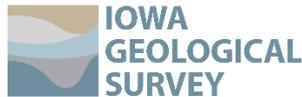


**SUMMARY REPORT OF THE
BEDROCK GEOLOGIC MAP OF
THE ORCHARD 7.5' QUADRANGLE,
FLOYD AND MITCHELL COUNTIES, IOWA**

**Iowa Geological Survey
Open File Map OFM-16-3
June 2016**

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

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



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



INTRODUCTION

The Orchard 7.5' Quadrangle is located on the border of Floyd and Mitchell counties, north-central Iowa. It covers an area from 43° 7' 30" to 43° 15' N latitude and 92° 52' 30" to 92° 45' W longitude. The detailed bedrock geologic map of the Orchard 7.5' Quadrangle was completed as part of the Iowa Geological Survey's (IGS) ongoing participation in the STATEMAP mapping program in north-central Iowa.

The bedrock surface of the Orchard 7.5' Quadrangle is dominated by Devonian strata, with scattered Cretaceous deposits. The Devonian strata consist of carbonates, shale, and minor other lithologies. These carbonate rocks form the important upper bedrock aquifer in the mapping area (Libra et al., 1984, 1994). This Devonian aquifer becomes vulnerable when it is shallow, and the carbonate rocks, especially relatively pure limestones, are easily karstified (Moore, 1995). Historic flooding, and the associated damage to this area in 2008, created significant interest from local government and conservation groups that led to the formation of several watershed protection and management coalitions and initiatives in north-central Iowa. Key societal concerns that can be addressed with these mapping projects include watershed management, water quality and quantity issues, flood management, and aggregate production and resource protection. Thus, as part of the geologic mapping program for the upper Cedar River watershed, producing a bedrock geologic map for the Orchard 7.5' Quadrangle was strongly recommended by the Iowa State Mapping Advisory Committee (SMAC), and approved by the National Cooperative Geologic Mapping Program (STATEMAP).

The previous bedrock geologic map of north-central Iowa was completed by Witzke and others in 2001. Since then, new geologic data from this area have been accumulated and become available for more detailed geologic mapping. To better understand the geology in the mapping area, the new bedrock geologic map presented herein subdivides the widespread Devonian Cedar Valley Group and Wapsipinicon Group into their distinct formations, which were undifferentiated on both the Bedrock Geologic Map of North-Central Iowa (1:250,000) (Witzke et al., 2001) and the Bedrock Geologic Map of Iowa (1:500,000) (Witzke et al., 2010).

GEOLOGIC SETTING AND RESEARCH HISTORY

In terms of landforms, the Orchard 7.5' Quadrangle lies in the Iowan Surface landform region where the land surface had been modified by various episodes of erosion before and during Wisconsin-age glacial events (Prior, 1991). Due to extensive glacial and erosional activities, the landscape of this area is characterized by relatively low topographic relief, slightly inclined to gently rolling with long slopes, and open horizons. This landform region also features common fieldstones of glacial origin known as glacial erratics. The land surface of this mapping area is mostly covered by Quaternary deposits with a thickness commonly less than 12 m (40 ft), but it can reach a maximum thickness of 36 m (117 ft) in bedrock valleys. These unconsolidated Quaternary sediments are undifferentiated in this map. For the detailed surficial geology and Quaternary stratigraphy, see the surficial geologic map of this quadrangle (Kerr et al., 2016).

As described above, the bedrock surface of the Orchard 7.5' Quadrangle is dominated by Devonian deposits. Paleogeographically, the mapping area is within the northern portion of the Devonian Iowa Basin, a region with thickened carbonates, shale, and minor other lithologies deposited from the Eifelian through part of the Famennian age (Witzke et al., 1988; Witzke and Bunker, 2006; Day, 2006; Day et al., 2008). Lower Devonian strata have not been recognized in this part of the basin. The Iowa Basin was the site of shallow marine to supratidal deposition during the Devonian. Sedimentation kept pace with subsidence, and did not develop as a bathymetric basin (Witzke et al., 1988). Many stratigraphic units in the Iowa Basin

are fossiliferous. Based on the lithology and fossils, a stratigraphic sequence consisting of seven formations was established in the northern part of the Devonian Iowa Basin, and it has been recognized that these deposits were controlled by seven corresponding major 3rd order relative sea level fluctuations which have been labeled as the Iowa Devonian transgressive-regressive (T-R) cycles (Witzke et al., 1988; Day et al., 2013a). Several type sections of the Devonian stratigraphic sequence are located in the surrounding area, and the type section of the Lithograph City Formation is located within the mapping area. Six formations of the Devonian sequence have been recognized in the mapping area, and four of which comprise major parts of the bedrock surface of the map.

