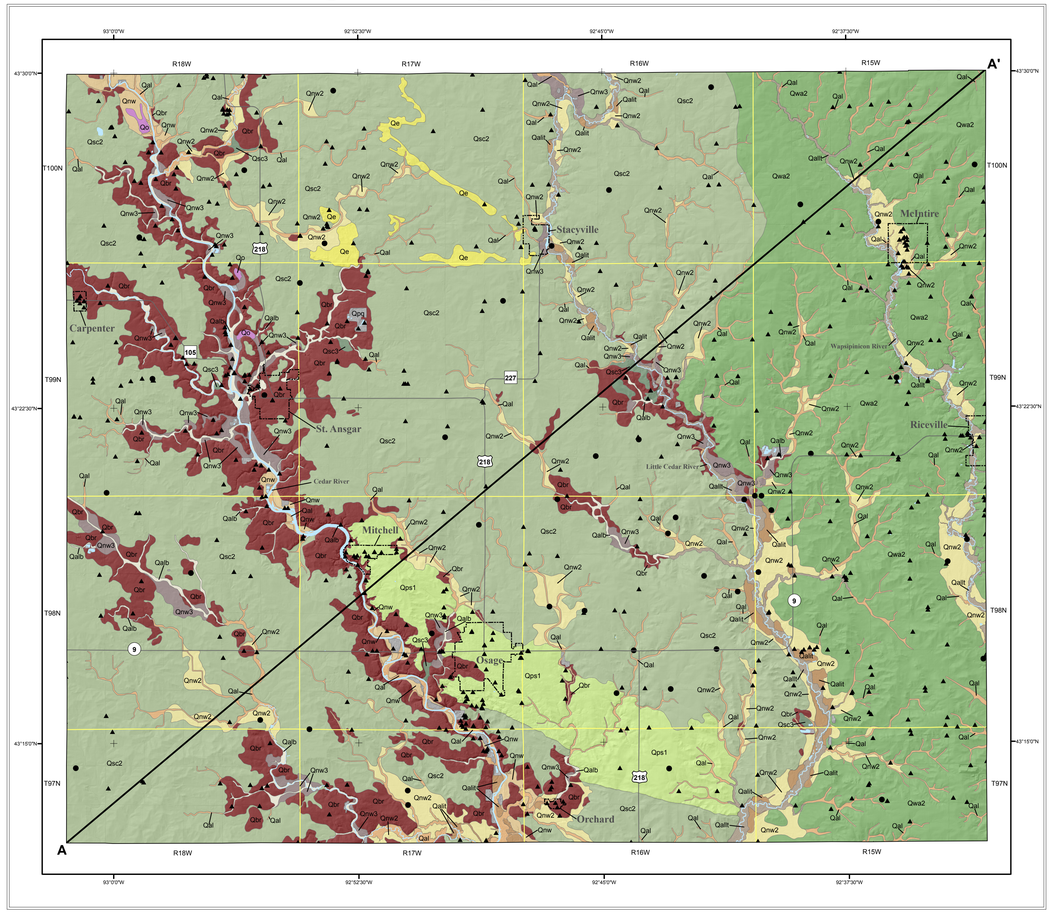
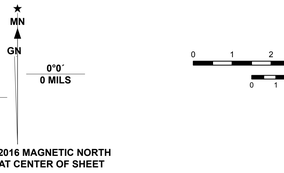
Surficial Geologic Map of Mitchell County, Iowa





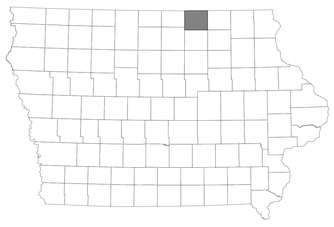
UTM GRID AND 2016 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

