SUMMARY REPORT
OF THE BEDROCK GEOLOGIC MAP OF
FLOYD COUNTY, IOWA

Iowa Geological Survey
Open File Map OFM-18-1
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1. INTRODUCTION

Floyd County is located in north-central Iowa, and covers an area from 42° 54’ to 43° 13’ N latitude and 93° 1’ to 92° 33’ W longitude. The bedrock geologic map of this county was completed as part of the Iowa Geological Survey’s (IGS) ongoing participation in the National Cooperative Geologic Mapping Program (STATEMAP) in north-central Iowa, and was supported in part by the U.S. Geological Survey (USGS; grant number G17AC00258) and under contract with the Iowa Department of Natural Resources (IDNR), state of Iowa.

The land surface of Floyd County is commonly covered by Quaternary sediments, but with abundant shallow bedrock exposures, especially along the Shell Rock River, Flood Creek, and Cedar River in the mapping area (Fig. 1). In terms of landforms, this area lies in the Iowan 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 fieldstones of glacial origin known as glacial erratics (Fig. 2).

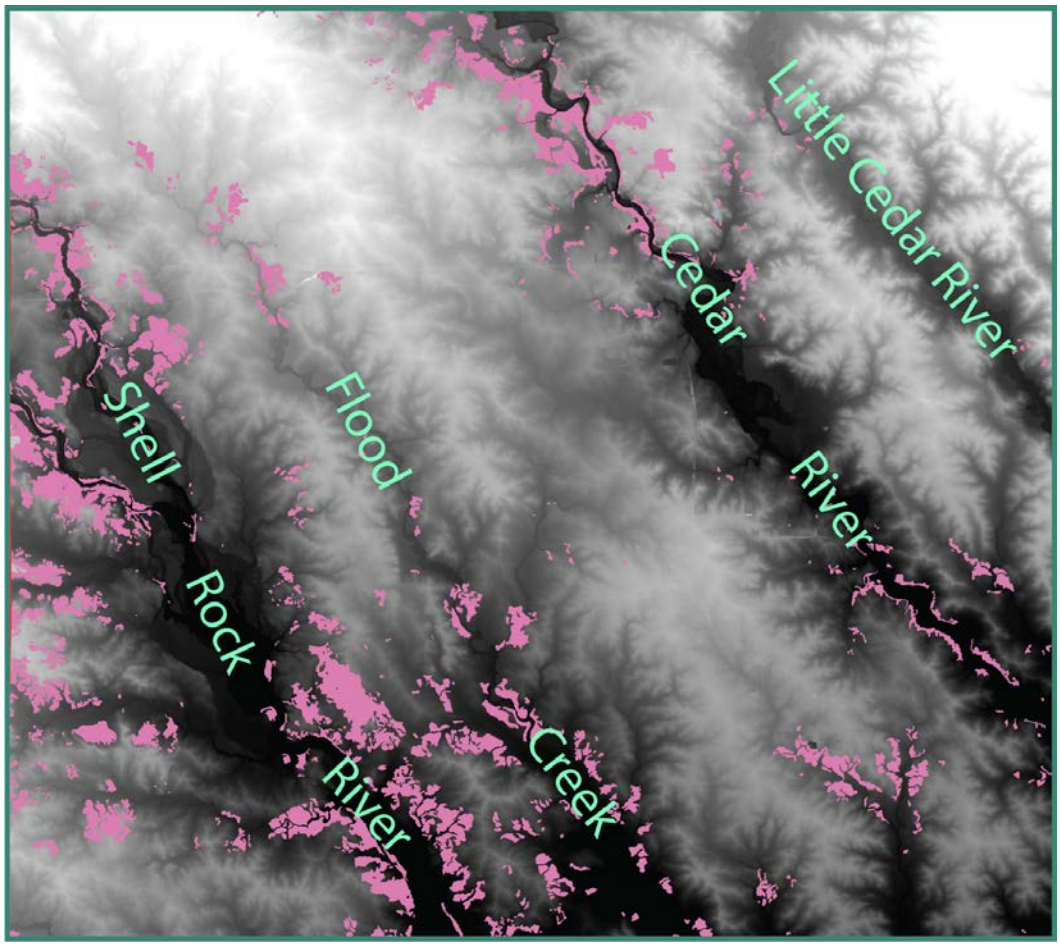

Fig. 1: The shaded relief map (DEM-3M) of Floyd County, Iowa and shallow bedrock distribution (in purple; derived from Voy, 1995) in the county.

Fig. 2: Typical landscape of the mapping area and a large glacial erratic on the land surface.

