# SUMMARY REPORT OF THE SURFICIAL GEOLOGIC MAP OF THE ORCHARD 7.5' QUADRANGLE, FLOYD AND MITCHELL COUNTIES, IOWA

**Iowa Geological Survey**
**Open File Map OFM-16-4**
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## INTRODUCTION

This mapping exercise is the first phase of a multi-year project that will lead to the mapping of Floyd County. The Orchard 7.5' Quadrangle of Floyd and Mitchell counties covers an area from 43˚ 7' 30" to 43˚ 15' 0" N latitude and 92˚ 52' 30" to 92˚ 45'0" W longitude. A bedrock geologic map was also produced in conjunction with the surficial geologic map (Liu et al., 2016). It is located within the Wisconsin-age Iowan Surface landform region of north-central Iowa which is defined by large scale erosion that occurred at varying rates since the advance and the 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 Wisconsin-age Sheldon Creek Formation glacial sediments and shallow Devonian carbonate bedrock. Significant areas of bedrock outcrop or areas with less than 5 m (16 ft) of loamy material over rock are present, especially along the Cedar River and its tributaries. The thickness of Quaternary deposits in the Orchard Quadrangle are generally thin as they are typically less than 15 m (50 ft) in the quadrangle, though deposits reach a maximum thickness of 31 m (117 ft) in a bedrock valley found on the western edge of the mapping area.

Calvin (1902) described and mapped the Quaternary and Paleozoic bedrock geology of Mitchell County. He noted the extreme variability of the till units and the presence of significant sand and gravel bodies. 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 and Mitchell counties. Adjacent surficial geologic mapping projects completed as part of the STATEMAP program include Surficial Geology of the Osage Quadrangle (Tassier-Surine et al., 2014a), Surficial Geology of the St. Ansgar Quadrangle (Tassier-Surine et al., 2014b) and Surficial Geology of the New Haven Quadrangle (Kerr et al., 2015).

## PURPOSE

Detailed geologic mapping of the Orchard 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 Mitchell and Floyd 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. The mapping location also includes the Cedar River, which carried outwash from the Des Moines Lobe glacial advance, and has helped to further identify and characterize sand and gravel resources associated with glacial outwash plains and channels. A more refined knowledge of both bedrock topography and bedrock geology provides an important bedrock perspective within this region that has significant shallow bedrock and karst terrain. The Quaternary IS materials are highly variable and poorly consolidated and therefore do not provide good groundwater quality protection in 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 earlier and middle Wisconsin-age, ice advances dating from approximately 40,000 to 26,000 years before present were deposited 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). 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 much further east than previously thought. The Orchard Quadrangle’s upland area is dominated by Sheldon Creek deposits, though they are highly altered in places due to the periglacial processes of the IS and the proximity to shallow bedrock. Along the Cedar River and Rock Creek, the Sheldon Creek deposits have been eroded.

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. 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. 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 surfaces were significantly eroded. A regional colluvial lag deposit referred to as a "stone line" developed. 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 landsurfaces in eastern Iowa from 25,000 to 21,000 years ago (Bettis, 1989). In the mapping area there is a thin dune thought to be Peoria Formation to the north-east of Orchard. 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 Orchard Quadrangle can be divided in three rough regions: the southern till plain, the Cedar River valley, and the colluvium filled bedrock valleys. The southern till plain is relatively flat with small drainages starting to dissect the sediments. The majority of the deposits consist of loamy, reworked unnamed erosion surface sediments. Beneath them is generally the Sheldon Creek Formation; toward the southwest the bedrock depth increases and Pre-Illinoian till (Wolf Creek or Alburnett formations) can be found. The maximum depth is found in the southwest corner of the region in the southwest corner of the map, 31 m (101 ft). The Cedar River flows NNW to SSE through the mapping area. It is generally channelized in bedrock except for a portion that intersects with a bedrock valley near the Floyd-Mitchell county border. This valley trends to the NW. Where the river intersects the bedrock valley, the size of the river valley greatly increases. The lower terraces are Holocene aged (Deforest Formation). The valley generally has its highest terrace being made of Wisconsin age outwash (Noah Creek Formation). The outwash also is found beneath the Holocene deposits and the Wolf Creek or the Alburnett formations are found beneath the outwash. The colluvium filled bedrock valleys represent older channels that formed mainly in the Devonian aged Lithograph City Formation (limestone and dolomite) and were later filled in with colluvium and alluvium. These channels can sit up to 15 m (50 ft) higher than the modern Cedar River channel and have generally less than 5 m (16 ft) of unconsolidated materials in them, though the deposits can be as deep as 24 m (78 ft). The formation of the bedrock channels is thought to have been made at least before the middle Wisconsin glaciation and were consequently buried by Sheldon Creek deposits. They have since been exhumed by periglacial and fluvial erosion. Areas with bedrock less than 2 m (7 ft) are found rimming most of these valleys. Some of these channels have modern streams dissecting the older sediments.