1:100,000

0 1 2 4 6 8 Miles

0 1 2 4 6 8 Kilometers

Location Map

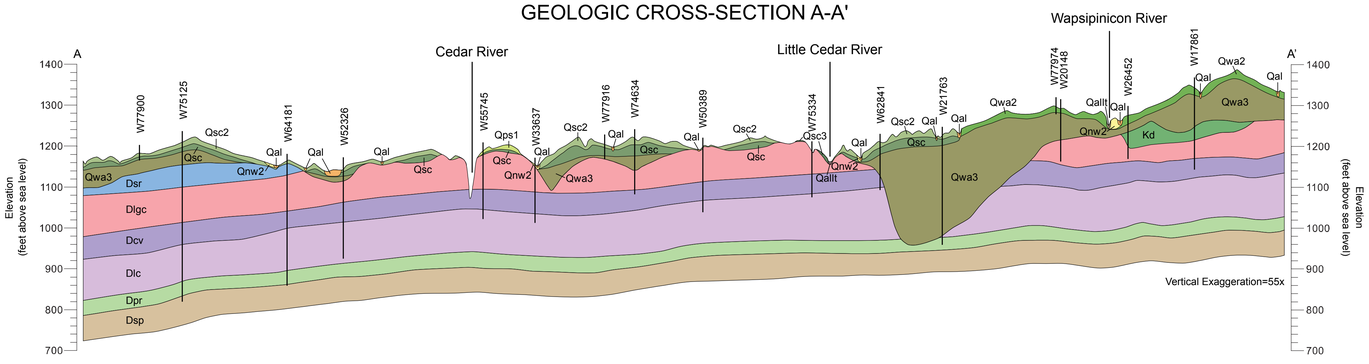


CORRELATION OF MAP UNITS

	Iowan Surface			Epoch	Series	System
	Sheldon Creek Till Plain	Pre-Illinoian Till Plain	Shallow Rock			
Alluvium	Qo			Holocene		Quaternary
	Qal, Qallt, Qalit	Qal, Qallt, Qalit	Qalb	Hudson		
Eolian and Colluvium	Qe			Hudson and Wisconsin		
	Qnw2					
	Qps1			Wisconsin		
Outwash	Qnw		Qnw3			
Erosion Surface and Glacial	Qsc2		Qsc3	Pleistocene		
	Qsc*					
		Qwa2		Pre-Illinois		
	Qwa3*					
Bedrock	Kd*		Qsc	Cretaceous		
	Dsr*			Devonian		
	Dlgc*					
	Dcv*					
	Dlc*					
	Dpr*					
	Dsp*					

*units only shown on the cross-section

GEOLOGIC CROSS-SECTION A-A'



LEGEND

CENOZOIC

QUATERNARY SYSTEM

HUDSON EPISODE

Qo - **Depressions** (DeForest Formation- Woden Member) - Generally 2.5 to 6 m (8-20 ft) of black to very dark gray, calcareous, muck, peat and silty clay loam colluvium and organic sediments in drained and undrained closed and semi-closed depressions. Overlies gray, calcareous, loam diamicton (Sheldon Creek, Wolf Creek, or Alburnett formations) or Noah Creek Formation sand and gravel. Associated with low relief features that occupy depressions and low sags on the landscape. Supports wetland vegetation and can be permanently covered by water. High water table.

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 the Noah Creek, Sheldon Creek, Wolf Creek, or Alburnett formations; fractured Devonian carbonate bedrock or Cretaceous sandstone or mudstone. 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, Devonian carbonate bedrock, or Cretaceous 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. *This unit is too thin to be shown on the cross -section where it intersects the Cedar River.*

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 Little Cedar and Wapsipinicon river valleys and their tributaries. 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. Along the Little Cedar River, the bedrock surface may be within 5 m (16 ft) of the surface south of Stacyville.

Qalit - Intermediate Terrace (DeForest Formation- Camp Creek, Roberts Creek, and Gunder members) - Variable thickness of less than 1 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 low terrace position. 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 loamy sediments.

Qnw2 - Sand and Gravel (Noah Creek Formation) - 2 to 15 m (7-49 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-alluvial 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) - Generally 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. Overlies massive, fractured, loamy glacial till of the Sheldon Creek, Wolf Creek or Alburnett formations with or without the intervening clayey Farmdale/Sangamon Geosol. Near the towns of Osage and Mitchell, this unit may be significantly thinner (less than 2 m, 7 ft) and overlie fractured Devonian carbonate bedrock.