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. These deposits cover most of the land surface except in the valleys of some major rivers in the mapping area. The thickness of the Quaternary deposits usually varies between 9 and 24 m (30 and 80 ft) with a maximum thickness of up to 90 m (295 ft). These unconsolidated sediments are undifferentiated and shown only on the cross-section of the bedrock geologic map. For the detailed Quaternary stratigraphy and distribution, see the Surficial Geologic Map of Floyd County, Iowa (Kerr et al., 2018).

The bedrock surface of Floyd County is mainly comprised of Devonian strata, with some relatively thin patches of Cretaceous deposits. The Devonian deposits in this region consist of carbonates, shale and minor other lithologies. These carbonate rocks, especially those of relatively thin-bedded pure limestone layers which are commonly occurring in this area, can be easily karstified (Moore, 1995), and result in geologic hazards such as sinkholes (Fig. 3). These Devonian carbonates form the important upper bedrock aquifer in the mapping area (Libra et al., 1984, 1994), and this aquifer is vulnerable to contamination when covered by thin surficial materials. Historic flooding in 2008 caused serious damage to north-central Iowa, and it 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 geologic mapping projects in this area include watershed management, water quality and quantity issues, flood management, geologic hazards, and aggregate production and resource protection. Thus, as part of the geologic mapping program for north-central Iowa, producing a bedrock geologic map for Floyd County was strongly recommended by the Iowa State Mapping Advisory Committee (SMAC), and approved by the National Cooperative Geologic Mapping Program (STATEMAP). This map is part of the final phase of the geologic mapping project of Floyd County.

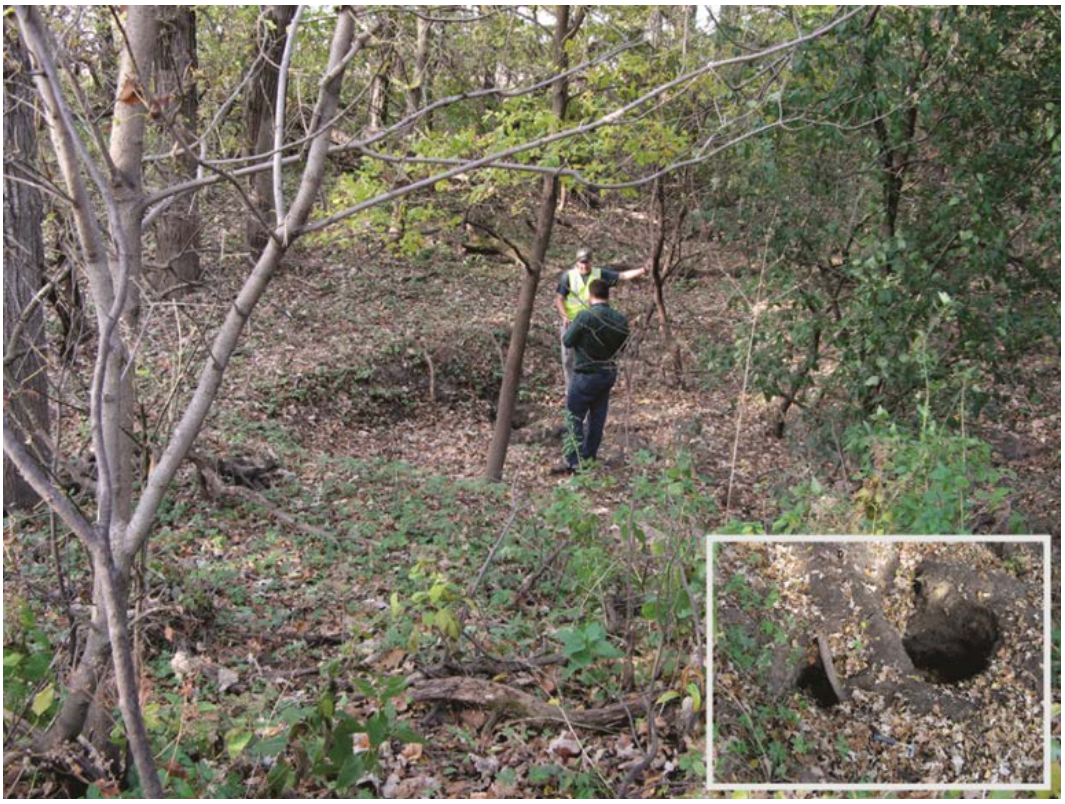

Fig. 3: A developing sinkhole found in the mapping area. The lower-right picture shows the central hole of the structure.

2. GEOLOGIC SETTING AND RESEARCH HISTORY

The bedrock geology in north-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 into its distinct formations, which were undifferentiated on the bedrock geologic map of north-central Iowa (1:250,000; Witzke et al., 2001), as well as the bedrock geologic map of Iowa (1:500,000; Witzke et al., 2010). The underlying Devonian Wapsipinicon Group has also been subdivided into formations for the bedrock geologic map of Floyd County.

