon Paleosol. Low

Terrace deposits are younger and not overlain by the Peoria loess. These terraces are found along the Skunk River.

Hudson age deposits are associated with fine-grained alluvial, organic, and colluvial sediments and include the DeForest Formation which is subdivided into the Camp Creek, Roberts Creek, and Gunder members. These deposits are present in valleys and upland drainages throughout the map area. The Holocene low terrace deposits occupy the active channel belt of the Skunk River. Both an intermediate and high Holocene terrace are present along the Skunk River and may be several meters above the modern floodplain. Due to the difficulty of differentiating these terraces where only one was present, they were combined into one mapping unit.

METHODS

Numerous existing sources of geologic information were utilized in the production of the surficial and bedrock geologic maps of the Salem Quadrangle including subsurface information, USDA NRCS soil survey data, aerial photography, DEM's, satellite imagery, landform characteristics, and LiDAR. Where available, engineering borings from public utilities, the Iowa Department of Transportation, and monitoring well records of the USGS were used. Subsurface lithologic and stratigraphic information was mostly derived from analysis of water well cutting samples reposited at the IGS and stored in the IGS online GeoSam database. Over 250 public and private wells in GeoSam, including strip logs, were reviewed for lithology, stratigraphy and locational accuracy, and updated where needed. NRCS digitized soils data (Lockridge, 1979; Seaholm, 1985) provided information regarding shallow rock areas, helped to guide valley mapping units, and defined slope areas where glacial till is exposed. Bedrock mappers also used the digital soil surveys to help delineate areas of shallow rock outcrop prior to field reconnaissance. New geologic information was obtained from logging of well cutting samples for 35 unstudied wells totaling 4,988 feet. Quaternary geologists utilized the IGS truck mounted Giddings probe to drill a mix of solid stem and continuous core holes. Ten new drill holes totaling 279 feet were completed in or near the quadrangle to characterize the Quaternary sediments and establish unit thickness. Samples are being processed for grain-size with all results expected by July, 2019. Laboratory data will be incorporated into the online IGS GeoLab database. A preliminary study using HVSR passive seismic equipment was conducted to determine depth to bedrock in select areas to assist with producing the bedrock topography map.

Project geologists combined information from the sources listed above to delineate surficial geologic mapping units at 1:24,000 scale for the Salem Quadrangle. IGS mappers used ArcGIS and on-screen digitizing techniques developed during previous STATEMAP projects. The final map entitled 'Surficial Geologic Map of the Salem 7.5' Quadrangle, Henry and Lee Counties, Iowa' will be available as a shapefile in the Iowa GEODATA Clearing House (https://geodata.iowa.gov), as a PDF file on the IGS Publications website, and will be submitted to the USGS National Geologic Map Database. This Summary Report is also available as a PDF file on the IGS Publications website.

STRATIGRAPHIC FRAMEWORK FOR SOUTHEAST IOWA

The stratigraphic framework for southeast Iowa was established by Hallberg (1980a,b) nearly 40 years ago. Surficial deposits in the map area are composed of six formations (youngest to oldest): Hudson DeForest; Wisconsin Peoria, Pisgah, and Noah Creek; and Pre-Illinoian Wolf Creek and Alburnett. Hudson age deposits associated with fine-grained alluvial, organic, and colluvial sediments include the DeForest Formation which is subdivided into the Camp Creek, Roberts Creek, Gunder, and Corrington members.

The Noah Creek Formation includes coarse sand and gravel associated with outwash from the Des Moines Lobe. Loess deposits include both Peoria and Pisgah formation silt that are present mantling the upland till units and high terraces. On the high terraces, the Peoria Formation grades downward to eolian sand. Eolian deposits are found intermittently on Holocene terraces. Pre-Illinoian glacial deposits are found throughout the mapping area and consist of two formations: the younger Wolf Creek Formation and the Alburnett Formation. The Wolf Creek Formation is divided into the Winthrop, Aurora, and Hickory Hills members (oldest to youngest). The Alburnett Formation consists of several “undifferentiated” members. Pre-Illinoian tills are only exposed in drainages and relatively steep slopes.

