SUMMARY REPORT OF THE SURFICIAL GEOLOGIC MAP OF THE COLWELL 7.5' QUADRANGLE, CHICKASAW, FLOYD, HOWARD, AND MITCHELL COUNTIES, IOWA

Iowa Geological Survey
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INTRODUCTION

This mapping exercise is the second phase of a multi-year project that will lead to a 1:100,000 scale map of Floyd County. The Colwell 7.5’ Quadrangle of Chickasaw, Floyd, Howard, and Mitchell counties covers an area from 43˚ 7’ 30” to 43˚ 15’ 0” N latitude and 92˚ 37’ 30” to 92˚ 30’0” W longitude. A bedrock geologic map was also produced in conjunction with the surficial geologic map (Liu et al., 2017). It is located within the Wisconsin-age Iowan Surface (IS) landform region of north-central Iowa which is defined by large scale erosion that occurred at varying rates since the advance and retreat of the late Wisconsin glacial advance (Prior and Korht, 2006). The map area is dominated by unnamed loamy sediments (IS materials) of variable thickness overlying Pre-Illinioan age Wolf Creek or Alburnett glacial sediments and shallow Devonian carbonate bedrock. Few areas of bedrock outcrop or areas with less than 5 m (16 ft) of loamy material over rock are present, along the Wapsipinicon River. The thickness of Quaternary deposits in the Colwell Quadrangle are generally thick as they are typically more than 18 m (60 ft) in the quadrangle. Quaternary deposits in this valley reach a maximum thickness of 90 m (295 ft) in a deep bedrock valley found on the western edge of the mapping area.

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. The interplay between bedrock and surficial geology can be better understood by in-depth mapping. Nearby surficial geologic mapping projects completed as part of the STATEMAP program include the Surficial Geologic Map of Mitchell County (Tassier-Surine et al., 2016), the Surficial Geologic Map of the Charles City Quadrangle (Streeter et al., 2016) and the Surficial Geologic Map of the Orchard Quadrangle (Kerr et al., 2016).

PURPOSE

Detailed geologic mapping of the Colwell 7.5’ Quadrangle was completed as part of the Iowa Geological Survey’s (IGS) ongoing participation in the STATEMAP mapping program. These maps are the basis for further development of derivative datasets and map products for use by local, county and state decision-makers. In recent years, Iowa’s State Mapping Advisory Committee (SMAC) has recommended mapping in areas with environmental concerns related to groundwater quality and land-use planning issues, and/or in rapidly developing areas. The IGS and SMAC recognize the need for maps of varying scales to address the complex environmental issues facing urban and rural Iowans. Mapping in Floyd and surrounding counties provides much needed geologic maps in the Upper Cedar River watershed. The basin has been the subject of water quality projects in the past, but there was a renewed focus on the Cedar River following catastrophic flooding in 2008. Many new partners are concentrating efforts on water supply, water quantity and quality, land-use planning, and flood protection studies. Geologic mapping is crucial and foundational for many of these studies and the project enjoys broad support from the Iowa-Cedar

Watershed Interagency Coordination Team (ICWICT) and the Cedar River Watershed Coalition (CRWC).

Bedrock mapping efforts were successful in subdividing the Devonian mapping units used by Witzke and others (2010) into formations and in better identifying Cretaceous outliers. From a Quaternary perspective, characterizing and identifying the extent of the middle Wisconsin Sheldon Creek Formation is a fundamental question, as this unit extends much farther east than was previously mapped. A more refined dataset of bedrock topography and bedrock geology provides an important service within this region; significant areas of shallow bedrock and karst terrain are present in surrounding areas. The Quaternary IS materials are highly variable and poorly consolidated and therefore do not provide good groundwater quality protection in these shallow rock areas. It is necessary to identify areas of either better consolidated Quaternary materials or bedrock aquitards. Combining the bedrock and surficial map information is allowing stakeholders to address key questions related to shallow rock areas, karst issues, aggregate resource potential and protection, and groundwater vulnerability, while achieving the evolving goals of the watershed management plans.

QUATERNARY HISTORY AND REGIONAL SETTING

Iowa has a rich and complex Quaternary geologic history punctuated by at least seven periods of glaciation between 2.6 million to 500,000 years ago. 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, 1980, 1986). Hallberg (1980; 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 to lithostratigraphic 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 primarily 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. Following the Pre-Illinoian glaciations, 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).