Due to its special depositional environments, complex sedimentary lithology, and many richly fossiliferous units, the geology, paleoenvironments, paleontology and stratigraphy of the Devonian Iowa Basin have been intensively studied (e.g., Belanski, 1927, 1928; Koch, 1970). Recent important studies of the Iowa Basin include Witzke and Bunker (1984), Anderson (1984), Bunker and others (1986), Bunker (1995), Anderson and Bunker (1998), Groves and others (2008), McKay and Liu (2012), and Day and others (2006, 2008, 2013b). Geologic mapping projects at 1:24,000 and 1:100,000 scales in north-central Iowa have been conducted by the IGS since 2009. In addition to 7.5' quadrangle maps, bedrock geologic maps at 1:100,000 scale have been recently completed for Bremer County (McKay et al., 2010), Worth County (Liu et al., 2012), Black Hawk County (Rowden et al., 2013), Cerro Gordo County (Liu et al., 2015), and Mitchell County (Clark et al., 2016) in the northern portion of the Devonian Iowa Basin. Results from these geologic studies and bedrock mapping projects provide significant regional geologic information and new data for the present bedrock map.

METHODS

The bedrock geologic mapping process includes data collection, subsurface geologic data analysis, descriptive logging when drilling materials are available, geologic field investigations and test drilling when needed, and map compilation.

All available sources of geologic information for the region were utilized in the production of this map, including subsurface information, USDA Natural Resources Conservation Service (NRCS) soil survey data, aerial photography, satellite imagery, and LiDAR. Since much of the bedrock surface in the map area is buried by Quaternary sediments, subsurface bedrock information was mainly derived from the analysis of water well data stored in the IGS GEOSAM database. Where available, engineering borings from public utilities, the Iowa Department of Transportation, and monitoring well records of the U.S. Geological Survey (USGS) and IGS were also used.

For the bedrock geologic map, a total of 73 private and public wells located in the mapping area were studied, including 9 shallow drill holes which were completed for this mapping project. Among these wells, 30 have descriptive striplogs with cutting samples repositied in IGS, 21 of which were newly logged for this bedrock geologic mapping task. These striplogs and many driller's logs provide important subsurface geologic information of bedrock mapping units. The locations of data points in the IGS GEOSAM database were checked for accuracy and updated where needed. The topography of the buried bedrock surface has been updated based on all available well penetrations, and a newly constructed bedrock topographic map formed an essential basis for the development of the new bedrock geologic map.

New geologic information was also obtained from field investigations of outcrops and quarry exposures. During the field investigations, shallow bedrock information from the digital soil surveys in Floyd County (Voy, 1995) and Mitchell County (Voy and Highland, 1975) was used for delineating potential bedrock outcrops. In the mapping area, 55 bedrock outcrops including several rock quarries were

accessed and studied, which provided important regional stratigraphic information for the bedrock geologic mapping. Bedrock stratigraphic information from the surrounding area, including bedrock outcrops, quarries, and well information, was also studied and utilized for this mapping project.

ArcGIS and on-screen digitizing techniques developed during previous STATEMAP projects have been used for this mapping project. The newly compiled bedrock geologic map is stored and available as a shapefile in the NRGIS library of the Iowa Department of Natural Resources (IDNR), and as a PDF file on the IGS Publications website <http://www.ihr.uiowa.edu/igs/>.

BEDROCK STRATIGRAPHY AND MAPPING UNITS

The bedrock strata occurring in the Orchard 7.5' Quadrangle include Cretaceous and Devonian deposits. Stratigraphic units mapped on the new bedrock geologic map are outlined on the map Legend and the Stratigraphic Column. The boundaries separating the various map units were selected to reflect 1) prominent lithologic changes, 2) fossils when available, and 3) major regional unconformities and/or disconformities. The bedrock stratigraphic nomenclature and correlation of the Devonian for this map follow the stratigraphic framework proposed by Witzke and others (1988). The thickness of each map unit was derived from well penetrations within the map area. However, variations in thickness occur for each unit across the map area.

