BEDROCK GEOLOGIC MAP OF THE WEST BURLINGTON (IOWA) 7.5' QUADRANGLE

1:24,000

0 0.5 1 2 3 4 Miles

0 0.5 1 2 3 4 Kilometers

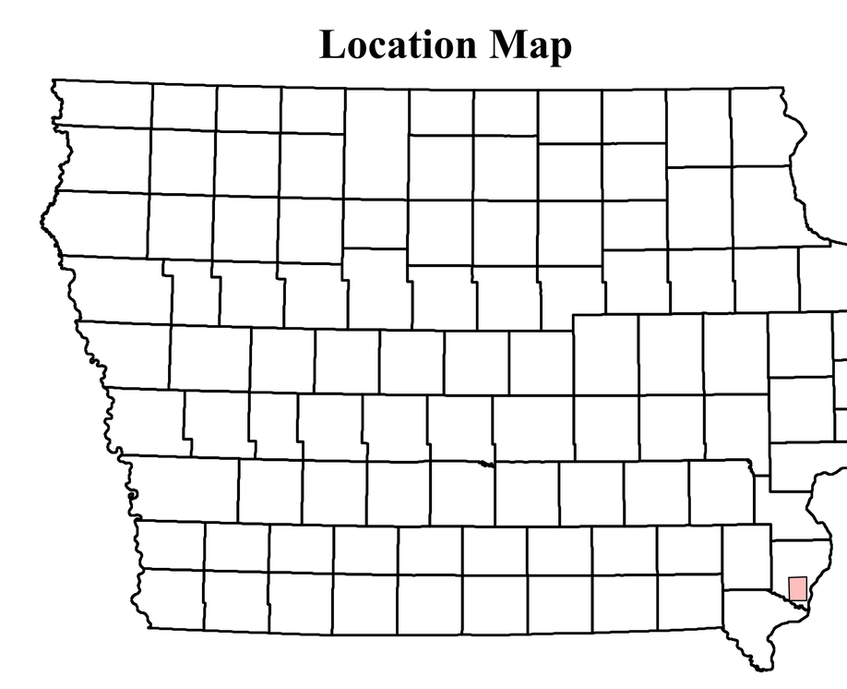
MN
GN
0°34´
6 MILS
1°20´
21 MILS

UTM GRID AND 2018 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Adjacent 7.5' Quadrangles

PLEASANT GROVE, IOWA	SPERRY, IOWA	KINGSTON, IOWA-ILL.
DANVILLE, IOWA	WEST BURLINGTON, IOWA	BURLINGTON, IOWA-ILL.
FORT MADISON, IOWA-ILL	DALLAS CITY, IOWA-ILL.	LOMAX, ILL.-IOWA

Location Map



LEGEND

CENOZOIC

QUATERNARY SYSTEM

Qu

Qu - Undifferentiated Unconsolidated Sediments - Consists of loamy soils developed in loess, glacial till, and colluvium of variable thickness, and alluvial clay, silt, sand, and gravel. The total thickness of the Quaternary deposits generally ranges between 5 and 20 m (16 – 66ft), but can be as much as 125 m (410 ft) thick in the northeastern part of the mapping area. This unit is shown only on the cross-section, not on the map.

PALEOZOIC

CARBONIFEROUS SYSTEM

MISSISSIPPIAN SUBSYSTEM

Mpsl

Mpsl – Limestone, Sandstone, and Dolomite (Pella and "St. Louis" formations) Middle-Upper Mississippian, Meramecian-lower Chesterian. This map unit can be up to 12 m (40 ft) thick within the mapping area. It is dominated by limestone and dolomite, partly sandy, with minor shale and chert. Limestones of the Pella Formation are typically sub-lithographic with scattered to abundant fossils, primarily brachiopods, echinoderms, and ostracods. The limestone facies of the "St. Louis" Formation can be fossiliferous with brachiopods, echinoderms, and several varieties of coral while the dolomitic facies typically exhibit fossil molds. Some fossils are silicified. The lower portion of this unit (historically referred to as the Spergen) is commonly gray to dark brown dolomite, locally brecciated and sandy, with rare fossils. This mapping unit is isolated to an upland bedrock high in the western portion of the mapping area. Outcrops of this mapping unit were not found within the mapping area.

