BEDROCK GEOLOGIC MAP OF THE VINTON 7.5' QUADRANGLE, BENTON COUNTY, IOWA

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1. INTRODUCTION

The Vinton 7.5’ quadrangle is located in central Iowa, and covers an area from 42° 07’ 30” to 42° 15’ N latitude and 92° 07’ 30” to 92° 00’ W longitude. The bedrock geologic map of this quadrangle was completed as part of the Iowa Geological Survey’s (IGS) ongoing participation in the National Cooperative Geologic Mapping Program (STATEMAP) in Iowa and was supported in part by the U.S. Geological Survey grant number G18AC00194.

The land surface of the Vinton 7.5’ quadrangle is commonly covered by Quaternary sediments, with some shallow bedrock exposures mostly along the Cedar River and tributaries in the mapping area (Fig. 1). In terms of landforms, this area lies in the Iowan Erosion Surface landform region where the land surface has been modified by various episodes of erosion before and during the 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 “paha” ridges and large fieldstones known as glacial erratics of glacial origin (Fig. 2).

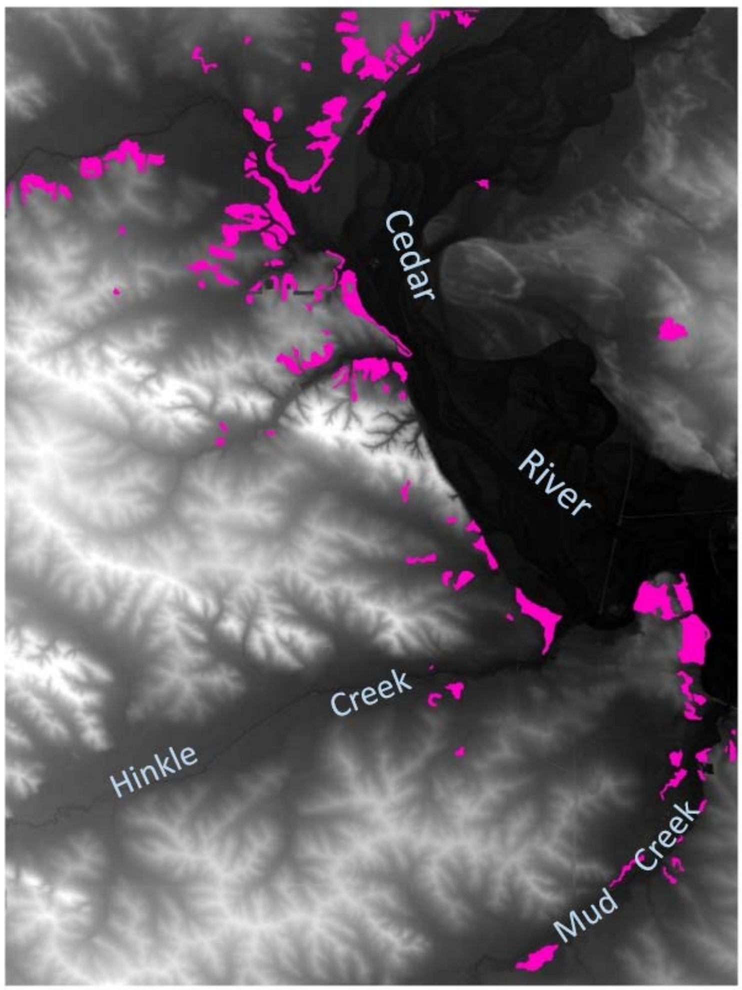

Fig. 1: The shaded relief map (DEM-3M) and shallow bedrock distribution (in purple; derived from Brown and Highland, 1980) of the Vinton 7.5’ quadrangle.

Fig. 2: Large glacial erratic on the land surface of the Iowan Surface landform region.

The Quaternary sediments in the mapping area consist of loamy soils developed in loess, glacial till, and colluvium of variable thickness, and alluvial clay, silt, sand, and gravel. The thickness of the Quaternary deposits usually varies between 8 and 24 m (25-80 ft), with a maximum of more than 60 m (200 ft) in deep bedrock valleys in the southwestern part of the quadrangle. These unconsolidated Quaternary sediments are undifferentiated in this map. For the detailed Quaternary stratigraphy and distribution, see the surficial geologic map of this quadrangle (Kerr et al., 2019).