As described above, the bedrock surface of Floyd County 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 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 fossiliferous. Based on the lithology and

fossils, a stratigraphic sequence consisting of a series of formations was established in the northern part of the 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 (Johnson et al., 1985; Witzke et al., 1988; Day et al., 2013). The seven specified sedimentary units deposited during the T-R cycles have been recognized on the bedrock surface of Floyd County. Represented by such typical sediments and fossils, several type sections (stratotypes) of the Devonian stratigraphic sequence, such as the Lithograph City Formation and the Shell Rock Formation, are located within or surrounding the mapping area.

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 studies of the Devonian Iowa Basin are represented by Witzke and Bunker (1984), Anderson (1984), Bunker and others (1986), Witzke and others (1988), Bunker (1995), Anderson and Bunker (1998), Groves and others (2008), McKay and Liu (2012), and Day and others (2006, 2008, 2013). Comprehensive geologic mapping projects in north-central Iowa have been undertaken by the IGS since 2009. In addition to 7.5' quadrangle maps (1:24,000), 1:100,000 scale bedrock geologic maps 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 Devonian Iowa Basin. The bedrock geologic map of north-central Iowa (1:250,000) and the bedrock geologic map of Iowa (1:500,000) were completed by Witzke and others in 2001 and 2010, respectively. Results from these geologic studies and bedrock geologic mapping projects provide significant regional geologic information and valuable data for the compilation of the present bedrock geologic map of Floyd County.

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 databases GeoSam (https://www.iihr.uiowa.edu/igs/geosam/home) and GeoCore (https://www.iihr.uiowa.edu/igs/geocore/home). Where available, engineering borings from public utilities, the Iowa Department of Transportation (IDOT), and monitoring well records of the U.S. Geological Survey (USGS) and IGS were also used. Information from Floyd and surrounding county assessors helped to determine some of the well locations.

During the compilation of this bedrock geologic map, a total of 1,045 private and public wells located within the mapping area were studied, including 29 newly drilled holes especially for this year mapping project. Among these wells, 306 have descriptive striplogs with cutting samples which are

reposited at the IGS Oakdale Rock Library, and 143 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 Floyd County has been updated based on all available well penetrations, as well as bedrock exposures. The previous bedrock topographic map (with 50' contour interval) was reconstructed with a 25' contour interval (Fig. 4). These activities formed an essential basis for the development and compilation of the new bedrock geologic map of Floyd County.