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. Overlies middle Wisconsin-age Sheldon Creek Formation diamicton or Pre-Illinois Episode diamicton of the Wolf Creek or Alburnett formations. 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 material. In places mantled with fine to medium well sorted feldspathic quartz sand derived from wind reworking of the alluvium. Fractured Devonian carbonate bedrock or Cretaceous sandstone and mudstone 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.

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); this is especially common between the Cedar and Little Cedar rivers. Formed in and often overlies massive, fractured, slightly firm glacial till of the Sheldon Creek Formation. This unit may be absent in isolated areas at lower elevation west of the Little Cedar River, is absent in the most eastern portion of Mitchell County, and may be intermittent east of the Little Cedar River.

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 sand facies (eolian sand). Formed in Sheldon Creek Formation materials and overlies fractured Devonian carbonate bedrock.

Qsc - Glacial Till (Sheldon Creek Formation- Undifferentiated) - Generally 3 to 15 m (10-49 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 with a thickness generally ranging from 2 to 8 m (7-26 ft). The upper 3 to 6 m (10-20 ft) may be pedogenically altered. This unit overlies Pre-Illinois diamicton, Devonian carbonate bedrock or Cretaceous sandstone and mudstone and is only shown on the cross-section. This unit may be absent in isolated areas at lower elevation west of the Little Cedar River, is absent in the most eastern portion of Mitchell County, and may be intermittent east of the Little Cedar River.

Qwa2 - Loamy and Sandy Sediment Shallow to Glacial Till (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 two meters of Peoria Formation materials (loess and eolian sand). Overlies massive, fractured, firm glacial till of the Wolf Creek and Alburnett formations. Seasonal high water table may occur in this map unit.

PRE-ILLINOIS EPISODE

Qwa3 -Glacial Till (Wolf Creek or Alburnett formations) - Generally 3 to 12 m (10-39 ft), but can be as thick as 100 m (330 ft) within the prominent bedrock valley in the eastern part of the mapping area. Map unit consists of very dense, massive, fractured, loamy glacial till of the Wolf Creek or Alburnett formations Significant sand and gravel bodies up to 14 m (45 ft) in thickness are present within this mapping unit and often occur in the base of the bedrock channel in the eastern portion of Mitchell County. This mapping unit can be buried by glacial sediments (Sheldon Creek Formation), unnamed erosion surface sediments, loess or alluvium and is shown only on the cross-section.

OTHER MAPPING UNITS

Qbr - Loamy Sediments Shallow to Dolomite, Limestone, Shale and Sandstone (DeForest, Noah Creek, Sheldon Creek, 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 alluvial sediments that overlie the Middle to Upper Devonian or "Mal" Cretaceous 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 Mitchell County with the following descriptions:

MESOZOIC

CRETACEOUS SYSTEM

Kd - Sandstone, Mudstone, and Siderite Pellets (Dakota/Windrow Formation) "Mal"-Cretaceous. This map unit occurs as erosional outliers in the northern half of the mapping area. The formation consists of a variety of lithologies including quartz arenite, non-calcareous shale and mudstone, and chert-pebble conglomerate; with lesser amounts of siderite occurring as granules and pellets. Commonly reddish, although yellow, green, white, gray, and brown are observed both in well cuttings and outcrop. Sandstone and conglomerate lithologies display iron, pyrite, goethite, and chert cementation. Typically identified in well cuttings, although outcrops have been identified in 'overburden' piles of one limestone quarry within the county. Two know sand and gravel pits located along the northern boundary of the mapping area are mining sandstone and conglomerate from this unit. The thickness of this unit is variable, usually less than 12 m (40 ft), although observed up to 27 m (90 ft) within the mapping area.