The bedrock surface of the Vinton 7.5' Quadrangle is dominated by Devonian strata which consist of carbonates, shale, and minor other lithologies including evaporites (Figs 3 & 4). Some Silurian carbonates also occur on the bedrock surface in a deep bedrock valley across the map area. The dominant Devonian strata form the important regional upper bedrock aquifer in this area (Libra et al., 1984, 1994), and this aquifer is vulnerable to contamination when covered by relatively thin surficial materials. Shallow carbonate rocks are also sensitive to precipitation. Historic flooding in 2008, for example, caused serious damage to Iowa including the Cedar River watershed. To prevent these geology-related hazards, it becomes intelligible for local government, conservation groups, and the public to better understand local geology for the issues of watershed management, water quality and quantity problems, flood management, and aggregate production and resource protection. Thus, as part of the geologic mapping program for Iowa, producing more detailed bedrock geologic maps for the Cedar River watershed was strongly recommended by the Iowa State Mapping Advisory Committee (SMAC), and approved by the National Cooperative Geologic Mapping Program (STATEMAP). This map resulted as part of the first phase of geologic mapping in Benton County.

The bedrock geology in east central Iowa has been extensively studied and previously mapped at various scales. However, 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 the bedrock geologic map of east central Iowa (1:250,000; Witzke et al., 2003) and the bedrock geologic map of Iowa (1:500,000; Witzke et al., 2010).

2. GEOLOGIC SETTING AND RESEARCH HISTORY

As described above, the bedrock surface of the map area is mainly composed of Devonian deposits. Paleogeographically, this area is within the Devonian Iowa Basin, a region with thickened carbonates, shale, and minor other lithologies including supratidal evaporites 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 Devonian Iowa Basin are well-known and fossiliferous (Figs. 3 & 4). Based on the lithology and fossils, a stratigraphic sequence consisting of a series of formations was established in the 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 (Johnson et al., 1985; Witzke et al., 1988; Day et al., 2013). Represented by typical sediments and fossils, several type sections (stratotypes) of the Devonian stratigraphic sequence are located within the northern part of the Devonian basin.

Due to the distinctive depositional environments, complex sedimentary lithologies, and many richly fossiliferous units, the geology, paleoenvironments, paleontology and stratigraphy of the Devonian Iowa Basin have been extensively studied. Early studies include the publications of Hall and Whitney (1858), Belanski (1927 and 1928) and Koch (1970). Recent important studies of the Devonian Iowa Basin are represented by Witzke and Bunker (1984), Anderson (1984), Bunker and others (1986), Witzke and others (1988), Day and Bunker (1992), Bunker (1995), Anderson and Bunker (1998), Groves and others (2008), McKay and Liu (2012), and Day and others (2006, 2008, 2013). Studies on the regional Silurian stratigraphy and geology include the publications of Witzke (1981a, 1981b, 1992). Comprehensive geologic mapping projects in the Devonian Iowa Basin have been undertaken by the IGS since 2009. In addition to 7.5' quadrangle maps of 1:24,000 scale, bedrock geologic maps at 1:100,000 scale have been recently completed for several nearby counties. The bedrock geologic map of east central Iowa (1:250,000; Witzke et al., 2003) and the bedrock geologic map of Iowa (1:500,000; Witzke et al., 2010) have also been completed by IGS. Results from these geologic studies and bedrock geologic mapping projects provide significant regional geologic information and valuable new data for the compilation of the present bedrock geologic map.

Fig. 3: Bedrock outcrops in the Vinton 7.5' quadrangle. Left: The Little Cedar Formation occurs in the Coots Quarry. Right: An abandoned old quarry in the mapping area.

Fig. 4: Some typical fossils from the Devonian strata in the mapping area. Upper left: brachiopod; Upper right: cephalopod; Lower left: rugosa coral; Lower right: colony coral.

3. METHODS

The bedrock geologic mapping process includes data collection, subsurface geologic data analysis, descriptive logging when drilling materials are available, geologic field investigations, test drilling when needed, bedrock topographic map construction, mapping-unit (stratigraphic formation) structure line composition, and bedrock geologic map compilation.

All available sources of geologic information from the mapping region were utilized in the production of this map, including subsurface geologic information, U.S. Department of Agriculture (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 which are stored in the IGS GeoSam and GeoCore databases (https://www.iihr.uiowa.edu/igs/iowa-geological-survey-data-portal). Where available, engineering borings from public utilities, the Iowa Department of Transportation (IDOT), and monitoring well records of USGS and IGS were also used. Information from Benton and surrounding county assessors helped to determine some of the well locations.

During the compilation of this bedrock geologic map, a total of 120 private and public wells located within the mapping area were studied, including 14 newly drilled holes especially for this mapping project. Among these wells, 24 have descriptive striplogs with cutting samples which are reposited at the IGS Oakdale Rock Library, and 6 of these striplogs were newly logged for this bedrock geologic mapping task. The rest of the studied wells usually only have driller's logs containing basic geologic and locational information. These striplogs and most driller's logs provide important subsurface geologic information including bedrock depth, lithology, thickness, and distribution of mapping units. The locations of data points in the IGS GeoSam and GeoCore databases were checked for accuracy and updated where needed.