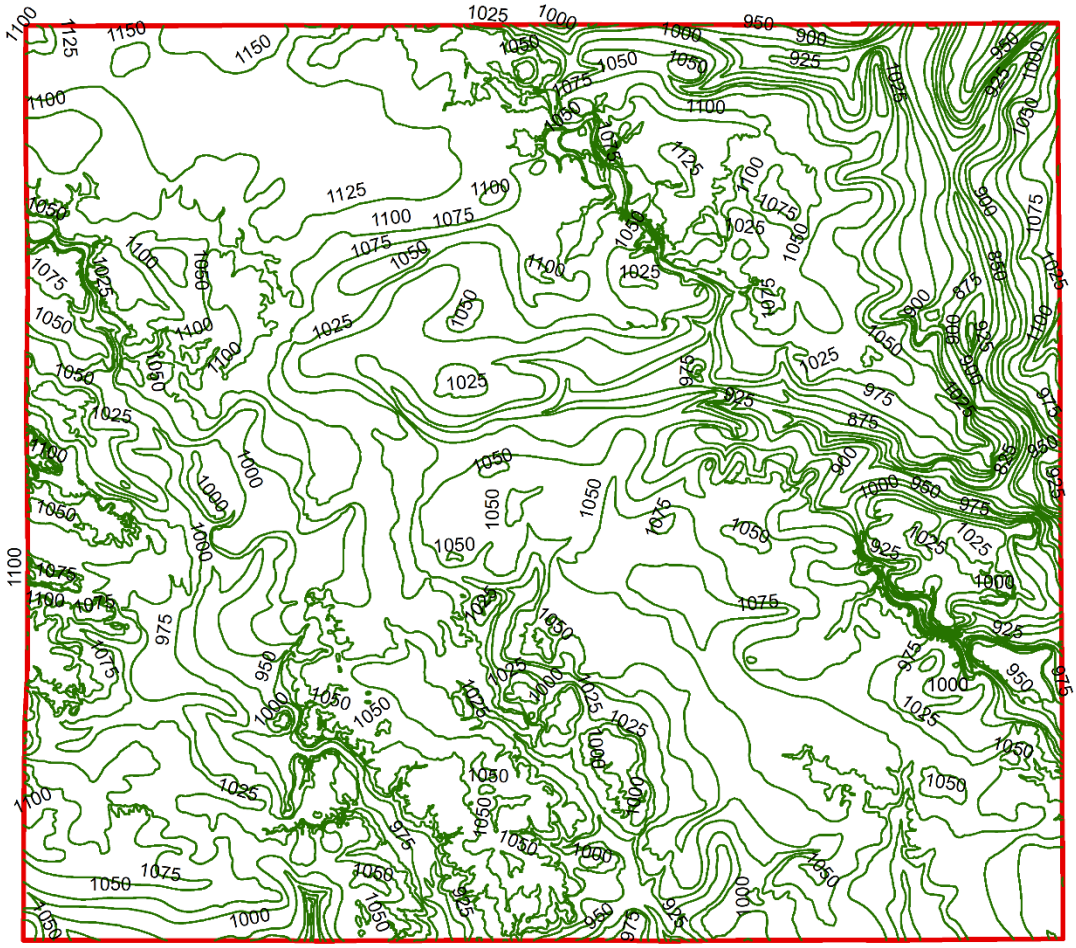

Fig. 4: The updated bedrock topographic map of Floyd County with the contour interval of 25'.

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 Floyd (Voy, 1995) and surrounding counties (Voy and Highland, 1975; DeWitt, 1981; Buckner, 1982; Wilson, 1996) was used for delineating potential bedrock outcrops and for determining some of the occurrence of the Cretaceous strata. Within the mapping area, a total of 129 bedrock

outcrops, including 29 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 Floyd County.

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 of Floyd County is stored and available as a shapefile in the NRGIS library of the Iowa Department of Natural Resources (IDNR), and as a PDF on the IGS Publications website http://www.iowageologicalsurvey.org.

4. BEDROCK STRATIGRAPHY AND MAPPING UNITS

The bedrock strata occurring in Floyd County 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.

Eight bedrock formations, in descending order, the Cretaceous Dakota (or Windrow) Formation, the Devonian Lime Creek, Shell Rock, Lithograph City, Coralville, Little Cedar, Pinicon Ridge and Spillville formations, comprise the bedrock surface of the map area. The general lithologic features and thickness of each bedrock mapping unit are briefly described as follows:

MESOZOIC

CRETACEOUS SYSTEM

Kd - Sandstone, Mudstone, and Siderite Pellets (Dakota/Windrow Formation) “Mid”-Cretaceous. This map unit occurs as scattered erosional outliers and is mostly identified by the soil surveys in the western part of the mapping area. This formation comprises a non-marine fluvial and pedogenic facies succession characterized by a variety of lithologies, which 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) when present in the mapping area.

PALEOZOIC

DEVONIAN SYSTEM

Dl – Shale, Limestone, and Dolomite (Lime Creek Formation) Upper Devonian. This map unit occurs on the bedrock surface in the western part of the mapping area. Thickness of this unit is usually less than 18 m (60 ft) when present, but it can be thicker than 35 m (115 ft) along the western border of the county. This formation consists of calcareous shales in the lower portion and limestone, dolomitic limestone, and dolomite in the upper portion. Some layers are fossiliferous and pyrite-rich.

Dsr - Limestone, Dolomite, and Shale (Shell Rock Formation) Upper Devonian. This map unit occurs on the bedrock surface mainly in the western part of the county. It usually has a thickness of 9 to 20 m (30-65 ft), but thins and pinches out toward the east of the mapping area. This formation 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, brachiopods and stromatoporoids, commonly occur in the lower part of the unit.

Dlgc - Limestone, Dolomite, and Shale (Lithograph City Formation) Middle to Upper Devonian. As the dominating bedrock unit, this formation occupies most of the bedrock surface of the mapping area. The general thickness of this unit is around 21 to 27 m (70-90 ft), but it can be thicker than 35 m (115 ft) in the mapping area. This unit consists of limestone, dolomitic limestone, dolomite, and some shaly deposits. It is usually characterized by interbeds of lithographic and sub-lithographic limestone and dolomitic limestone, in part laminated and argillaceous. "Birdseye" structures, intraclastic fabrics, 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 at the bedrock surface mainly along a bedrock valley in the eastern part of the map. The thickness of this map unit usually varies between 14 and 20 m (45-65 ft), but can be 23 m (75 ft) thick in the mapping area. This formation consists of limestone, dolomitic limestone, and dolomite, in part argillaceous or shaly. Laminated and brecciated textures may occur. Brachiopods, echinoderm debris and corals usually occur in the limestone facies.

Dlc - Dolomite, Limestone, and Shale (Little Cedar Formation) Middle Devonian. This formation dominates the bedrock surface of the deep bedrock valley in the eastern part of the mapping area. The thickness of this formation usually ranges from 24 to 37 m (80-120 ft), but can be 44 m (145 ft) thick in the mapping area. This unit is dominated by slightly argillaceous to argillaceous dolomite and dolomitic limestone, usually vuggy and partially cherty. A shaly layer about 3 to 8 m (10-25 ft) thick commonly occurs in the upper part of the formation. This unit is usually fossiliferous, and brachiopods are especially abundant in the lower portion.

