SUMMARY REPORT OF THE SURFICIAL GEOLOGIC MAP OF THE CHARLES CITY 7.5' QUADRANGLE, FLOYD COUNTY, IOWA

Iowa Geological Survey
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PURPOSE

Detailed geologic mapping of the Charles City 7.5' Quadrangle was completed as part of the Iowa Geological Survey's (IGS) ongoing participation in the STATEMAP mapping program. This initial mapping provides basic surficial geologic information which is the basis to further develop derivative datasets and map products for use by local, county and state decision-makers. The STATEMAP component of the National Cooperative Geologic Mapping Program has enhanced the IGS ability to produce geologic maps. Iowa's mapping program addresses short- and long-term priority state-wide issues. Input from the State Mapping Advisory Committee (SMAC) has recommended mapping in areas with environmental concerns, related to groundwater quality and land-use planning issues. IGS and SMAC recognize the need for maps of varying scales to address the complex environmental issues facing urban and rural Iowans. Issues in developing urban areas center around residential and commercial development along major transportation corridors, rapid subdivision expansion on the fringes of urban areas and related problems with septic system siting, aggregate potential (identification and protection of resources), sensitive areas identification, and water quality and quantity issues. In rural areas, issues are focused on the proper siting of animal confinement facilities, water quality, watershed management, nutrient management, wetland delineation and protection, and aggregate potential mapping.

INTRODUCTION

The Charles City 7.5' Quadrangle of Floyd County covers an area from 43° 0' to 43° 7' 30" N latitude and 92° 45' to 92° 37' 30" W longitude. It is located within the Wisconsin-age Iowan Surface landform region of north-central Iowa which is defined by large scale erosion (Prior and Kohrt, 2006). The current post-settlement landscape, which is heavily tilled, is being re-shaped by frequent precipitation and gradual overland water and sediment movement and dissected by less frequent large rainfall events (Cruse et al., 2006). Quaternary deposits in this quadrangle generally vary in thickness from 9 to 27 m (30-90 ft), but may reach a maximum thickness of 71 m (235 ft) in bedrock valleys occurring in the east-central and northeast parts of the mapping area. The map area is dominated by loamy sediments (unnamed erosion surface sediment) of variable thickness overlying Pre-Illinoian glacial sediments, but may also be overlying Wisconsin-age Sheldon Creek Formation glacial sediments or shallow rock. These deposits are regionally extensive as shown on the Des Moines 4° x 6° Quadrangle at a scale of 1:1,000,000 (Hallberg et al., 1991). Areas of bedrock outcrop or areas with less than 4.5 m (15 ft) of loamy material over rock are present, especially along the Cedar River.

Statewide bedrock geologic maps by Hershey (1969), and most recently by Witzke and others (2010), illustrate the improved understanding of the complex distribution of geologic units at the bedrock surface across north-central Iowa, including Floyd County. Previous surficial geologic mapping completed as part of the STATEMAP program near the project area includes Surficial Geology of Worth County, Iowa (Quade et al., 2012), Surficial Geology of the Osage Quadrangle (Tassier-Surine et al., 2014a), Surficial Geology of the St. Ansgar Quadrangle (Tassier-Surine et al., 2014b), Surficial Geology of the New Haven Quadrangle (Kerr et al., 2015), and Surficial Geology of Cerro Gordo County, Iowa (Tassier-Surine et al., 2015).