Mws

Mws – Shale, Dolomite, and Limestone (Warsaw Formation) Upper Osagean. The Warsaw Formation varies in thickness from 3 to 12 m (10 – 40 ft). This unit can generally be divided into two major lithologic groupings, a lower argillaceous dolomite sequence and an upper shale-dominated sequence. The upper shale is typically light to medium gray, silty, and variably dolomitic with minor chert, sand, and sparse quartz geodes. The lower dolomite, sometimes referred to as the "geode beds", is argillaceous to shaly, with scattered to abundant quartz geodes. Minor limestone units occur locally as thin, lensatic beds with crinoidal packstone/grainstone fabrics. Brachiopods, echinoderm debris, and bryozoans are found throughout this mapping unit, although are more common in the carbonate lithologies. This unit exhibits wide variability leaving only the upper shale or lower dolomite in place, suggesting strong erosional unconformities above and below this mapping unit. Outcrops of this unit were not found within the mapping area.

Mkeo

Mkeo – Limestone, Dolomite, Chert, and Shale (Keokuk Formation) Upper Osagean. The Keokuk Formation can be up to 21 m (70 ft) in thickness in the mapping area. This unit is dominated by tan to gray interbedded skeletal limestones displaying packstone/grainstone fabrics. Nodular to bedded chert, in part fossiliferous, is common in the lower half of the sequence. Dolomite, variably argillaceous, and thin shales also occur throughout the unit. The unit displays multiple hardground surfaces and bone beds with scattered to abundant fish debris, the most prominent of these serves as a marker bed at the base of the formation (sometimes referred to as the Burlington-Keokuk or B-K bone bed). Brachiopods, crinoids, bryozoans, solitary corals, and fish bones and teeth occur throughout this unit as both abraded debris and partly articulated specimens. Molds of sponge spicules are noted in the dolomite facies. Traces of glauconite and minor geodes are also found in this formation. A handful of outcrops were found along Long Creek in the southwestern corner as well as on a tributary of Spring Creek in the south-central part of the mapping area.

Mb

Mb – Limestone, Dolomite, and Chert (Burlington Formation) Lower Osagean. The Burlington Formation typically ranges between 12 to 18 m (40 – 60 ft) in thickness, reaching a maximum thickness of 23 m (75 ft) within the mapping area. This unit is subdivided into three members (in ascending order: the Dolbee Creek, Haight Creek, and Cedar Fork), characterized by distinct lithologic groupings. The Dolbee Creek Member is dominated by white to tan skeletal limestone displaying packstone/grainstone fabrics and nodular to bedded chert. The Haight Creek Member is characterized by dolomite with an intermittent unit of skeletal limestone (sometimes referred to as the "middle grainstone") and thick beds of chert. A glauconite-rich zone marks the lower contact between the Dolbee Creek and can be used as a regional marker bed. Fossil molds are also present in the dolomite facies. The Cedar Fork Member is a pure white crinoidal packstone limestone unit which is usually differentiated from the packstones of the overlying Keokuk Formation by its white appearance. Occasional fish debris and glauconite are also observed in this member. Outcrops of this mapping unit can be found throughout the Burlington/West Burlington metro area in the northeastern portion of the quadrangle as well as a few locations in the southeastern portion.

Mk

Mk – Dolomite, Limestone, and Siltstone (Kinderhookian formations) Lower Mississippian. The Kinderhookian sequence ranges in thickness from 6 to 11 m (20 – 36 ft) reaching a maximum thickness of 20 m (65 ft) within the mapping area. This unit comprises three formations (in ascending order: the McCraney, Prospect Hill, and Wassonville), characterized by distinct lithologic groupings. These formations are separated by minor unconformities noted by the occasional thinning or absence of one or more units observed within the mapping area. The McCraney Formation is composed of alternating beds of sparsely fossiliferous, sub-lithographic limestone and dark brown, unfossiliferous dolomite, generating a unique "zebra striped" appearance in outcrop. A basal oolite is locally present. The Prospect Hill Formation is a light to medium gray, dolomitic siltstone that grades to shale in some locations. This unit is often laminated with vertical and horizontal burrow fabrics and faint cross stratified bedforms. Fossils are rare to absent, although fossil molds are locally abundant. The Wassonville Formation, now including the former Starr's Cave Formation as the basal member, consists of massive dolomite that is variably cherty grading into dolomitic limestone lower in the section. The basal Starr's Cave Member is a fossiliferous limestone with packstone/grainstone fabrics and is commonly oolitic. Crinoids (partly articulated) are the dominant fossil type of the Starr's Cave Member. A diverse assemblage of brachiopods are present with lesser amounts of blastoids, starfish, corals, bryozoans, and trilobites reported. Outcrops of the Kinderhookian were found in the extreme southwest corner of the mapping area along Long Creek as well as in the northeastern corner of the mapping area at Starr's Cave State Preserve and in a bluff above Flint Creek east of Starr's Cave.