Dpr - Dolomite and Dolomitic Limestone (Pinicon Ridge Formation) Middle Devonian. This map unit occurs at the bedrock surface along the deep bedrock valley in the northeast part of the map. 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.

Dsp - Dolomite (Spillville Formation) Middle Devonian. This map unit only occurs at the bedrock surface within the deep bedrock valley in the northeast part of the map. This unit is dominated by medium to thick bedded dolomite with scattered to abundant fossil molds. Thickness of this formation usually varies between 12 and 21 m (40-70 ft), and with a maximum thickness of approximately 30 m (100 ft) in the mapping area. Its basal part, where present, is variably sandy, shaly, and/or conglomeratic with reworked Ordovician chert clasts.

5. HIGHLIGHTS OF THIS MAPPING PROJECT

Several geologic and stratigraphic features in the mapping area have been recognized during the mapping process, some of which were noticed by previous studies. This section highlights some important ones, including improved mapping method.

- **The new bedrock topographic map**

As mentioned above and illustrated in Fig. 4, the bedrock topographic map of Floyd County was compiled based on multiple geologic sources with a contour interval of 25'. The new bedrock topographic map provides the basis for accurate compilation of the bedrock geologic map herein.

- **The Cretaceous deposits**

The Cretaceous sediments commonly occur as scattered erosional outliers in the western part of Floyd County. Although they were mostly identified by the soil surveys, some *in situ* exposures have been found during field investigations. They occur as either sandstones (Fig. 5), which are high in quartz and can be referred to the Dakota Formation, or iron-rich residual deposits and nodules (Fig. 6), which are characteristic features of the Windrow Formation. Detailed study may provide further evidence about the Cretaceous depositional environments in the Midwest.

Fig. 5: Cretaceous deposits (brown in color) occur in farming land in the mapping area. The upper-right picture is a close-up image of the sandstone which is high in quartz.

Fig. 6: Cretaceous bedrock outcrop with abundant iron-rich nodules (upper-left image) found in the mapping area.

- **Completeness of the regional Devonian sequence**

The bedrock surface of the mapping area comprises all seven formations, which represent the seven sea-level changes through time (T-R cycles), deposited in the late Middle and early Late Devonian Iowa Basin. This complete depositional sequence with many fossiliferous distinctive units, therefore, as described by Witzke and others (1988), provides direct evidence for the studies of sedimentary history, depositional environments, and correlations with other coeval sequences.

- **The biostrome layer around the contact between the Devonian Lithograph City and Shell Rock formations**

A stratigraphic section with the contact of Devonian Lithograph City and Shell Rock formations was measured and described by Bunker et al. (1986) at Maxson Quarry near the city of Marble Rock, Iowa. This contact is represented by a pre-Shell Rock weathered zone between the thin-beds of dolomitic limestone of the Lithograph City Formation and the fossil-rich limestone of the Shell Rock Formation (Bunker et al., 1986, Stop 3). A biostrome layer near the contact was found from this section, which is characterized by abundant brachiopods, crinoid debris, stromatoporoids, corals, gastropods, and many others including some distinctive shallow-water sedimentary structures (Figs. 7 & 8). This skeletal biostrome layer at the bottom of the Shell Rock Formation has been recognized in several sections in north-central Iowa, but it may be dominated by different taxa. In the Mason City area, for example, this

layer is featured by massive hemispherical stromatoporoids (McKay & Liu, 2012), while it is dominated by abundant bryozoans at the Staff Quarry and the bedrock outcrop nearby Lacosta Quarry, and dominated by thin laminar stromatoporoids at the areas of Rudd and Rockford, Iowa. As the deposition of the early period of a new sea-level transgression, Iowa T-R Cycle 6 of Witzke et al. (1988), this massive biostrome layer represents a stable tidal-zone depositional facies, and variation of dominating taxa was likely controlled by local depositional environments. Therefore, this skeletal biostrome layer can be successfully used as an indicator of the contact between the Lithograph City and Shell Rock formations within and surrounding the mapping area, and further study of the relationship between dominating taxa and their paleoecologic niche may provide some paleoenvironmental details in the northern portion of the Devonian Iowa Basin.