The map region has a rich and complex geologic history punctuated by at least seven periods of glaciation between 2.6 million to 500,000 years before present (Boellstorff, 1978a, b; Hallberg, 1980b, 1986). In this area, Pre-Illinois Episode glacial deposits and associated buried soils are overlain by much younger Wisconsin-age glacial deposits. Early researchers believed there were only two episodes of Pre-

Illinoian glaciation in Iowa: Kansan and Nebraskan. Later regional studies determined that at least seven episodes of Pre-Illinoian glaciation occurred in this region between approximately 2.6 million to 500,000 years ago (Boellstorff, 1978a, b; Hallberg, 1980a, 1986). Hallberg (1980a, b; 1986) undertook a regional scale project that involved detailed outcrop and subsurface investigations including extensive laboratory work and synthesis of previous studies. This study led to the abandonment of the classic glacial and interglacial terminology: Kansan, Aftonian and Nebraskan. Hallberg's research marked a shift from the use of time-stratigraphic terms to lithostratigaphic classification. The result of Hallberg's study was 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. Regionally extensive upland units were not deposited in the map area between 500,000 to 300,000 years ago. During this period several episodes of landscape development resulted in the formation of an integrated drainage network, slope evolution and soil development on stable land surfaces (Bettis, 1989).

During the earlier and mid Wisconsin-age, ice advances dating from approximately 40,000 to 26,000 years before present deposited glacial materials throughout the map area. In Iowa, this glacial deposit is formally recognized as the Sheldon Creek Formation (Bettis et al., 1996, Bettis, 1997) and in earlier literature is referred to as the "Tazewell till" (Ruhe, 1950). Results from this mapping program and others in Worth and Cerro Gordo counties indicate that the Sheldon Creek glacial materials extend much farther east than was previously thought. In the Charles City Quadrangle, the Sheldon Creek boundary was defined based on drill hole data, topography, and current soil maps. A period of intense cold occurred during the Wisconsin full glacial episode from 21,000 to 16,500 years before present (Bettis, 1989). This cold episode and ensuing upland erosion led to the development of the distinctive landform recognized as the Iowan Surface (IS) (Prior, 1976). A periglacial environment prevailed during this period with intensive freeze-thaw action, solifluction, strong winds, and a host of other periglacial processes (Walters, 1996). As a result, soils were stripped from the IS, and the Sheldon Creek and Pre-Illinois till surface was significantly eroded, resulting in the development of a region-wide colluvial lag deposit referred to as a "stone line." Another common feature are ice-wedge casts which developed in the colluvial sediments and stone lines. The ice wedges are remnants of ice-wedge polygons that formed in frozen sediments (permafrost) during this period of intense cold. Thick packages of stratified loamy and sandy sediments located low in the upland landscape and adjacent to streams are remnants of solifluction lobes dating to this period. Associated with the formation of the IS, thick wedges of sediment were transported downslope. In the map area, along the course of the Cedar River and its tributaries, bedrock exposures are common along the valley and alluvial deposits are relatively thin. On slopes near this area, the colluvial cover is the only protection for local groundwater resources.

The depositional history of the IS was under great debate for an extended period of time. Early researchers believed the IS was a separate glaciation occurring sometime between the Illinois and the Wisconsin episodes. Later work disproved this idea and determined that erosional processes controlled the landscape development (Ruhe et al., 1968). Hallberg and others (1978) revisited the IS to further research studies into the mechanisms behind the formation of the erosion surface, to reiterate Ruhe's classic work on stepped erosion surfaces, and to illustrate the need for continued research in the area. Beyond the IS, the Peoria Loess continued to accumulate until 13,000 years before present, and in some parts of the IS a thin

increment of loess accumulated as the climate ameliorated approximately 14,000 to 12,000 years ago (Bettis, 1989).

Surficial deposits within the map area are composed of six formations: DeForest, Noah Creek, Peoria, Sheldon Creek, Wolf Creek, and Alburnett formations, as well as unnamed erosion surface sediments. Hudson-age DeForest formation deposits include fine-grained alluvial, organic, and colluvial sediments that are subdivided into the Camp Creek, Roberts Creek, Gunder, Corrington, Flack, and Woden members. The Noah Creek Formation includes coarse sand and gravel to finer grained fluvial deposits associated with local stream and river valleys. Unnamed erosion surface sediments consist of reworked till and slopewash deposits associated with periglacial activity during the Wisconsin ice advance. Areas of Peoria Formation eolian materials are intermittently present mantling most other mapping units, and are more abundant near stream valleys. Sheldon Creek Formation glacial deposits are undifferentiated and occur in northwest and north-central Iowa. The maximum extent of these deposits is still not fully understood. However, a boundary has been identified within the Charles City Quadrangle. Pre-Illinoian glacial deposits in Iowa 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.