PALEOZOIC

DEVONIAN SYSTEM

Dsr - Limestone, Dolomite, and Shale (Shell Rock Formation) Upper Devonian. This map unit forms the bedrock surface in the southwestern corner of the mapping area, usually with a thickness between 2 and 20 m (6-65 ft). The unit is characterized by fossiliferous limestone, dolomitic limestone and dolomite, with some gray to light green shale and/or argillaceous carbonates. Layers containing abundant subspherical and digitate stromatoporoids commonly occur in the lower part of the unit. Brachiopods, bryozoans, corals, and crinoids are abundant in some intervals, especially in the upper part of the unit. Outcrops of this unit are only found along portions of Rock Creek and in a few quarries along Rock Creek.

Dlgc - Dolomite, Limestone, and Shale (Lithograph City Formation) Middle to Upper Devonian. This map unit represents the majority of the bedrock surface in the mapping area reaching a maximum thickness of 32 m (105 ft). This unit consists of dolomite and dolomitic limestone, partially characterized by interbeds of laminated, lithographic and sub-lithographic limestone and dolomitic limestone, in part argillaceous with minor shale. "Birdseye", vugs, and calcite vug-fills are common, with some layers heavily bioturbated. Some layers are locally brecciated. Occasional intervals of fossiliferous and stromatoporoid-rich carbonates are present in the limestone facies with the lower dolomitic part exhibiting abundant brachiopod molds. Outcrops of this map unit are primarily found along the major river valleys and tributaries in the western two-thirds of the mapping area. Most of the quarries within the mapping area are mining this unit.

Dcv - Limestone and Dolomite (Coralville Formation) Middle Devonian. This map unit is between 12 and 20 m (40-70 ft) thick in the mapping area, generally thinning to the northwest. This unit is dominated by dolomite and dolomitic limestone; in part, laminated, argillaceous, and bioturbated with occasional sub-lithographic limestone. Prominent breccia zones occur in the upper part of the unit. Brachiopods, echinoderm debris, and corals usually occur in the limestone facies and as fossil molds in the dolomite facies in the lower part of the unit. Sparse outcrops can be found along parts of the Cedar and Little Cedar rivers and their tributary creeks.

Dlc - Dolomite, Limestone, and Shale (Little Cedar Formation) Middle Devonian. This map unit can be up to 37 m (120 ft) thick and is dominated by slightly argillaceous to argillaceous dolomite and dolomitic limestone, usually vuggy and partially laminated and/or cherty, with a moderately continuous shale unit occurring within the upper half of the formation. Brachiopod and crinoid fossil molds are common in the dolomite facies throughout this unit with occasional phosphatic fossiliferous units occurring in the limestone facies in the lower portion. This unit occurs at the bedrock surface within moderate bedrock valleys and along the shoulders of deep bedrock valleys in the mapping area.

Dpr - Dolomite and Limestone (Pinicon Ridge Formation) Middle Devonian. This map unit ranges from 9 to 15 m (30-50 ft) in thickness and consists of unfossiliferous dolomite and limestone with minor shale. This unit displays a variety of textures and compositions including laminated, pyritic, sandy, and cherty. This unit is characterized throughout the mapping area by being heavily brecciated, mixing all lithologies. The unit occurs at the bedrock surface within the prominent bedrock valley along the eastern margin of the mapping area.

Dsp - Dolomite (Spillville Formation) Middle Devonian. This map unit reaches a maximum thickness of approximately 24 m (80 ft) and is dominated by medium to thick bedded dolomite, commonly vuggy with calcite vug fills and scattered to abundant fossil molds. Sporadic fossiliferous limestone units have been observed. The basal unit, where present, is variably sandy, shaly, and/or conglomeratic with reworked Ordovician chert clasts. This formation only occurs at the bedrock surface within the core of the prominent bedrock valley along the eastern margin of the mapping area.

OTHER FEATURES

Qpq - Pits and Quarries - Sand and gravel pits and rock quarries. Extent mapped as shown in the county soil survey and as identified on aerial imagery.

Roads - with corresponding highway symbols

Water bodies - Rivers, lakes, and small ponds. Extent mapped as shown in the county soil survey.