DEOVNIAN SYSTEM

Der

Der – Siltstone and Shale (English River Formation) Upper Devonian, lower to upper Famennian. The English River Formation ranges in thickness from 4 to 9 m (13 – 30 ft) within the mapping area. This unit is dominated by gray to olive green siltstone with apparent bioturbated fabrics. Bivalves and brachiopods are common, especially in the upper beds, with scattered to abundant fossil molds as well. An outcrop of the English River Formation exists in the base of the exposure at Starr's Cave State Preserve in the northeastern portion of the mapping area.

Dss

Dss – Shale (Saverton Shale Formation) Upper Devonian, lower to upper Famennian. The Saverton Shale Formation can be up to 46 m (150 ft) thick within the mapping area. This unit is dominated by green-gray shale, commonly burrowed with sparse to absent macro-fossils. Outcrops of the Saverton Shale Formation were not observed within the mapping area.

Dgc

Dgc – Shale (Grassy Creek Formation) Upper Devonian, lower to upper Famennian. The Grassy Creek Formation can be up to 50 m (165 ft) thick within the mapping area. This unit is dominated by organic-rich brown shale with minor green-gray shale in the upper part of the unit. Differentiation between the Grassy Creek and the overlying Saverton Shale was primarily based on color and relative abundance of spore scarps identified in well cuttings. Outcrops of the Grassy Creek Formation were not observed within the mapping area

OTHER FEATURES

- **New drill holes for this map project**
- **Bedrock outcrops**
- **IGS GEOSAM data points** – records available at www.iowageolocialsurvey.org
- **Incorporated city boundary**
- **Quarries**
- **Roads**
- w1429 **Wells used for geologic cross-section**
- **Bedrock Hillshade-** shades of gray show the bedrock surface as it would be illuminated by an artificial light source from the NW direction

STRATIGRAPHIC COLUMN

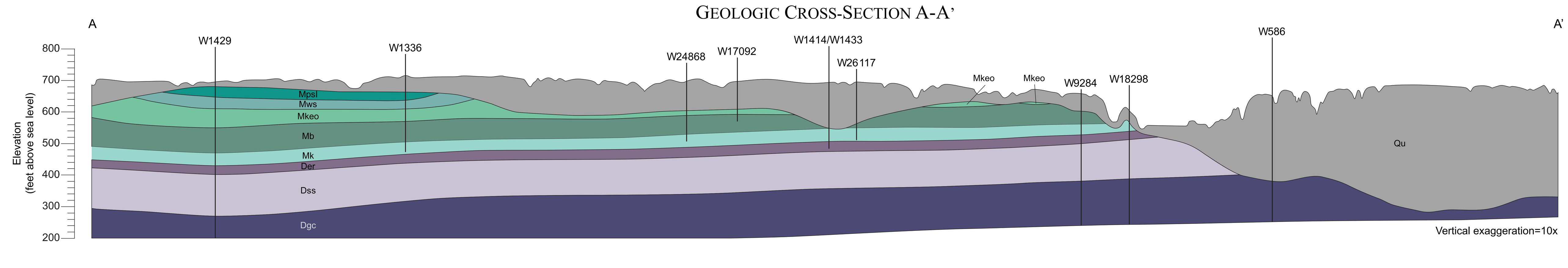
System[1]	Subsystem[1]	Series[1]	Stage[2]	Lithostratigraphic Unit	Map Symbol	Lithology	Thickness (in feet)
Carboniferous	Mississippian	Upper / Middle	Chesterian / Meramecian	Pella or "St. Louis" fms.	Mpsl		<40
		Middle	Osagean	Warsaw Fm.	Mws		10-40
		Middle / Lower	Osagean	Keokuk Fm.	Mkeo		<70
		Lower	Osagean	Burlington Fm.	Mb		40-60
		Lower	Kinderhookian		Mk		20-35
Devonian		Upper	Famennian	English River Fm.	Der		<30
				Saverton Shale Fm.	Dss		<150
				Grassy Creek Fm.	Dgc		<165