Four bedrock mapping units (Pennsylvanian lower Cherokee Group; and the Mississippian Pella or “St. Louis”, Warsaw, and Keokuk formations) are exposed at the bedrock surface in the Salem Quadrangle. The Mississippian Pella or “St. Louis” formations and the Pennsylvanian lower Cherokee Group comprise the bedrock surface in most of the map area, especially in the upland areas. The other Mississippian units occur within the bedrock valleys and tributaries. Bedrock exposures or rock present within one to two meters (7 ft) of the land surface are designated as ‘Qbr’ on the map. Specific bedrock units are shown on the cross-section and defined in the legend. For detailed bedrock information see The Bedrock Geologic Map of the Salem 7.5’ Quadrangle (Clark et al., 2019).

Recent studies and mapping indicate that the map area encompasses a complex suite of depositional landforms and sediment sequences related to glaciations, alluviation, subaerial erosion, and wind-blown transport. To map diverse landscapes at 1:24,000 scale, we have selected the most comprehensive mapping strategy- a landform sediment assemblage (LSA) approach. Various landforms are the result of specific processes at work in the geologic system. Landforms typically have similar relief, stratigraphic and sedimentologic characteristics. Recognition of the genetic relationship among landforms and their underlying sediment sequences allows one to generalize and map complex glacial terrains over areas of large extent (Sugden and John, 1976; Eyles and Menzies, 1983). Bettis and others (1999) found that LSA mapping concepts were extremely useful in overcoming the difficulties of mapping in large valleys and noted that LSA's provided a unique opportunity to associate landforms with their underlying sediment packages. Eight landform sediment assemblage units were identified in the map area utilizing aerial imagery, topographic expression, digitized soils, LiDar, and existing and new subsurface geologic boring information. The following is a description of each landform sediment assemblage listed in order of episode:

HUDSON EPISODE

Qal - Alluvium (DeForest Formation-Undifferentiated) Variable thickness of less than 1 to 5 m (3-16 ft) of very dark gray to brown, noncalcareous or calcareous, stratified silty clay loam, clay loam, loam to sandy loam alluvium and colluvium in stream valleys, on hill slopes and in closed depressions. May overlie Pre-Illinoian formation glacial tills, Peoria Formation loess or eolian sand, or Noah Creek Formation sand and gravel. Associated with low-relief modern floodplains, closed depressions, modern drainageways, or toeslope positions on the landscape. Seasonal high water table and potential for frequent flooding. The depth to bedrock may be less than 8 m (26 ft) along portions of Sugar Creek.

Qallt - Low Terrace (DeForest Formation-Camp Creek and Roberts Creek members) Variable thickness of less than 1 to 5 m (3-16 ft) of very dark gray to brown, noncalcareous, stratified silty clay loam, loam, or clay loam, associated with the modern channel belt of the Skunk River. Overlies Noah Creek Formation sand and gravel. Occupies the lowest position on the floodplain ie. modern channel belts. Seasonal high water table and frequent flooding potential.

Qali-ht - Intermediate-High Terrace (DeForest Formation-Roberts Creek and Gunder members) Variable thickness of less than 1 to 5 m (3-16 ft) of very dark gray to brown, noncalcareous, silty clay loam to loam alluvium or colluvium. Overlies Noah Creek Formation sand and gravel along the Skunk River. Occupies terrace and valley margin positions 1 to 2 m (3-7 ft) above the modern floodplain. Two terrace levels are present in some areas. Seasonal high water table and low to moderate flooding potential.

WISCONSIN EPISODE

Qnw - Sand and Gravel (Noah Creek Formation) Generally 3 to 9 m (10-30 ft) of yellowish brown to gray, poorly to well-sorted, massive to well-stratified, coarse to fine feldspathic quartz sand, pebbly sand and gravel with few intervening layers of silty clay. This unit is buried by Peoria Formation silt or younger Hudson-age alluvial deposits associated with the Skunk River valley and encompasses deposits that accumulated in river valleys during the Wisconsin Episode. This unit is shown only on the cross-section.