Four bedrock mapping units (the Cretaceous Dakota/Windrow Formation, and the Devonian Lithograph City, Coralville, and Little Cedar formations of the Cedar Valley Group) are present at the bedrock surface in the quadrangle. The Lithograph City Formation occurs at the bedrock surface over most of the mapping area while the Coralville and Little Cedar formations occur within bedrock valleys. One bedrock mapping unit (Lithograph City formation) is exposed as outcrop in the map area. A total of 17 bedrock outcrops including a few abandoned quarries, which are mostly along the Cedar River and its tributaries, have been accessed and studied in the map area. The Devonian rocks are dominated by carbonates varying between limestone and dolomite, accompanied with minor shale. The Cretaceous Dakota/Windrow Formation is characterized as a reddish, shaly sandstone with siderite pellets.

METHODS

Numerous sources of geologic information were utilized in the production of these maps including subsurface information, USDA Natural Resources Conservation Service (NRCS) soil survey data, aerial photography, satellite imagery, and LiDAR. Subsurface information was mostly derived from analysis of water well cutting samples reposited at the IGS. Lithologic and stratigraphic information from these samples are stored in the IGS online GEOSAM database. Where available, engineering borings from public utilities, the Iowa Department of Transportation, and monitoring well records of the USGS were used. A total of 250 public and private wells in GEOSAM were reviewed. New geologic information was obtained from field investigations of outcrops and quarry exposures, logging of unstudied well cutting samples, and core drilling. The locations of data points in the IGS GEOSAM database were checked for accuracy and updated where needed. Seventeen outcrops, including quarries, were visited and described. Cutting samples for unstudied wells in the project area were studied and logged. Quaternary mappers used available NRCS digitized soils data to assist with delineating areas with loess cover, thin or no loess cover, shallow bedrock, extent of alluvium, and to attempt to differentiate till sheets.

Quaternary geologists worked with a contract driller to drill deeper cores to sample the unconsolidated material package at selected locations across the study area. A total of 50 holes were drilled using a mix of solid-stem flight auger and continuous core methods. Representative samples have been submitted to the Quaternary Materials Lab at the University of Iowa's Earth and Environmental Sciences Department for

grain-size analysis. Project geologists combined information from many different sources, including water well logs, shallow landscape/sediment package drilling, deeper (to bedrock) drilling, digital elevation models, field mapping, data from soil surveys, and morphological characteristics viewed on aerial imagery to delineate surficial geologic mapping units at 1:24,000 scale for the Charles City 7.5' Quadrangle in Floyd County.

The IGS mappers used ArcGIS and on-screen digitizing techniques developed during previous STATEMAP projects. The map will be stored and available as a shapefile in the Iowa Department of Natural Resources NRGIS library, as a pdf file on the IGS Publications website, and will be submitted to the USGS National Geologic Map Database.