The topography of the bedrock surface of the mapping area has been updated based on all available well penetrations, as well as bedrock exposures. Some necessary estimates are made to the Quaternary thickness of some wells. For details, see the Discussion section of this report. Based on the updated data, the previous bedrock topographic map of Iowa, with a 50' contour interval, was reconstructed with a 25' contour interval in the map area (Fig. 5). These activities formed an essential basis for the development and compilation of the new bedrock geologic map of the Vinton 7.5' Quadrangle.

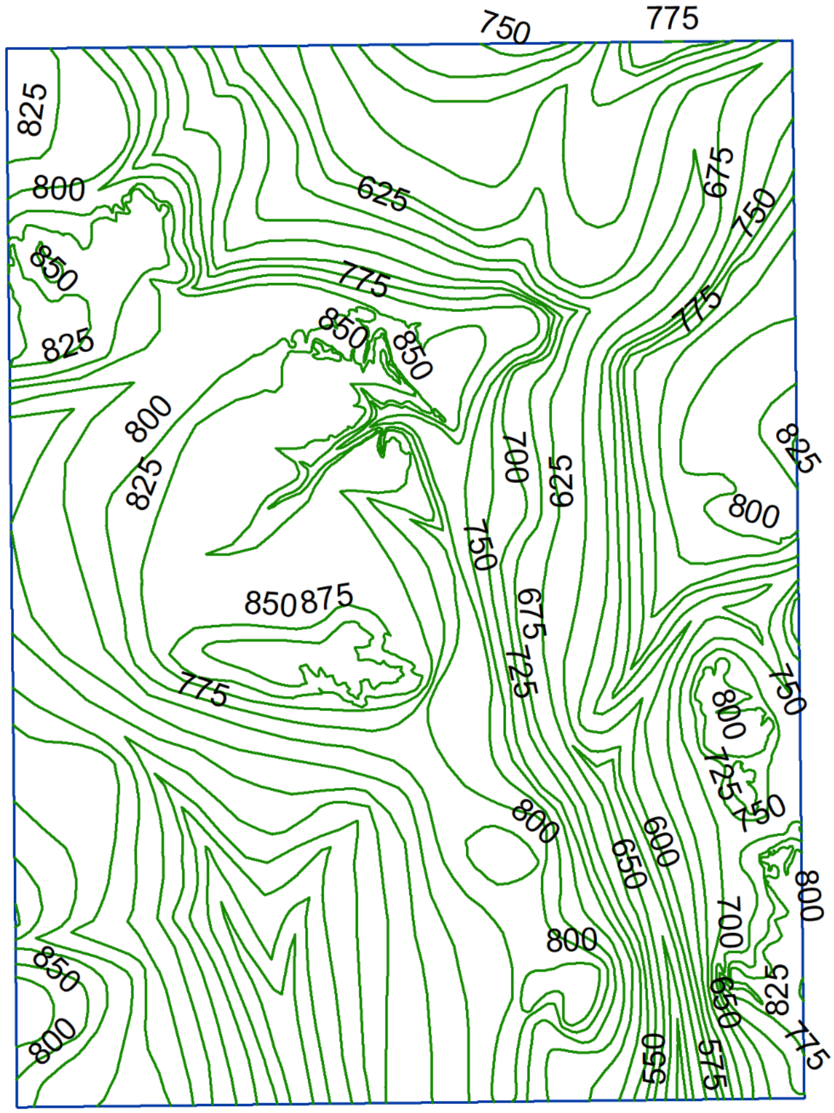

Fig. 5: The updated bedrock topographic map of the Vinton 7.5' Quadrangle with the contour interval of 25'.

New geologic information was also obtained from field investigations of bedrock outcrops and rock quarry exposures. During the field investigations, shallow bedrock information from the digital soil surveys in Benton County (Brown & Highland, 1980) was used for delineating potential bedrock outcrops. Within the mapping area, 8 bedrock outcrops, including several operating or abandoned rock quarries, were accessed and studied in the field. Bedrock information from surrounding areas, including bedrock outcrops, quarries, and subsurface geologic information from wells, was also studied and utilized for this mapping project. All the above geologic data and study results provided important regional stratigraphic information for the compilation of the bedrock geologic map of Vinton 7.5’ Quadrangle.

ArcGIS 10.5 software 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 Iowa GEODATA Clearing House (https://geodata.iowa.gov) and as a PDF file on the IGS Publications website (http://www.iowageologicalsurvey.org).