Incorporated city boundary

New drill holes for this map project

IGS GEOSAM data points- records available at www.iowageologicalsurvey.com

Wells used for geologic cross-section

W77900

SURFICIAL GEOLOGIC MAP OF MITCHELL COUNTY, IOWA

Iowa Geological Survey
Open File Map OFM-16-2
June 2016

Stephanie Tassier-Surine, Phil Kerr, Ryan Clark, Matthew Streeter, and Huaibao Liu

Iowa Geological Survey, IIHR-Hydroscience & Engineering, University of Iowa, Iowa City, Iowa

IOWA GEOLOGICAL SURVEY

Iowa Geological Survey, Robert D. Libra, State Geologist

Supported in part by the U.S. Geological Survey
Cooperative Agreement Number G15AC00242
National Cooperative Geologic Mapping Program (STATEMAP)
Completed under contract with the Iowa Department of Natural Resources

THE UNIVERSITY OF IOWA IIHR DNR

ACKNOWLEDGMENTS

Special thanks to the landowners who allowed access to their properties for drilling: Don Ahrens, Todd Bates, Marcella Brand, Larry Bless, Betty Clark, Charles Feldt, Larry Feldt, Greg Fox, Curt Halverson, Tony Hefther, Deb Igou, Robert and Darlene Jacot, Bill Johanns, Clem Johanns, Randy Kephart, Tom Knudsen, Jakki Kruse, Clausen Martin, Eugene Merten, Joe Merten, John Miller, Levi Miller, Dorothy Niess, Robert Niess, Isaac Nolt, Dana Norby, Dean Norby, Lisa Petersen, Richard Reding, Dar Ruehlow, Rick Sletter, Joe Smith, Paul Smith, Allen Suchy, Dan Schwark, John Schwark, Dave Tollefson (Mayor, City of St. Ansgar), Lynn Walk, Tyrel Williamson, and Dean Wright. The Mitchell County Conservation Board and Director Adam Shirley allowed access to numerous parks and wildlife areas. Drilling was provided under contract with Cahoy Well and Pump Service; special thanks to driller Kaes DeGroot.

Zachary Domanett of the Iowa Geological Survey (IGS) and Austin Pothoff, University of Iowa prepared well cutting samples for stratigraphic logging. Zachary Domanett also assisted with field work during drilling. New subsurface geologic data was generated by Tanner Hartsock, a University of Iowa Department of Earth and Environmental Sciences student, by producing descriptive logs of water well drilling samples. Thanks also to Rick Langel (IGS) for managing the Iowa geologic sampling database (GeoSam). Jason Vogelgesang (IGS) provided valuable depthto-bedrock information via geophysical surveys in select locations. Also, special thanks to Kathy Wenda, Natural Resources Conservation Service, Deborah Quade, Iowa Department of Natural Resources, and Art Bettis, University of Iowa Department of Earth and Environmental Sciences, for assistance with core description and for numerous valuable discussions regarding the geology of northcentral Iowa. Casey Kohrt and Chris Kahle of the Iowa Department of Natural Resources provided GIS technical help. Administrative support was provided by Megan Delaney, Teresa Gaffey, and Sara Conrad.

Introduction to the Surficial Geologic Map of Mitchell County, Iowa

Mitchell County is located in north-central Iowa on the Wisconsin-age Iowan Surface (IS) landform region (Prior and Kohrt, 2006). The map area is dominated by unnamed loamy sediments (IS materials) of variable thickness overlying Wisconsin-age Sheldon Creek Formation glacial sediments, Pre-Illinoian age glacial sediments, or shallow rock. Significant areas of bedrock outcrop or areas with less than 5 m (16 ft) of loamy material over rock are present, especially along Rock Creek, the Cedar River and its tributaries, and portions of Burr Oak Creek and the Little Cedar River. The thickness of Quaternary deposits in Mitchell County is highly variable as they are typically less than 15 m (50 ft)in the western part of the county and reach a maximum thickness of 100 m (330 ft) in a bedrock valley on the eastern side of Mitchell County.

