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

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INTRODUCTION

The Charles City 7.5' Quadrangle is located in Floyd County, north-central Iowa. It covers an area from 43° 0' to 43° 7' 30" N latitude and 92° 45' to 92° 37' 30" W longitude. The detailed bedrock geologic map of the Charles City 7.5' Quadrangle was completed as part of the Iowa Geological Survey's (IGS) ongoing participation in the STATEMAP mapping program in north-central Iowa.

The bedrock surface of the Charles City 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 Charles City 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 Charles City 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 varying between 9 and 27 m (30-90 ft), and it can reach a maximum thickness of 71 m (235 ft) in bedrock valleys occurring in the east-central and northeastern parts of the mapping area. 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 (Streeter et al., 2016).

As described above, the bedrock surface of the Charles City 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 miner 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 areas. Five formations of the Devonian sequence have been recognized in this mapping area, and three 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 at1:100,000 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 328 private and public wells located in the mapping area were studied, including 44 shallow drill holes which were completed for this mapping project. Among these wells, 59 have descriptive striplogs with cutting samples reposited in IGS, 15 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) was used for delineating potential bedrock outcrops. In the mapping area, 17 bedrock outcrops including a few 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.iihr.uiowa.edu/igs/.

BEDROCK STRATIGRAPHY AND MAPPING UNITS

The bedrock strata occurring in the Charles City 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.

Four bedrock formations, in descending order, the Cretaceous Dakota/Windrow Formation, the Devonian 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 found occasionally in well cuttings and identified by the soil survey of Floyd County in 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

Dlgc - Limestone, Dolomite, and Shale (Lithograph City Formation) Middle to Upper Devonian. This map unit dominates the bedrock surface except the large bedrock valley in the north and the areas with Cretaceous deposits in the southwest portion of the quadrangle, with a maximum thickness up to 30 m (100 ft). 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.

Dcv - Limestone and Dolomite (Coralville Formation) Middle Devonian. This map unit occurs on the bedrock surface along the bedrock valleys in the northern portion of the quadrangle. The thickness of this map unit mostly 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 east-central part of the quadrangle. The

thickness of this formation ranges from 26 to 40 m (85-130 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) 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 5 to 14 m (15-45 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. The thickness of this unit usually ranges from 21 to 26 m (70-85 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.

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