## METHODS

Numerous sources of geologic information were utilized in the production of the Orchard 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. Over 73 public and private wells in GEOSAM, including 30 strip logs, were reviewed for lithology, stratigraphy and locational accuracy and updated where needed. Quaternary mappers used NRCS digitized soils data (Voy 1995; Voy and Highland, 1975) 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 55 outcrops (including quarry exposures) and logging of well cutting samples for 21 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 10 drill holes totaling 198' 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, 2016.

Project geologists combined information from the sources listed above to delineate surficial geologic mapping units at 1:24,000 scale for the Orchard 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 Orchard 7.5'Quadrangle, Floyd 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 IS 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 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 northwest of Orchard and intermittently mantle the unnamed erosion surface mapping unit. 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, but generally coincides with the position of the Little Cedar River in Mitchell County and along a drainage divide in the Charles City quadrangle based on the work of Tassier-Surine and others (2016) and Streeter and others (2016). 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.

Three bedrock mapping units (Cretaceous Dakota/Windrow Formation; Devonian Shell Rock and Lithograph City formations) are exposed at the surface in the Orchard 7.5’ Quadrangle, with the Lithograph City and Coralville formations comprising most of the outcrop in the map area. Bedrock outcrops occur along most rivers and creeks in the mapping area and extensively along the Cedar River. Fifty-five 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. The Cretaceous Dakota/Windrow Formation is characterized as a reddish, shaly sandstone with siderite pellets.

## 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.

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

**Qalit - Intermediate Terrace** (DeForest Formation- Camp Creek, Roberts Creek, and Gunder members) **-** 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 low terrace position in the Cedar River Valley. 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 unnamed erosion surface loamy sediments.

**Qkd - Loamy Sediments Shallow to Sandstone and Mudstone** (DeForest, Noah Creek, or Dakota/Windrow 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 “Mid”-Cretaceous bedrock surface. Bedrock outcrop may be present in isolated areas.

**Qdsr - Loamy Sediments Shallow to Limestone, Dolomite, and Shale** (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 Upper Devonian bedrock surface. Bedrock outcrop may be present in isolated areas.

**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. Thickness in the bedrock valley in the center of the mapping area may exceed 30 m (98 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 valleys during the Wisconsin and Hudson episodes.

## WISCONSIN EPISODE

**Qnw - Sand and Gravel** (Noah Creek Formation) - Generally less than 10 m (33 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. In the map area this unit usually overlies the middle Wisconsin-age Sheldon Creek Formation, but may overlie Pre-Illinois Espisode diamicton of the Wolf Creek or Alburnett formations in isolated areas. 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 and the deposits that fill the paleo channel in the center of the mapping area during the late Wisconsin as well as exhumed middle Wisconsin and Pre-Illinois Episode deposits of the Wolf Creek and Alburnett formations.

**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). Overlies massive, fractured, slightly firm glacial till of the Sheldon Creek Formation.

**Qsc3 - Loamy and Sandy Sediment Shallow to Rock** (Unnamed erosion surface sediment) - Generally 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 3 m (10 ft) of Peoria Formation (eolian sand or silt). Overlies fractured Devonian carbonate rocks. Seasonal high water table may occur in this map unit.

**Qsc - Glacial Till** (Sheldon Creek Formation- Undifferentiated) - Generally 3 to 15 m (10-50 ft) of a 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 15 m (10-50 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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