4. BEDROCK STRATIGRAPHY AND MAPPING UNITS

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 follow the stratigraphic framework proposed by Witzke and others (1988) for the Devonian strata, and Witzke (1992) for the Silurian deposits of the map. The thickness of each map unit was derived from well penetrations within and surrounding the map area. However, variations in thickness occur for each unit across the map area.

Seven bedrock formations, in descending order, the Lithograph City, Coralville, Little Cedar, Pinicon Ridge, Otis and Bertram formations of the Devonian and the LaPorte City Formation of Silurian comprise the bedrock surface of the map area. However, the Otis and Bertram formations are not differentiated in the map because of their lithological similarity and distribution restriction. The general lithologic features and thickness of each bedrock mapping unit are briefly described as follows:

PALEOZOIC

DEVONIAN SYSTEM

Dlgc - Limestone, Dolomite, and Shale (Lithograph City Formation) Middle to Upper Devonian. This map unit has been mostly eroded and occurs only as a small spot on the bedrock surface in southwest corner of the quadrangle. Although thickness of this unit is regionary around 23 m (75 ft), erosion remains of this unit is much thinner than regular in the mapping area. This unit consists of limestone, dolomitic limestone, dolomite, and shale. Regionary this unit is 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 consists of limestone, dolomitic limestone, and dolomite, in part argillaceous or shaly. The thickness of this unit varies between 12 and 21 m (40-70 ft) in the mapping area. Brachiopods, echinoderm debris and corals are usually found in the limestone facies. This unit usually occurs as separated patches at the bedrock surface of the quadrangle.

Dlc - Dolomite, Limestone, and Shale (Little Cedar Formation) Middle Devonian. As the dominating bedrock unit, this formation occupies most of the bedrock surface in the mapping area. This unit mostly consists of limestone, dolomitic limestone and dolomite, slightly argillaceous, and partially laminated and/or cherty. Some minor shale may occur in the upper part of this formation. The thickness of this unit ranges from 27 to 52 m (90-170 ft) in the mapping area. This formation is commonly fossiliferous, and brachiopods are especially abundant in limestone facies.

Dpr – Dolomite and Dolomitic Limestone (Pinicon Ridge Formation) Middle Devonian. This map unit occurs at the bedrock surface of the deep bedrock valleys in southcentral and northeastern parts of the map.

This formation consists of dolomite and dolomitic limestone with varying textures (shaly, laminated, brecciated, sandy, and/or cherty), and occasional evaporites. The thickness of this unit usually ranges from 12 to 24 m (40-80 ft). Compared to other Devonian strata in the mapping area, this formation is usually unfossiliferous.

Dob – Limestone and Dolomite (Otis and Bertram formations) Middle Devonian. This map unit only occurs at the bedrock surface of the bedrock valley in south central mapping area. These two formations are not differentiated because the Bertram Formation only identified from very few wells with a thickness less than 10 ft. This map unit usually consists of limestone and dolomite, laminated or thick bedded. Sand and shale may occur at the bottom of the unit. The thickness of this unit ranges from 6 to 15 m (20-50 ft) in the mapping area.

SILURIAN SYSTEM

Slpc – Limestone and Dolomitic Limestone (LaPorte City Formation) upper Llandovery-lower Wenlock. This unit occurs in a bedrock valley through the quadrangle. It is a limestone facies that correlates with the upper Hopkinton-lower Scotch Grove formations of Silurian. These rocks are unconformably overlain by the Devonian rocks. The formation is dominated by dense, fossiliferous limestone and dolomitic limestone, commonly cherty to very cherty. Minor lithologies include argillaceous to shaly chert residuum at the top of the interval (may be basal Devonian rocks) and green -gray shale. The thickness of the map unit varies and is up to 43 m (140 ft).

5. DISCUSSION

Uncertainty of some well records in the mapping area has become a challenge for the mapping project. Although a total of 106 water wells were previously recorded in the mapping area and the related well information is preserved in the IGS GeoSam database, some judgements and corrections of the Quaternary thickness are required for some well records, including both driller's logs and striplogs, in this area. For the driller's logs, questions mostly come from the inaccurate lithologic descriptions. For example, so-called shale layers on the top of the well succession may be Quaternary glacial tills or loess. Because there are very few wells in this quadrangle with drill samples which can be used as the lithologic reference, the real Quaternary thickness of the well must be estimated based on surrounding well records.

The same problem also occurs with some descriptive striplogs because seemingly some drillers only collected samples for bedrock. In this situation, striplogs of wells in the mapping area are often missing the upper parts of their succession. Additionallly, other logs may not contain parts of the bedrock lithologies, which may not have been collected because they were mistaken for Quaternary deposits or the like. Thus, corrections with estimated Quaternary thickness become necessary for the accurate compilation of bedrock topography as well as the bedrock geologic map of the quadrangle.

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