[1]Global stratigraphic units
[2]Regional stratigraphic units

Lithologies
- Dolomite
- Dolomitic shale
- Fossiliferous Packstone
- Limestone
- Lithographic Limestone
- Sandstone
- Sandy Limestone
- Shale
- Siltstone

Symbols
- Geodes
- Chert
- Oolitic
- Argillaceous zone
- Breccia
- Unconformity

GEOLOGIC CROSS-SECTION A-A'



BEDROCK GEOLOGIC MAP OF THE WEST BURLINGTON 7.5' QUADRANGLE, DES MOINES COUNTY, IOWA

Iowa Geological Survey
Open File Map OFM-18-5
June 2018

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INTRODUCTION TO THE BEDROCK GEOLOGY OF THE WEST BURLINGTON 7.5' QUADRANGLE, DES MOINES COUNTY, IOWA

The West Burlington Quadrangle lies within the Southern Iowa Drift Plain landform region (Prior, 1991). The map area is dominated by loess mantled till plains in the uplands, and fine to coarse grained alluvial deposits within Flint Creek and its tributaries. This area hosts glacial deposits of both Illinoian (130,000 to 190,000 years before present) and Pre-Illinoian age (ranging from 0.5 to 2.6 million years ago).

The thickness of Quaternary materials overlying the bedrock surface varies widely across the quadrangle ranging from 5 to 20 m (16 – 66 ft), reaching a maximum thickness of 125 m (410 ft) in the extreme northeastern part of the mapping area. Shallow bedrock information from the soil survey of Des Moines County (Brown, 1983) was used for identifying potential bedrock outcrop locations during field mapping activities. Bedrock outcrops were found mostly along tributaries of Flint Creek in the northern part of the mapping area and along tributary creeks of the Skunk River in the southern part. Outcrops exposed are comprised of Keokuk, Burlington, and Kinderhookian formation rocks. There are no operational quarries within the quadrangle. Subsurface information was mostly derived from the analysis of water well cutting samples reposited at the Iowa Geological Survey (IGS). Lithologic and stratigraphic information from these samples are stored in the online GeoSam database of the IGS. Geologic information from eight outcrops and more than 200 private and public wells within the West Burlington Quadrangle and the surrounding area were used for bedrock geologic mapping purposes.

The Mississippian System (now Subsystem) was historically proposed for the succession of strata exposed in the Mississippi River Valley between Burlington, Iowa and southern Illinois. Therefore, the bedrock exposures in southeastern Iowa take on a special significance as they comprise part of the historic "body stratotype" on which the concept of the Mississippian System was defined and based (Witzke et al., 2002). The Mississippian had been primarily a North American chronostratigraphic label roughly synonymous with the Lower Carboniferous of the Old World. After approval by the Subcommission on Carboniferous Stratigraphy in 1999 and ratification by the International Union of Geological Sciences and the International Commission on Stratigraphy in 2000, the Carboniferous System was officially subdivided into lower and upper subsystems, the Mississippian and Pennsylvanian, respectively. As such, the Mississippian now has meaning and application as a major subdivision of geologic time not only in North America, but as a globally defined subsystem. The bedrock strata seen in the West Burlington Quadrangle and surrounding area provide a significant historic reference for the Mississippian as a whole.