Calvin (1902) described and mapped the Quaternary and Paleozoic bedrock geology of Mitchell County. He noted the extreme variability of the till units, the presence of significant sand and gravel bodies, and also a relatively thick loess unit in the southern part of the county. 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 Mitchell County. Previous surficial geologic mapping completed as part of the STATEMAP program in Mitchell County includes 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). Mapping adjacent to the project area includes Surficial Geology of Worth County, Iowa (Quade et al., 2012) and Surficial Geology of Cerro Gordo County, Iowa (Tassier-Surine et al., 2015).

Iowa has a rich and complex Quaternary geologic history punctuated by at least seven periods of glaciation between 2.6 million and 500,000 years ago (Boellstorff, 1978a,b; Hallberg, 1980, 1986). In the map area, Pre-Illinois Episode glacial deposits and associated buried soils may be overlain by much younger Wisconsin-age materials, dating from approximately 40,000 to 26,000 years before present. In Iowa, these glacial deposits are formally recognized as the Sheldon Creek Formation (Bettis et al., 1996; Bettis, 1997) and in earlier literature are referred to as the "Tazewell till" (Ruhe, 1950). The most recent glacial advance of the Des Moines Lobe did not extend into Mitchell County, 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 and Cerro Gordo counties indicate that the Sheldon Creek glacial materials extend much farther east than were previously mapped. The Little Cedar River is thought to generally represent an ice marginal position related to middle Wisconsin or earlier glaciation. The geometry of the river, differences in drainage pattern and density on the east and west sides of the Little Cedar River, and significant differences in geologic materials have led to this conclusion. The Sheldon Creek Formation is present west of the Little Cedar River, except in isolated low-lying landscape positions where it has been eroded, and extends four to five miles east of the Little Cedar River near Stacyville. Extensive sand and gravel deposits within the upper till package in the central and southeastern part of the county may represent either outwash deposits associated with the advance of the Sheldon Creek or colluvial deposits related to downcutting of the Iowan Surface. These sand bodies and the presence of overlying weathered till make it difficult to absolutely differentiate stratigraphic units and complicate establishing an exact ice-marginal position.

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 ensuing upland erosion led to the development of the distinctive landform recognized as the 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, surface soils were removed from the IS and the Sheldon Creek and Pre-Illinois till surfaces were significantly eroded. 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. These materials can be found along the Little Cedar River and its tributaries, the Wapsipinicon River near McIntire, and portions of Otter, Goose, Rock, and Spring creeks in southwest Mitchell County.

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 southeast of Osage and intermittently mantle most other mapping units. 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. West of the Little Cedar River the predominant till unit is the Sheldon Creek Formation and to the east Pre-Illinoian till is exposed at the surface. 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 (Cretaceous Dakota/Windrow Formation; Devonian Shell Rock, Lithograph City, and Coralville formations) are exposed at the surface in Mitchell County, 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 western half of the county and occasionally along the Little Cedar River. More than 100 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.

References

Bettis, E.A., III, 1989, Late Quaternary history of the Iowa River Valley in the Coralville Lake area *in* Plocher, O.W., Geologic Reconnaissance of the Coralville Lake area: Geological Society of Iowa Guidebook 51, p. 93-100.

Bettis, E.A. III, 1997, Late-Middle and Early-Late Wisconsin Glaciation in North-Central Iowa: Geological Society of America North-Central Section Meeting Abstracts with Programs 29, Issue 4, p. 5.

Bettis, E.A. III, Quade, D.J., and Kemmis, T.J., 1996, Hogs, bogs, and logs: Quaternary deposits and environmental geology of the Des Moines Lobe: Iowa Department of Natural Resources Geological Survey Bureau, Guidebook Series No. 18, 170 p.

Boellstorff, J., 1978a, North American Pleistocene Stages reconsidered in light of probable Pliocene-Pleistocene continental glaciation: Science, v. 202, p. 305-307.

Boellstorff, J., 1978b, Chronology of some late Cenozoic deposits from the central United States and the ice ages: Transactions of the Nebraska Academy of Science, v. 6, p. 35-49.