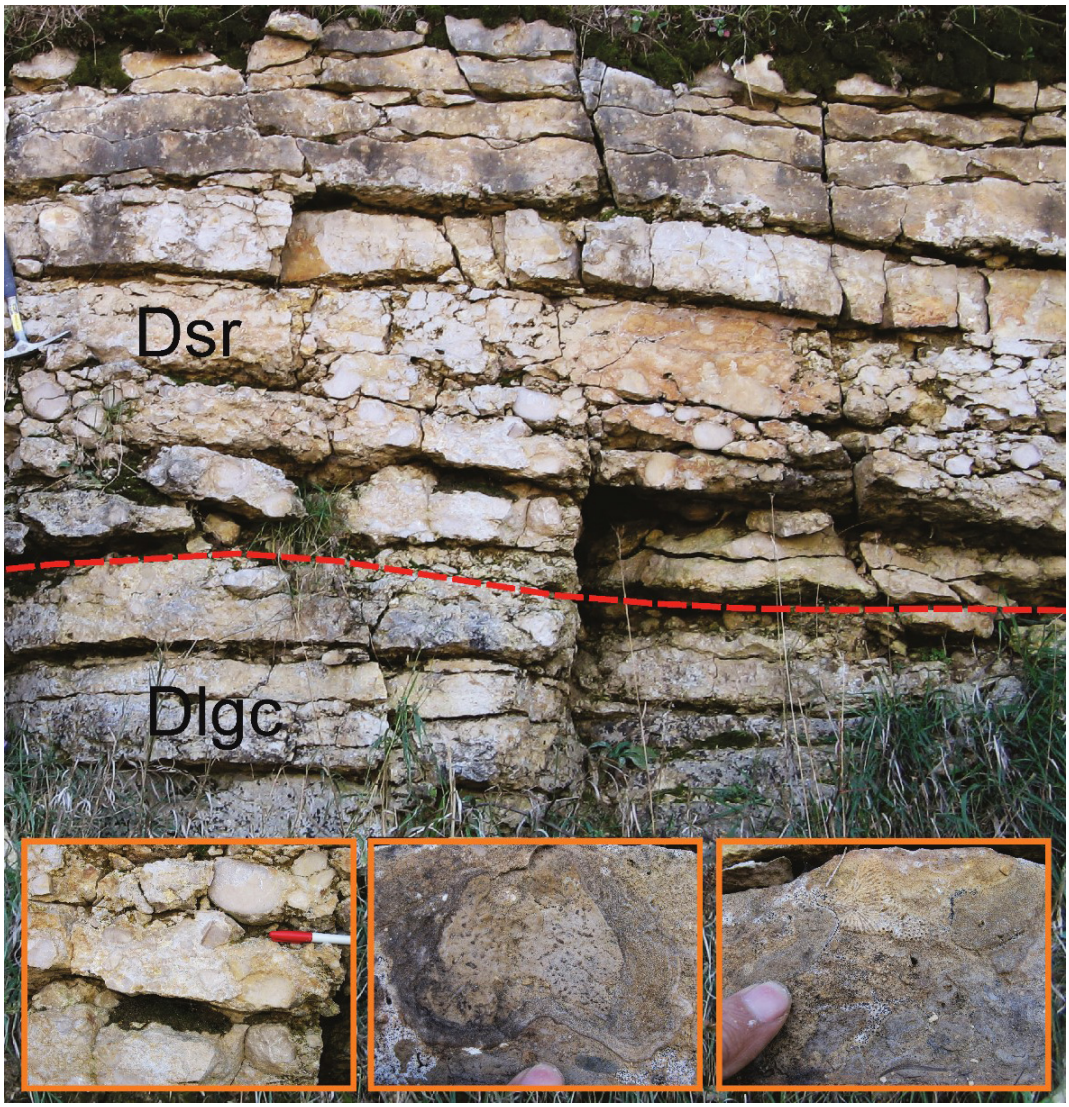

Fig. 7: The south wall section of Maxson Quarry near the city of Marble Rock shows the contact between the Devonian Lithograph City Formation (Dlgc) and Shell Rock Formation (Dsr). A massive skeletal biostrome layer containing abundant stromatoporoids, bryozoans, corals, brachiopods, and others occurs at the bottom of the Shell Rock Formation. The lower images show some typical fossils from this biostrome layer.