DESCRIPTION OF NORTH-CENTRAL IOWA STRATIGRAPHY

An important aspect of surficial geologic mapping on the IS is the development of map units that utilize previously established lithostratigraphic frameworks for the Hudson, Wisconsin and Pre-Illinoian deposits in Iowa. A stratigraphic framework allows us to better understand the surficial materials of north-central Iowa. Hudson, Wisconsin and Pre-Illinois Episode deposits (Johnson et al., 1997) of north-central Iowa are included in six formations: DeForest Formation (Hudson), Noah Creek Formation (Hudson and Wisconsin), Peoria Formation (Wisconsin), Sheldon Creek Formation (Wisconsin), and Wolf Creek and Alburnett formations (Pre-Illinois). 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, Corrington, Flack and Woden members. The Noah Creek Formation includes coarse sand and gravel associated with outwash from the Des Moines Lobe as well as coarse to finer grained fluvial deposits associated with local stream and river valleys. Unnamed erosion surface sediments consist of reworked till and slopewash deposits associated with periglacial activity during the Wisconsin ice advance. Areas of Peoria Formation eolian materials are present along the Cedar River valley as well as stringers on the IS surface. Eolian materials may also be intermittently present mantling most other mapping units, and are more abundant near stream valleys. Sheldon Creek Formation glacial deposits are undifferentiated and occur in northwest and north-central Iowa. The full extent of these deposits is still not fully understood, but the boundary is believed to be present in Floyd County near Charles City, Iowa. Pre-Illinoian glacial deposits in Iowa consist of two formations: the younger Wolf Creek Formation and the Alburnett Formation. The Wolf Creek is divided into the Winthrop, Aurora and Hickory Hills members (oldest to youngest). The Alburnett Formation consists of several "undifferentiated" members.

DESCRIPTION OF LANDFORM SEDIMENT ASSEMBLAGE MAP UNITS

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 LSA mapping concepts were extremely useful in overcoming the difficulties of mapping in large valleys and noted LSA's provided a unique opportunity to associate landforms with their underlying sediment packages.

Thirteen Quaternary-age landform sediment assemblage units were identified in the map area utilizing orthophotos, topographic expression, digitized soil and existing and new subsurface 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 to calcareous, massive to stratified silty clay loam, clay loam, loam to sandy loam alluvium and colluvium in stream valleys, on hillslopes and in closed depressions. May overlie Noah Creek, Sheldon Creek, Wolf Creek or Alburnett formations or fractured Devonian carbonate bedrock. Associated with low-relief modern floodplain, closed depressions, modern drainageways or toeslope positions on the landscape. Seasonal high water table and potential for frequent flooding.

Qalb - Alluvium Shallow to Bedrock (DeForest Formation- Undifferentiated) - Variable thickness of less than 1 to 5 m (3-16 ft) of very dark gray to brown, noncalcareous to calcareous, stratified silty clay loam, clay loam, loam to sandy loam alluvium and colluvium in stream valleys, on hillslopes and in closed depressions. May overlie the Noah Creek Formation or Devonian carbonate bedrock. Bedrock surface is within 5 m (16 ft) of the land surface. Associated with low-relief modern floodplain, closed depressions, modern drainageways or toeslope positions on the landscape. Seasonal high water table and potential for frequent flooding.

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 Cedar River valley. Overlies the Noah Creek Formation. Occupies the lowest position on the floodplain i.e. modern channel belts. Seasonal high water table and frequent flooding potential.

Hudson and Wisconsin Episodes

Qe - Sand Dunes and Sand Sheets (Peoria Formation- sand facies) - Generally less than 3 m (10 ft) of yellowish brown, massive, calcareous loamy sand to fine sand. It may overlie yellowish-brown coarse-grained sand and gravel (Noah Creek Formation), or it may overlie yellowish to grayish brown, usually calcareous, stratified loam to silt loam to sandy loam diamicton (Sheldon Creek, Wolf Creek, or Alburnett formations). Usually restricted to a narrow belt along major river valley bottoms, adjacent uplands, or may occur as sand stringers or dunes overlying unnamed erosion surface sediments.

Qdlgc - Loamy Sediments Shallow to Limestone, Dolomite, and Shale (DeForest, Noah Creek, or Lithograph City formations) - 0 to 2 m (0-7 ft) of yellowish brown to gray, massive to weakly stratified, well to poorly sorted loamy, sandy and silty alluvial sediments that overlie the Middle to Upper Devonian bedrock surface. Bedrock outcrop may be present in isolated areas.