Five bedrock formations, in descending order, the Cretaceous Dakota/Windrow Formation, the Devonian Shell Rock, Lithograph City, Coralville, and Little Cedar formations comprise the bedrock surface of the map area. Two other formations, the Devonian Pinicon Ridge and Spillville formations, are found in wells only and do not occur at the bedrock surface. The general lithologic features and thickness of each bedrock mapping unit are described as follows.

Cretaceous System

Kd - Sandstone, Mudstone, and Siderite Pellets (Dakota/Windrow Formation) "Mid"-Cretaceous. This map unit occurs as scattered erosional outliers and is only identified by the soil surveys in the southern part of the mapping area. This formation comprises a non-marine fluvial and pedogenic facies succession characterized by a variety of lithologies, commonly dominated by quartzose sandstones with secondary chert/quartz conglomerates, in part cemented by iron oxides. The thickness of this unit is variable, but is usually less than 6 m (20 ft) in the mapping area.

Devonian System

Dsr - Limestone, Dolomite, and Shale (Shell Rock Formation) Upper Devonian. This map unit forms the bedrock surface mainly in the southwestern part of the quadrangle. It usually has a thickness of 0 to 14 m (0-45 ft) in the mapping area, and is characterized by limestone, dolomitic limestone and dolomite, with some gray to light green shale and/or argillaceous carbonates. Fossiliferous layers, especially characterized by abundant bryozoans and other fossils, commonly occur in the lower part of the unit. Stromatoporoids, brachiopods, corals, and crinoids are abundant in some intervals of this formation.

Dlgc - Limestone, Dolomite, and Shale (Lithograph City Formation) Middle to Upper Devonian. This map unit dominates the bedrock surface except the southwestern part and bedrock valleys in the northern part of the quadrangle. The thickness of this unit is usually around 21 to 27 m (70-90 ft), with a maximum thickness up to 35 m (115 ft) in the mapping area. It consists of limestone, dolomitic limestone, dolomite, and minor shale. This unit is usually characterized by interbeds of laminated lithographic and sub-lithographic limestone and dolomitic limestone, in part argillaceous. "Birdseye" structures, vugs and calcite vug-fills are common. Some intervals are fossiliferous and stromatoporoid-rich.

Dev - Limestone and Dolomite (Coralville Formation) Middle Devonian. This map unit occurs on the bedrock surface along the Cedar River and in bedrock valleys in the northern part of the quadrangle. The thickness of this map unit varies between 12 and 21 m (40-70 ft) in the mapping area. It is dominated by limestone, dolomitic limestone, and dolomite, in part laminated, argillaceous, or shaly. Brachiopods, echinoderm debris and corals usually occur in the limestone facies.

Dlc - Dolomite, Limestone, and Shale (Little Cedar Formation) Middle Devonian. This map unit only occurs at the bedrock surface within the bedrock valley in the northeastern part of the quadrangle. The thickness of this formation ranges from 27 to 40 m (90-130 ft) in the mapping area. This unit is dominated by slightly argillaceous to argillaceous dolomite and dolomitic limestone, usually vuggy and partially laminated and/or cherty. A shaly layer about 3 to 6 m (10-20 ft) thick commonly occurs in the upper part of the formation. This unit is commonly fossiliferous, and brachiopods are especially abundant in the lower portion.

Dpr - Dolomite and Dolomitic Limestone (Pinicon Ridge Formation) Middle Devonian. This formation consists of dolomite and dolomitic limestone with varying textures (shaly, laminated, brecciated, sandy, and/or cherty). The thickness of this unit usually ranges from 6 to 14 m (20-45 ft). Compared to other Devonian strata in the mapping area, this formation is usually unfossiliferous. This unit does not occur at the bedrock surface of the map, and is only shown on the cross-section.

Dsp - Dolomite (Spillville Formation) Middle Devonian. This unit is dominated by medium to thick bedded dolomite with scattered to abundant fossil molds, with a maximum thickness of approximately 21 m (70 ft) in the mapping area. Its basal part, where present, is variably sandy, shaly, and/or conglomeratic with reworked Ordovician chert clasts. This formation is only shown on the cross-section, and does not occur at the bedrock surface in the mapping area.

