Preliminary Map of the Bedrock Geology of the Northern Half of the Bedford 30- X 60-Minute Quadrangle, Indiana

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Bloomington, Indiana
2021

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INTRODUCTION

The Bedford 1:100,000-scale quadrangle includes eight counties and five physiographic divisions of the Southern Hills and Lowlands Region of Indiana (Gray, 2000). From west to east, the physiographic divisions include the Wabash Lowland, Crawford Upland, Mitchell Plateau, Norman Upland, and Scottsboro Lowland. The underlying bedrock geology strongly influences the geomorphology of these physiographic divisions. Beneath rolling hills separated by broad areas of poorly drained glacial sediment in the Wabash Lowland are soft shales of the Pennsylvanian Racoon Creek Group. To the east, the rugged topography of the Crawford Upland contains steep banked stream valleys deeply cut into siliclastic rocks of the Mansfield Formation (Pennsylvanian), which overlies interbedded siliclastic and carbonate rocks of the West Baden and Stephensport Groups (Mississippian). Continuing east of the Springville Escarpment, the Mitchell Plateau adjoins with the Crawford Upland, and is characterized by karst terrain features including multitudes of sinkholes and disappearing streams, transmitting groundwater through the carbonate rocks of the Blue River and Sanders Groups (Mississippian). Further east is the Norman Upland with rugged terrain and deeply cut drainages which are due in part to the easily erodible underlying siliclastic rocks of the Borden Group (Mississippian). Eastward, the Knobstone Escarpment marks the boundary between the Norman Upland and the Scottsboro Lowland, which is characterized by broad, flat lowlands that overlie the New Providence Shale of the Borden Group.

Rocks in the northern half of the Bedford 1:100,000 quadrangle dip generally toward the southwest. Along the northern portion of the Bedford quadrangle, most of the time the dip direction rotates from 260 degrees to a more southward direction of 238 degrees. East of the Mt. Carmel Fault, the dip magnitude ranges from 15 to 20 feet per mile (0.1 to 0.2 degrees). West of the Mt. Carmel Fault, the dip magnitude increases and ranges from 24 to 60 feet per mile (0.3 to 0.8 degrees).

The varied terrain and geology of the Bedford quadrangle contains abundant natural resources including natural gas, dimension and crushed limestone, groundwater, gypsum, and extensive public lands used for recreation. The dome structures on the crest of the Leeville Anticline (Melhorn and Smith, 1959) have been drilled for natural gas and oil with some of the structures being used more recently for natural gas storage (Keith and others, 2014). The internationally acclaimed Salem Limestone (Mississippian), also known as Indiana Limestone, has been extensively quarried throughout this region for dimension stone. Crossed limestone containing high purity levels of calcite for chemical applications has also been quarried from deposits of various carbonate rocks of the Blue River Group (Mississippian) (Hasenmueller and others, 2008; Keith and others, 2014). Additionally, the abundant springs and groundwater have been used to provide water for local communities and towns, including Naval Surface Warfare Center, Crane, and for the extensive agricultural activities that occur throughout the region.

Previous geologic maps and studies of the quadrangle and surrounding areas were useful in the construction of this map, including Stockdale (1931), Mallott (1952), Keller (1991), Kvale (1992), Barnhill (1994), Gray (2000), Shaver and others (1986), Rexroad and Lane (1984), Hasenmueller and others (2008), and Keith and others (2014).

METHODS

The map and characterization of stratigraphic units is based upon data collected from six new Indiana Geological and Water Survey (IGWS) drill hole cores, 93 outcrop surveys, 25 data points from previous workers' field notes, and four Indiana Department of Transportation (INDOT) cores, combined with pre-existing data collected from 326 outcrop exposures, and 111 IGWS drill holes. In addition, 1,400 public domain records stored in the IGWS Petroleum Database Management System were used. These data sets were amalgamated into a single database used for this map.

Computer gridding and contouring software was used to create three-dimensional models of the surface and subsurface bedrock contacts. Rock unit contact lines were generated by computing the intersections between the topographic surface and bedrock subsurface.

The contact between unconsolidated material and bedrock was modeled by using a digital elevation model and subtracting the thickness trends of the overlying unconsolidated deposits. In the eastern portion of the Bedford quadrangle, predominantly Borden Group units, the topographic surface is essentially coincident with the bedrock surface, and therefore the contacts between rock units closely conform to the topography. The younger rocks toward the central and western portion of the quadrangle are covered by varying thicknesses of unconsolidated overburden, which was accounted for during the bedrock surface modeling. Therefore, the contacts between rock units reflect the varied topography and unconsolidated thickness patterns within the central and western regions. Soil maps for the Bedford Quadrangle (USDA, 2019) were used to create the unconsolidated map units.

This map represents the summaries and interpretations of available geological data and is intended to only serve as a general guideline for site-specific evaluations. This map should not be considered accurate at a scale smaller than 1:100,000.