In north-central Iowa, the highly eroded and dissected Pre-Illinoian upland is overlain by much younger Wisconsin-age glacial sediments. During the early-late and middle Wisconsin-age, ice advances dating from approximately 40,000 to 26,000 years before present were deposited in north central 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). These sediments are typically buried by loamy erosional sediments associated with the IS. The most recent glacial advance of the Des Moines Lobe did not extend into Floyd or Mitchell counties, but its influence is evident in the development of river valleys and periglacial alteration of the landforms.

Results from this mapping project and others in Worth, Cerro Gordo, and Mitchell counties have led to significate changes to the understanding of the middle Wisconsin glacial advances in north-central Iowa (Quade et al., 2012; Tassier-Surine et al., 2015; Tassier-Surine et al., 2016). The maximum extent of the Sheldon Creek advance is not fully understood, but recent mapping projects have indicated that the deposits are found further east than previously thought. However, the Sheldon Creek Formation is not present within the Colwell Quadrangle. This is significant since it helps constrain the extent of the formation. Future work in the area will help further delineate the boundary. The upland in the mapping area is dominated by Pre-Illinoian deposits, though they are highly altered in places due to the periglacial processes of the IS. The till deposits are generally leached and oxidized with only thick deposits exhibiting unaltered characteristics.

Following the deposition of Sheldon Creek materials, a period of intense cold occurred during the Wisconsin full glacial episode from 21,000 to 16,500 years ago (Bettis, 1989). This cold episode and the ensuing upland erosion led to the distinctive landform region recognized as the IS (Prior, 1976). 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 Wisconsin episodes that covered majority of the Iowan Surface. Later work disproved this idea and determined that erosional processes controlled the landscape development (Ruhe et al., 1968). Hallberg and others (1978) revisited the "Iowan Erosion Surface" 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. Modern workers have taken a more climate based approach than Ruhe (Mason, 2015). The IS boundary was further refined by Prior and Kohrt (2006) utilizing higher resolution topographic information and slope classification.

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, surface soils were removed from the IS and the Sheldon Creek and Pre-Illinois till deposits were significantly eroded. A regional colluvial lag deposit referred to as a "stone line" developed and is generally found one meter beneath the surface on hillslopes. Thick packages of stratified loamy and sandy sediments located low in the upland landscape and adjacent to streams are remnants of solifluction lobes associated with the formation of the IS. Where bedrock is shallow, IS materials do not provide an effective barrier (confining unit) to protect local groundwater resources.

Younger sediments may include Peoria Formation eolian deposits and Hudson Episode alluvial sediments. Two loess units were deposited across eastern Iowa between 30,000 and 12,000 years ago (Bettis, 1989), the older Pisgah Formation and the younger Peoria Formation. The Pisgah is thin and includes loess and related slope sediments that have been altered by colluvial hillslope processes, pedogenic and periglacial processes. The Pisgah loess was deposited on the eastern

Iowa landscape from 30,000 to 24,000 years ago and is typically buried by Peoria Formation loess. The Peoria Formation loess accumulated on stable land surfaces in eastern Iowa from 25,000 to 21,000 years ago (Bettis, 1989). The Peoria Formation also has an eolian sand facies, and in the mapping area, sand accumulation on the older terraces of the Wapsipinicon are comprised of this unit.

Sediment continued to accumulate in stream valleys throughout the Holocene Hudson Episode between 14,000 to 11,000 RCYBP. These deposits are part of the Deforest Formation which is subdivided into the Camp Creek, Roberts Creek, Gunder, Corrington, Flack and Woden members. These materials consist of fine grained alluvium, colluvium and pond sediments in steam valleys, on hillslopes, and in closed and semi-closed depressions (Bettis, 1996).

The Colwell Quadrangle can be divided in two regions: the upland till plain and the Wapsipinicon and Little Cedar river valleys. The till plain is relatively flat with small, modern drainages dissecting the IS sediments. The majority of the surficial materials consist of loamy, reworked unnamed erosion surface sediments typically derived from Pre-Illinoian till, though loess may be incorporated into them. The Quaternary sediments in this area are very thick relative to the surrounding area and are generally thicker than 18 m (60 ft). These sediements are underlain by Devonian carbonate and shale. The maximum thickness of till is found in the western third of the mapping area, and is 90 m (295 ft) thick. The Wapsipinicon River flows north to south through the mapping area. Its valley is broad with an extensive area of subtle Holocene aged terraces (Deforest Formation). The Noah Creek Formation colluvial sand and gravel underlies the Holocene deposits and extends out onto the valley slope. The higher terrace occupies more broad areas in the valley while the lower is constrained more in the valley. The Little Cedar River flows NW to SE in the SW corner of the quadrangle and has the same general relationships as the Wapsipinicon River valley.