ACKNOWLEDGMENTS

We thank Bruening Rock Products Inc., Croell Redi-Mix Inc., Falk L. R. Construction Co., and Greene Limestone Co. for allowing us to work in their quarries or gravel pits in and around the mapping area. Zachary Demanett of the Iowa Geological Survey (IGS) and Austin Pothoff of the University of Iowa (UI) prepared well cutting samples for stratigraphic logging. Tanner Hartsock (UI) logged most of the new well materials for this map. Richard Langel (IGS) managed the Iowa geologic sampling database (GEOSAM). Jed Day of Illinois State University, Bill Bunker, Robert McKay, Ray Anderson, and Brian Witzke of IDNR provided important information and valued discussions concerning the stratigraphic sequence of the mapping area. Bedrock topography is updated from Ray Anderson's (IDNR) previous work. Casey Kohrt (IDNR) provided GIS library and technical help. Administrative support was provided by Megan Delaney, Teresa Gaffey, and Sara Conrad.

REFERENCES

- Anderson, R.R., and Bunker, B.J., (eds.), 1998: Fossil shells, glacial swells, piggy smells, and drainage wells: the geology of the Mason City, Iowa, area. Geol. Soc. of Iowa Guidebook No. 65, 71 p.
- Anderson, W.I., (ed.), 1984: General Geology of north-central Iowa. Guidebook for the 48th Annual Tri-State Geol. Field Conf., 150 p.
- Belanski, C.H., 1927: The Shellrock Stage of the Devonian. American Midland Naturalist, v. 10, p. 316-370.
- Belanski, C.H., 1928: The Shellrock Stage of the Devonian; Description of some typical fossils of the Shellrock Stage. American Midland Naturalist, v. 11, p. 165-212.

- Bunker, B.J., Witzke, B.J. and Day, J.E., 1986: Upper Cedar Valley Stratigraphy, North-Central Iowa, Lithograph City Formation. Geol. Soc. of Iowa Guidebook No. 44, 41 p.
- Bunker, B.J., (ed.), 1995: Geology and hydrogeology of Floyd-Mitchell counties, north-central Iowa. Geol. Soc. of Iowa Guidebook No. 62, 169 p.
- Clark, R., Liu, H., Kerr, P., Tassier-Surine, S., Rowden, R., and Streeter, M., 2016: Bedrock geology of Mitchell County, Iowa. Iowa Geological Survey Open File Map OFM-16-1.
- Day, J., 2006: Overview of the Middle-Upper Devonian sea level history of the Wapsipinicon and Cedar Valley Groups, with discussion of new conodont data from the subsurface Cedar Valley Group of southeastern Iowa. *in* Day, J., Luczaj, J., and Anderson, R., (eds.), *New Perspectives and Advances in the Understanding of Lower and Middle Paleozoic Epeiric Carbonate Depositional Systems of the Iowa and Illinois Basins*. Iowa Geological Survey Guidebook Series No. 25, p. 3-21.
- Day, J., Witzke B., and Bunker, B.J., 2008: Overview of Middle and Upper Devonian Cedar Valley Group and Lime Creek Formation carbonate platform facies, faunas, and event stratigraphy of northern Iowa. *in* Groves, J.R., Walters, J.C., and Day, J., (eds.), *Carbonate platform facies and faunas of the Middle and Upper Devonian Cedar Valley Group and Lime Creek Formation, northern Iowa*. Iowa Geological Survey Guidebook, No. 28, p. 15-39.
- Day, J., Witzke B., and Bunker, B.J., 2013a: Overview of Middle and Upper Devonian northern shelf facies in the Iowa Basin. *in* Day, J., Witzke B., and Lundy, S., (eds.), *Aspects of the Paleozoic history of epeiric seas of the Iowa Basin*. Iowa Geological and Water Survey Guidebook No. 29, p. 1-40.
- Day, J., Witzke B., and Lundy, S., (eds.), 2013b: *Aspects of the Paleozoic history of epeiric seas of the Iowa basin*. Iowa Geological and Water Survey Guidebook No. 29, 118 p.
- Groves, J.R., Walters, J.C., and Day, J. (eds.), 2008: Carbonate platform facies and faunas of the Middle and Upper Devonian Cedar Valley Group and Lime Creek Formation, northern Iowa. Iowa Geological Survey Guidebook No. 28, 96 p.
- Kerr, P., Tassier-Surine, S., Streeter, M., Liu, H., and Clark, R., 2016: Surficial geologic map of the Orchard 7.5' Quadrangle, Floyd and Mitchell counties, Iowa. Iowa Geological Survey Open File Map OFM-16-4.
- Koch, D.L., 1970: Stratigraphy of the Upper Devonian Shell Rock Formation of north-central Iowa. Iowa Geological Survey Report of Investigations 10, 123 p.
- Libra, R.D., Hallberg, G.R., Ressmeyer, G.G., and Hoyer, B.E., 1984: Groundwater quality and hydrogeology of Devonian-Carbonate aquifers in Floyd and Mitchell counties, Iowa. Iowa Geological Survey Open File Report 84-2, p. 1-106.
- Libra, R.D., Quade, D.J., Hallberg, G.R., and Littke, J.P., 1994: Groundwater quality, hydrogeology, and agricultural drainage wells, Floyd and Mitchell counties, Iowa. Iowa Geological Survey Technical Information Series 29, 64 p.
- Liu, H., McKay, R., Rowden, R., Quade, D., Tassier-Surine, S., and Giglierano, J., 2012: Bedrock Geology of Worth County, Iowa. Iowa Geological and Water Survey Open File Map OFM-12-1.
- Liu, H., Clark, R., Fields, C., McKay, R., Rowden, R., Tassier-Surine, S., Kerr, P., and Streeter, M., 2015: Bedrock Geology of Cerro Gordo County, Iowa. Iowa Geological Survey Open File Map OFM-15-1.
- McKay, R.M., Liu, H., and Giglierano, J.D., 2010: Bedrock Geology of Bremer County, Iowa. Iowa Geological and Water Survey Open File Map OFM-10-10.
- McKay, R.M. & Liu, H., 2012: Cedar Valley Group: the Lithograph City – Shellrock Formation contact at Mason City, Iowa. Geol. Soc. of Iowa Guidebook No. 90, 12 p.
- Moore, F., 1995: Floyd County groundwater protection project and sinkhole cleanout. *in* Bunker, B.J., (ed.), *Geology and hydrogeology of Floyd-Mitchell counties, north-central Iowa*. Geol. Soc. of Iowa Guidebook No. 62, p. 75.
- Prior, J.C., 1991: Landforms of Iowa. University of Iowa Press, Iowa City, 154 p.
- Rowden, R., McKay, R., Liu, H., Quade, D., Tassier-Surine, S., and Giglierano, J., 2012: Bedrock Geology of Black Hawk County, Iowa. Iowa Geological and Water Survey Open File Map OFM-13-3.
- Voy, K.D., 1995: Soil Survey of Floyd County, Iowa. U.S. Dept. of Agriculture, Soil Conservation Service, 260 p. with 63 map sheets.