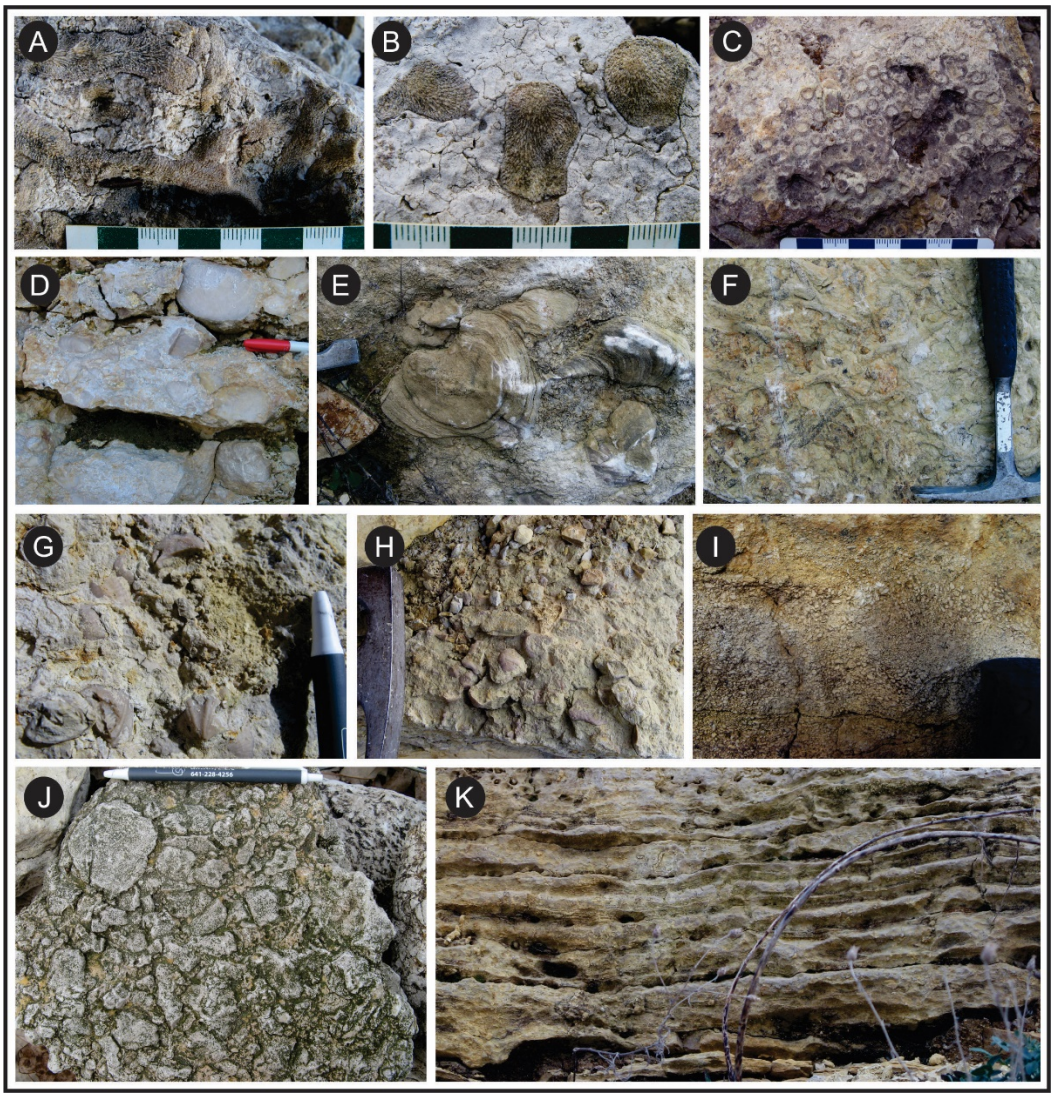

Fig. 8: Some typical fossils and sedimentary structures from the bottom fossiliferous layer (biostrome) of the Shell Rock Formation: **A & B**, Bryozoans; **C:** Corals; **D & E**, Spherical stromatoporoids; **F**, Branching stromatoporoids; **G & H**, Brachiopods (*Cyrtina* sp.); **I**, Tidal-reworked skeletal fragments and pellets; **J,** Bioclasts; and **K**, Laminar stromatoporoids (pictures of A and B were taken by Robert McKay).

- **Occurrence and thickness of the Shell Rock Formation**

As shown in the bedrock geologic map, the Devonian Shell Rock Formation is one of the dominant units on the bedrock surface of Floyd County, especially in the northwest part of the mapping area. However, this unit is thinning and tends to pinch out toward the east of the mapping area. For example, in an exposed section by Beaver Creek near the village of Roseville, the Lime Creek Formation unconformably overlies the lower part of the Shell Rock Formation (Fig. 9), which is characterized by the massive skeletal biostrome layer mentioned above, and indicates that the Shell Rock Formation is less than 10 feet thick at this location. Such stratigraphic thickness change likely resulted from the extensive pre-Lime Creek erosion that occurred in the Devonian Iowa Basin (Witzke et al., 1988).