Qnw2 - Sand and Gravel (Noah Creek Formation) - 2 to 12 m (7-40 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. Along many valleys, a thin mantle of loess, reworked loess, or fine-grained alluvium (Qal) may be present. This unit includes silty colluvial deposits derived from the adjacent map units. In places this unit is mantled with 1 to 3 m (3-10 ft) of well sorted fine to medium sand derived from wind reworking of the alluvium. This unit encompasses deposits that accumulated in low-relief stream valleys during the Wisconsin and Hudson episodes. Seasonal high water table and some potential for flooding.

Wisconsin Episode

Qps1 - Loess and Intercalated Eolian Sand (Peoria Formation- silt facies) - 2 to 5 m (7-16 ft) of yellowish brown to gray, massive, fractured, noncalcareous grading downward to calcareous silt loam and intercalated fine to medium, well sorted, sand. Sand is most abundant in lower part of the eolian package. Overlies massive, fractured, loamy glacial till of the Wolf Creek, Alburnett or Sheldon Creek formations with or without the intervening clayey Farmdale /Sangamon Geosol.

Qnw - Sand and Gravel (Noah Creek Formation) - Generally 5 to 15 m (16-49 ft), but there may be significantly thinner coarse-grained deposits in smaller stream valleys. Yellowish brown to gray, poorly to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand, pebbly sand and gravel. This unit encompasses outwash deposits that accumulated in valley trains during the Wisconsin Episode.

Qnw3 - Sand and Gravel Shallow to Bedrock (Noah Creek Formation) - 1 to 3 m (3-10 ft) of yellowish brown to gray, poorly to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand, pebbly sand and gravel. May be overlain by up to 2 m (7 ft) of silty alluvial sediments. In places mantled with fine to medium well sorted feldspathic quartz sand derived from wind reworking of the alluvium. Fractured carbonate bedrock is less than 5 m (16 ft) below the land surface. The unit encompasses deposits that accumulated in river and stream valleys during the late Wisconsin as well as exhumed middle Wisconsin Sheldon Creek Formation materials and/or Pre-Illinois Episode deposits of the Wolf Creek and Alburnett formations.

Qwa2 - Loamy and Sandy Sediment Shallow to Glacial Till (Unnamed erosion surface sediment) - 1 to 3 m (3-10 ft) of yellowish brown to gray, massive to weakly stratified, well to poorly sorted loamy, sandy and silty erosion surface sediment. Map unit includes some areas mantled with less than 2 m (7 ft) of Peoria Silt (loess). Overlies massive, fractured, firm glacial till of the Wolf Creek and Alburnett formations. Seasonally high water table may occur in this map unit.

Qsc2 - Loamy Sediments Shallow to Glacial Till (Unnamed erosion surface sediment) - 1 to 6 m (3-20 ft) of yellowish brown to gray, massive to weakly stratified, well to poorly sorted loamy, sandy and silty erosion surface sediment. Map unit includes some areas mantled with less than 1 m (3 ft) of Peoria Formation (silt or sand facies). Formed in and often overlies massive, fractured, slightly firm glacial till of the Sheldon Creek Formation.

Qsc - Glacial Till (Sheldon Creek Formation- Undifferentiated) - Generally 3 to 6 m (10-20 ft) of yellowish brown to gray, calcareous, fractured to massive clay loam; at depth this unit can be variably textured and contain significant sand and gravel bodies. The upper 3 to 7 m (10-20 ft) may be periglacially altered. This unit overlies Pre-Illinois diamicton or Devonian carbonate bedrock.

Pre-Illinois Episode

Qwa3 - Glacial Till (Wolf Creek or Alburnett formations) - Generally 3 to 49 m (10-215 ft) of very dense, massive, fractured, loamy glacial till of the Wolf Creek or Alburnett formations. This mapping unit can be buried by glacial sediments (Sheldon Creek Formation), unnamed erosion surface sediments, loess, or alluvium.

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