- Voy, K.D. and Highland, J.D., 1975: Soil Survey of Mitchell County, Iowa. U.S. Dept. of Agriculture, Soil Conservation Service, 125 p. with 70 map sheets.
- Witzke, B.J. and Bunker, B.J., 1984: Devonian stratigraphy of north-central Iowa. Iowa Geological Survey Open File Report 84-2, p. 107-149.
- Witzke, B.J. and Bunker, B.J., 2006: Middle shelf facies of the Cedar Valley Group (Devonian) and their stratigraphic relationships in eastern Iowa. *in* Day, J. E., Luczaj, J., and Anderson, R., (eds.), *New Perspectives and Advances in the Understanding of Lower and Middle Paleozoic Epeiric Carbonate Depositional Systems of the Iowa and Illinois Basins*. Iowa Geological Survey Guidebook Series No. 25, p. 23-46.
- Witzke, B.J., Anderson, R.R., and Pope, J.P., 2010: Bedrock geologic map of Iowa (1:500,000). Iowa Geological and Water Survey Open File Map OFM-10-1.
- Witzke, B.J., Bunker, B.J., and Rogers, F.S., 1988: Eifelian through lower Frasnian stratigraphy and deposition in the Iowa area, central midcontinent, U.S.A. *in* McMillan, N.J., Embry, A.F, and Glass, D.J., (eds.): *Devonian of the World*. Canadian Soc. of Petroleum Geologists, Memoir 14, vol. I, p. 221-250.
- Witzke, B.J., Anderson, R.R., Bunker, B.J., Ludvigson, G.A., and Greeney, S., 2001: Bedrock geology of north-central Iowa (1:250,000). Iowa Geological Survey Open File Map OFM-01-3.