Calvin, S., 1902, Geology of Mitchell County: Iowa Geological Survey Annual Report, v. 13, p. 293-338.

Hallberg, G.R., 1980, Pleistocene stratigraphy in east-central Iowa: Iowa Geological Survey Technical Information Series, v. 10, 168 p.

Hallberg, G.R., 1986, Pre-Wisconsin glacial stratigraphy of the central plains region in Iowa, Nebraska, Kansas, and Missouri *in* Sibrava, V., Bowen, D.Q., and Richmond, G.M., eds., Quaternary Glaciations in the Northern Hemisphere: Quaternary Science Reviews, v. 5, p. 11-15.

Hershey, H. G., 1969, Geologic map of Iowa: Iowa Geological Survey, scale 1:500,000.

Kerr, P., Streeter, M., Tassier-Surine, S., Clark, R., and Liu, H., 2015, Surficial Geology of the New Haven Quadrangle, Mitchell County, Iowa: Iowa Geological Survey, Open File Map OFM-15-4, 1:24,000 scale map sheet.

Prior, J.C., 1976, Landforms of Iowa: Iowa City, Iowa, University of Iowa Press, 154 p.

Prior, J.C. and Kohrt, C.J., 2006, The Landform Regions of Iowa: Iowa Geological Survey, digital map, available on IDNR NRGIS Library.

Quade, D., Tassier-Surine, S., Liu, H., McKay, R.M., and Giglierano, J.D., 2012, Surficial Geology of Worth County, Iowa: Iowa Geological and Water Survey, Open File Map OFM-12-2, 1:100,000 scale map sheet.

Ruhe, R.V., 1950, Reclassification and correlation of the glacial drifts of northwestern Iowa and adjacent areas: University of Iowa Department of Geology, Iowa City, unpublished Ph.D. thesis, 124 p.

Tassier-Surine, S., Quade, D., Kerr, P., Streeter, M., Liu, H., Clark, R., Fields, C., McKay, R., and Rowden, R., 2015, Surficial Geology of Cerro Gordo County, Iowa: Iowa Geological Survey, Open File Map OFM-15-2, 1:100,000 scale map sheet.

Tassier-Surine, S., Quade, D., Streeter, M., Kerr, P., Rowden, R., McKay, R., Liu, H., Clark, R., and Galer, R., 2014a, Surficial Geology of the Osage Quadrangle, Mitchell County, Iowa: Iowa Geological Survey, Open File Map OFM-14-8, 1:24,000 scale map sheet.

Tassier-Surine, S., Quade, D., Streeter, M., Kerr, P., Rowden, R., McKay, R., Liu, H., Clark, R., and Galer, R., 2014b, Surficial Geology of the St. Ansgar Quadrangle, Mitchell County, Iowa: Iowa Geological Survey, Open File Map OFM-14-6, 1:24,000 scale map sheet.

Walters, J.C., 1996, General and environmental geology of the Cedar Falls/Waterloo Area, The Iowan Surface, in General and environmental geology of Cedar Falls/Waterloo and surrounding area, Northeast Iowa: Iowa Geological Survey Guidebook Series No. 22, p. 7-9.

Witzke, B.J., Anderson, R.R. and Pope, J.P., 2010, Bedrock Geologic Map of Iowa, scale: 1:500,000: Iowa Geological and Water Survey, Open File Digital Map OFM-10-1.

Base map from Iowa DOT Road Map Layers 2006. Shaded relief from Iowa Lidar Project 2007-2011.

Iowa Geological Survey digital cartographic file Mitchell_Co_SurficialGeology.mxd, version 6/30/16 (ArcGIS 10.3)
Map projection and coordinate system based on Universal Transverse Mercator (UTM) Zone 15 N, datum NAD83.

The map and cross-section are based on interpretations of the best available information at the time of mapping. Map interpretations are not a substitute for detailed site specific studies.

Research supported by the U. S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number G15AC00242. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U. S. Government.