Qpt - Loess Mantled Terrace (Peoria Formation-silt and/or sand facies) 2 to 7 m (7-23 ft) of yellowish brown to gray, massive, jointed, calcareous or noncalcareous, silt loam and intercalated fine to medium, well-sorted, sand. May grade downward to poorly to moderately well-sorted, moderately to well-stratified, coarse to fine feldspathic quartz sand, loam, or silt loam alluvium (Late Phase High Terrace) or may overlie the Farmdale Geosol developed in Pisgah Silt which in turn overlies a well-expressed Sangamon Geosol developed in poorly to moderately well-sorted, moderately to well-stratified, coarse to fine sand, loam, or silt loam alluvium (Early Phase High Terrace).

Qps - Loess (Peoria Formation-silt facies) Generally 2 to 5 m (7-15 ft) of yellowish to grayish brown, massive, jointed calcareous or noncalcareous silt loam to silty clay loam. May overlie a grayish brown to olive gray silty clay loam to silty clay (Pisgah Formation and/or Farmdale Geosol) which is less than 1.5 m (5 ft) thick. The Pisgah Formation is in the same stratigraphic position as the Roxanna Silt which is mapped in Illinois. The Farmdale Geosol may be welded to an older Sangamon Geosol developed in loamy glacial till of the Wolf Creek or Alburnett formations. This mapping unit encompasses upland divides, ridgetops, and convex sideslopes. Well to somewhat poorly drained.

PRE-ILLINOIS EPISODE

Qwa3 - Till (Wolf Creek or Alburnett formations) Generally 10 to 18 m (33-60 ft) of very dense, massive, fractured, loamy glacial till of the Wolf Creek or Alburnett formations with or without a thin loess mantle (Peoria Formation- less than 2 m) and intervening clayey Farmdale/Sangamon Geosol. This mapping unit encompasses narrowly dissected interfluves and side slopes, and side valley slopes. Drainage is variable from well drained to poorly drained.

OTHER MAPPING UNITS

Qbr - Loamy Sediments Shallow to Dolomite, Limestone, Shale and Sandstone (DeForest, Noah Creek, Peoria, Wolf Creek, and Alburnett formations) - 1 to 2 m (3-7 ft) of yellowish brown to gray, massive to weakly-stratified, well to poorly-sorted loamy, sandy and silty sediments that overlie the Pennsylvanian or Mississippian bedrock surface. All areas of bedrock outcrop or shallow to bedrock soils are shown in red on the map, regardless of the bedrock mapping unit. Bedrock units are shown on the cross-section and may be identified on the bedrock map of the Salem Quadrangle.

ACKNOWLEDGEMENTS

Special thanks to the landowners who allowed access to their properties for drilling: JoAnn Holtkamp, David Shinstock, Marcus Smith, Nick Smith, and Phillip Pietz. Drilling was provided by Matthew Streeter of the Iowa Geological Survey (IGS) with the assistance of University of Iowa (UI) student Brennan Slater. Jason Vogelgesang of the IGS helped with geophysical data acquisition. UI student Travis Maher and Cornell College student Gabi Hiatt prepared well cutting samples for stratigraphic logging. New subsurface geologic data was generated by Megan Koch and Alethea Kapolas, UI Department of Earth and Environmental Sciences students, by producing descriptive logs of water well drilling samples. Megan Koch and Allison Kusick also helped with well locations and data management. Thanks also to Rick Langel (IGS) for managing the Iowa geologic sampling database (GeoSam). Special thanks to Kathy Woida of the Natural Resources Conservation Service and Art Bettis (retired), UI Department of Earth and Environmental Sciences, for assistance with core description and for numerous valuable discussions regarding the geology of southeast Iowa. Casey Kohrt and Chris Kahle of the Iowa Department of Natural Resources provided GIS technical help. Administrative support was provided by Suzanne Doershuk, Melissa Eckrich, Teresa Gaffey, Carmen Langel, and Rosemary Tiwari.

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