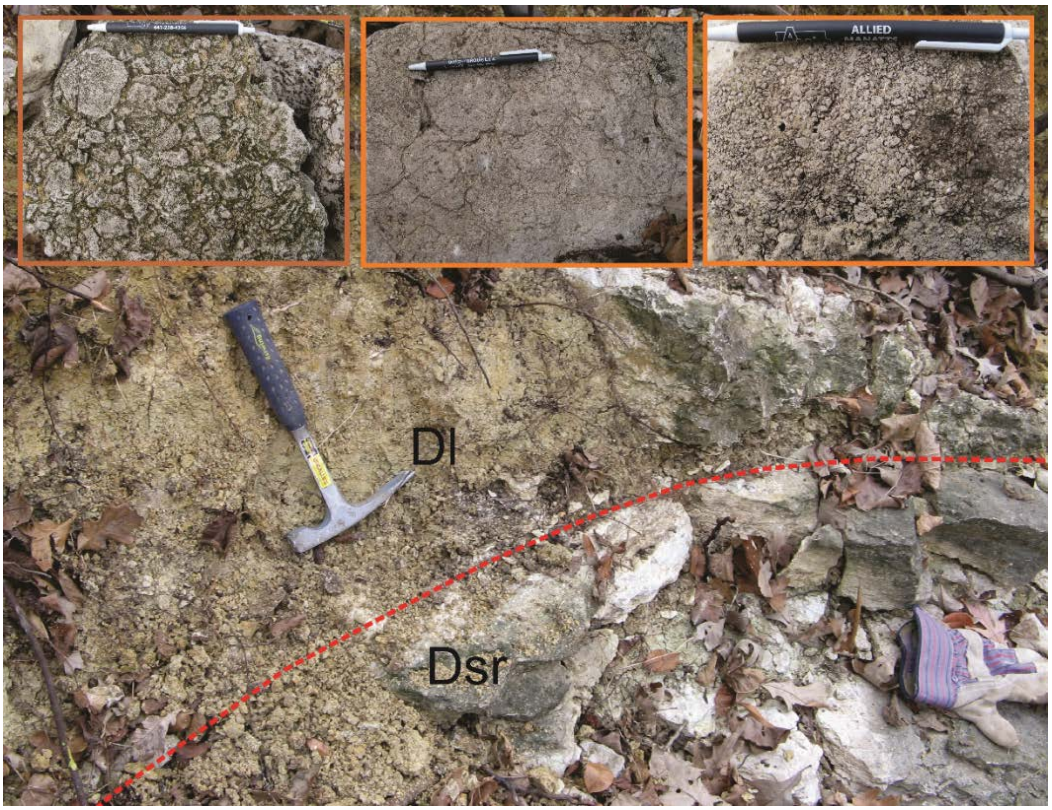

Fig. 9: A bedrock section exposed by Beaver Creek near the village of Roseville shows the Lime Creek Formation (Dl) directly overlying the lower portion of the Shell Rock Formation (Dsr) which is characterized by the massive biostrome layer containing typical fossils (see Fig. 8). Some of the fossils and sedimentary structures from this exposure are shown in the small images on the top of the figure.

6. DISCUSSION

- **The type sections of some stratigraphic units in the mapping area**

As described by Witzke and others (1988), the depositional environment in the Devonian Iowa Basin was characterized by extensive shallow marine with frequent sea-level changes, therefore, stratigraphic sequences deposited in multiple T-R cycles are different from other Devonian basins. Based on their distinctive lithologies and fossils, several units in the Devonian Iowa Basin stratigraphic framework (e.g. Koch, 1970; Witzke et al., 1988) were established in the mapping and surrounding areas. Because stratotypes (type sections) of some such units were exposed in rock quarries, their appearances may have been significantly changed during quarry operations (such as the type section of Lithograph City Formation), partially removed (such as the type section of Mason City Member), or even completely disappeared (such as the type section of Nora Member). Although some cores (such as IGS FM-1 and FM-4) in the mapping area have been assigned as subsurface reference sections of related stratotypes, it should be more straightforward and intuitive to set up a paratype for partially lacked type section(s) or a neotype for the original stratotype(s) that have been completely removed.

- **A possible geologic structure in the mapping area**

In the eastern part of Floyd County, bedrock geologic features are relatively complex. In addition to a deep bedrock valley buried by the Quaternary deposits up to 300 ft (90 m) thick along the eastern border of the county, distribution and dipping slope of the Devonian stratigraphic units in this area are significantly different from regional regular tendency, resulting in bedrock units with different ages occurring at similar elevations within a short distance. Witzke and Bunker (1984) attributed this phenomena to a relatively regional steep slope which was illustrated by the cross-section of the Devonian rocks across north-central Iowa (fig. 1 of Witzke & Bunker, 1984). However, Libra and others (1984) noted that the concentration of sinkholes is dramatically variable on different sides of the Cedar River valley in Floyd County, ranging from 100 per township east of the river to less than 20 per township west of the river (Libra et al., 1984, p. 7, fig. 2), although the bedrock surface west of the Cedar River is dominated by the Lithograph City Formation, which is commonly considered more susceptible to karst. Put the questions together, it is possible that all the abnormal features appearing in this area may be the result of a local fault instead of a steep slope. However, more geologic evidence, including new subsurface information, is necessary to confirm the occurrence of this possible structure.

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