The conundrum that is the Mississippian in Iowa has been the subject of curiosity for many previous workers. Owen (1852) and Hall (1857) were the first to recognize that the abundant bedrock exposures in southeastern Iowa likely correlated with those observed farther down the Mississippi River Valley. Decades later, Van Tuyl (1923) took on the ambitious task of correlating all of the Mississippian units across Iowa. Many of their lithologic interpretations were valuable; however, the correlations were, and continue to be, subject to revision as later workers attempted to piece the Mississippian into the global stratigraphic framework. Harris and Parker (1964) provided inspirational insights into the structural context of southeastern Iowa by identifying a series of northwest-southeast trending anticlines that were later found to be superimposed on the larger northeast-southwest trending structural feature known as the Mississippi Arch (Witzke et al., 1990). Many questions remain regarding the stratigraphic correlations within the Mississippian such as whether the "St. Louis" Formation in Iowa truly belongs in the St. Louis Formation or should some of the upper members be reassigned to the Ste. Genevieve Formation; whether the Prospect Hill Formation is an offshoot of the Hannibal Formation of Missouri and Illinois; and whether the McCraney Formation is correlative to the McCraney in Illinois or if it should become a new stratigraphic interval (as proposed by Witzke et al., 2002). In an effort to address the question regarding the "St. Louis" Formation, detrital zircon analyses from sandstone samples collected near the mapping area were processed with the help of Emily Finzel (Assistant Professor of Geology at the University of Iowa (UI)). The geochronologic data provided by the detrital zircon analyses were not able to differentiate the sandstone units within the "St. Louis" Formation, however, further study of the geochemistry and lithology of these sandstones may provide the evidence needed to identify whether these units belong in the St. Louis proper or in the Ste. Genevieve. Clarifying the issue regarding the Prospect Hill and McCraney formations is being done with the help of Brad Cramer (Assistant Professor of Geology at the UI), Brittany Stolfus (UI undergraduate student), and James "Jed" Day (Professor of Geology at Illinois State University). Samples collected from within the mapping area as well as at other locations in southeastern Iowa, eastern Illinois, and northeastern Missouri for conodonts and carbon isotopes have provided valuable bio- and chemostratigraphic information. Preliminary results suggest that the Prospect Hill and McCraney formations in Iowa may correlate with the Hannibal Formation. Further study will commence with additional sampling of surface exposures as well as core samples. Rectifying the questions posed by Witzke et al., 2002 may now become attainable.

Although the Mississippian bedrock in southeastern Iowa is no longer a widely used aquifer due to low yields and locally poor water quality, many of the bedrock units are highly desirable sources of aggregate, thus necessitating the continued effort to gain a better understanding of the local and regional stratigraphic characteristics and relationships of the Mississippian Subsystem in southeastern Iowa.

The mapping area is dominated by bedrock of the Mississippian Subsystem that was deposited in a variety of marine environments from the late Kinderhookian to early Chesterian, approximately 355–330 million years ago (Ogg et al., 2008). Famennian strata are represented by brown, organic rich shales of the Grassy Creek Formation followed by gray-green silty shales of the Saverton Shale Formation and capped by the English River Formation siltstone. The thick shale packages represent major transgressive-regressive cycles of deposition in a stratified seaway (Witzke, 1987). Kinderhookian strata represent a sequence of interbedded carbonates and siltstones that unconformably underlie the Burlington Formation (early Osagean) within the mapping area. The Burlington, Keokuk, and Warsaw formations (collectively the Augusta Group of Witzke et al., 2010) represent a relatively conformable package of marine rocks deposited during the Osagean transgressive-regressive (T-R) cycle. Interpreted as part of the central middle shelf of the Osagean sea that transgressed toward the northwest and the Transcontinental Arch, the Burlington Formation rocks were deposited across a vast subtidal epicontinental shelf that stretched from Illinois and Iowa into central Kansas and Oklahoma (Lane, 1978; Witzke et al., 1990). The Keokuk and Warsaw formations represent the regressive phase of the Osagean T-R cycle punctuated by a stark unconformity below the overlying Pella and "St. Louis" formations, regionally displaying up to 40 m (130 ft) of erosional relief (Witzke et al., 2002). For a more detailed description of the lithologic units and further discussion of mapping methodologies, please refer to the accompanying Summary Report.

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Base map from USGS West Burlington 7.5' Digital Raster Graphic (IGS GIS file IA_West_Burlington_USGS_topo.tif) which was scanned and modified from the West Burlington 7.5' Topographic Quadrangle map, published by The US Geological Survey in 2015 Land elevation contours (10' interval). Bedrock topography raster created internally for this map project.

Iowa Geological Survey digital cartographic file West_Burlington_BedrockGeology.mxd, version 6/30/18 (ArcGIS 10.5) Map projection and coordinate system based on Universal Transverse Mercator (UTM) Zone 15N, 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.

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