METHODS

Numerous sources of geologic information were utilized in the production of the Colwell 7.5' Quadrangle Surficial Geologic Map. These include subsurface data, USDA NRCS soil survey data, aerial photography, DEMs, satellite imagery, landform characteristics, and LiDAR. 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. 87 public and private wells in GEOSAM, including 49 strip logs, were reviewed for lithology, stratigraphy and locational accuracy and updated where needed. Quaternary mappers used NRCS digitized county soils data (Buckner and Highland, 1974; Voy, 1995; Voy and Highland, 1975; Wilson, 1996) to assist with delineating areas with loess cover, thin or no loess cover, shallow bedrock, extent of alluvium, and to attempt to differentiate till units. 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 field investigations of three outcrops (including quarry exposures) and logging of well cutting samples for 26 unstudied wells. Quaternary geologists worked with a contract driller and utilized the IGS Giddings probe to drill a mix of solid stem and continuous core holes. A total of six drill holes totaling 131 feet were completed for the mapping exercise. Samples have been submitted to the Quaternary Materials Lab at the University of Iowa's Earth and Environmental Sciences Department for grain-size analysis. All results are expected by August, 2017.

Project geologists combined information from the sources listed above to delineate surficial geologic mapping units at 1:24,000 scale for the Colwell 7.5' Quadrangle. The IGS mappers used ArcGIS and on-screen digitizing techniques developed during previous STATEMAP projects. The final map entitled 'Surficial Geologic Map of the Colwell 7.5' Quadrangle, Chickasaw, Floyd, Howard, and Mitchell Counties, Iowa' will be 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. This Summary Report is also available as a PDF file.

STRATIGRAPHIC FRAMEWORK FOR NORTH-CENTRAL IOWA

An important aspect of surficial geologic mapping on the Iowan Surface is the development of map units that utilize previously established lithostratigraphic frameworks for the Hudson, Wisconsin and Pre-Illinoian deposits in Iowa (Johnson et al., 1997). A stratigraphic framework allows us to better understand the surficial materials of north-central Iowa. Surficial deposits in 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 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 colluvial 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 Wapsipinicon and Little Cedar rivers. 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.

Five bedrock mapping units (Devonian Lithograph City, Coralville, Little Cedar, Pinicon Ridge, and Spillville formations) are exposed at the surface in the Colwell 7.5' Quadrangle, with the Coralville and Little Cedar formations comprising most of the bedrock surface in the map area. Only three rock outcrops, including quarries, are located in the map area and were investigated in the field. The Devonian rocks are dominated by carbonates varying between limestone and dolomite, accompanied with minor shale.

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 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.

Eleven landform sediment assemblage units were identified in the map area utilizing aerial imagery, topographic expression, digitized soils, 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 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, 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. Overlies the Noah Creek Formation. Occupies the lowest position on the floodplain, i.e. modern channel belts in the Little Cedar and Wapsipinicon river valleys. Seasonal high water table and frequent flooding potential.

Qali-ht - Intermediate-High Terrace (DeForest Formation- Gunder Member) Variable thickness of less than 1 m to 5 m (3-16 ft) of very dark gray to brown, noncalcareous, stratified silty clay loam to loam that overlies the Noah Creek Formation. Occupies the intermediate to high terrace position in the Little Cedar and Wapsipinicon river valleys. Seasonal high water table and frequent flooding potential.

HUDSON and WISCONSIN EPISODE

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 occurs as sand stringers or dunes overlying Holocene terraces unnamed erosion surface loamy sediments.

Qdlgc - Loamy Sediments Shallow to Limestone, Dolomite, or 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. A detailed description of the Lithograph City Formation is provided below.

Qdcv - Loamy Sediments Shallow to Limestone or Dolomite (DeForest, Noah Creek, or Shell Rock 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 sediment that overlies the Middle Devonian bedrock surface. Bedrock outcrop may be present in isolated areas. A detailed description of the Coralville Formation is provided below.

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. Thickness in the Wapsipinicon River valley may exceed 10 m (33 ft). 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. This unit encompasses deposits that accumulated in low-relief stream and river valleys during the Wisconsin and Hudson episodes.

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.

Qwa2 - 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). Overlies massive, fractured, extremely firm glacial till of the Wolf Creek or Alburnett formations.

PRE-ILLINOIS EPISODE

Qwa3 - Glacial Till (Wolf Creek or Alburnett formations) - 3 to 85 m (10-278 ft) of very dense, massive, fractured, clay loam glacial till of the Wolf Creek or Alburnett formations. This mapping unit can be buried by unnamed erosion surface sediments, loess, or alluvium. This unit is shown only on the cross-section.

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