MAP INFORMATION

Digital cartography by Matthew R. Johnson.

Transportation network from OpenStreetMap.org (© OpenStreetMap contributors).

Hydrography from U.S. Geological Survey National Hydrography Dataset (local resolution).

Topographic shading and contours based on 2011–2013 Indiana Lidar data.

Projection: Universal Transverse Mercator (UTM), Zone 16N.

Horizontal Datum: North American Datum of 1983 (NAD83).

DESCRIPTION OF MAP UNITS

Quaternary

Quaternary (undivided)

Modern floodplains and lower elevation terraces are composed of overbank and channel deposits of rivers and streams on valley bottoms — mainly fine-grained silts and clays at the surface, but coarser-grained lateral accretion silt/clay beds are commonly found under floodplain surfaces. Overbank vertical accretion deposits are typically more fine-grained than channel deposits. These channel deposits are characterized by well-sorted and well-rounded sand and gravel. Filled channel swales often contain organic-rich silt and clay. Sediments in valleys of major streams and rivers are generally well sorted and fine grained in the broad low-gradient river segments. More poorly sorted and coarser-grained sediments are typical in the narrow, steeper-gradient valleys of tributary streams where locally derived rock fragments may be a conspicuous component of the sediment. Under alluvial terraces and floodplains, sediment thickness ranges from a few feet to several tens of feet and is typically the thickest in the broad low-gradient valleys of major streams and thinnest in narrow, steeper-gradient tributary streams. Alluvium may be underlain by much thicker deposits of older unconsolidated valley fill deposits, especially in broad low-gradient valleys, such as the East Fork White River Valley. Some lower and presumably late Holocene terraces are present within the modern channels. Upper elevation terrace surfaces are typically underlain by undifferentiated coarse-grained and clast-supported debris flows, composed mainly of gravel and sand deposited by older rivers and streams. Basal sediments are usually poorly sorted and nonstratified. However, thin units of fining upward sands and silts with pebble inclusions may be present toward the top of the basal outwash sediments. Terrace sediments are thickest in deeply incised valleys where these deposits may extend well below the present-day valley. Some upper terraces contain colluvial or alluvial fan sediments in near-surface horizons; grain sizes within these deposits vary according to their source and origin. Terrace fills in tributary valleys are often more fine-grained; thickness varies from a few feet to tens of feet (Keith and others, 2014).

Pennsylvanian

Mansfield Formation

Dominantly cross-bedded to massive, poorly sorted, fine- to medium-grained sandstone with minor wavy- to flaser-bedded sandstone and shale. Color is light to medium gray with occasional red to orange coloration. Cross-bedded sandstones are slightly coarser and may show disturbed bedding. The remainder of the formation consists of dark gray and black shale with variable stringers and laminations of fine-grained white sandstone and locally abundant plant debris along partings, medium gray siltstone with disturbed bedding, medium gray mudstone with slickensides, and coal (Keith and others, 2014).

Mississippian

Stephensport Group (undivided)

Described in descending stratigraphic order, the Stephensport Group consists of five named formations. The Glen Dean Limestone is a gray to light brown-gray fossiliferous and oolitic limestone with dolomitization common toward the top of the formation. The thickness for the Glen Dean Limestone range from nine to 31 feet. The Hardinsburg Formation is a cross-bedded and massive medium- to fine-grained sandstone bound by shale units above and below. The color of the sandstone is light gray with red-brown mottling with one-centimeter-sized marcescent nodules commonly seen. Above the sandstone unit is a green-gray shale unit with flaser bedding that weathers to a yellow- to red-brown color. The shale unit below the sandstone is calcareous and dark gray. Thicknesses range from 20 to 62 feet. The Haney Limestone (formerly the Golconda Limestone) consists of interbedded lithologies of fossiliferous grainstone and packstone to argillaceous limestone with interbedded thin shale units. Individual beds are massively bedded. Bryozoa, especially Archimedes, are common. Color is medium to light gray and thicknesses range from 11 to 25 feet where it is present. The Big Clifty Formation contains equal amounts of dark gray to black horizontally bedded shale and a horizontal- to ripple-bedded and occasionally wavy-bedded fine-grained sandstone with possible tidal rhythmites. Color is light to medium gray that weathers orange-tan. Fine-grained siltstone and dark shale are present in the upper part of the unit represent the Indian Springs Shale Member. The total thickness ranges from 60 to 130 feet. The Beech Creek Limestone, informally referred to as 'Barlow Lime', consists of a grainstone, containing abundant Archimedes bryozoans on bedding planes. Moving down stratigraphically, the grainstone transitions to a packstone where crinoid debris dominates. Color is dark gray to medium pinkish-gray that weathers orangish-gray. Thicknesses from cores range from 12 to 22 feet. Total thickness measurements of the Stephensport Group were not possible because complete cores of this group are not present (Keith and others, 2014).

West Baden Group (undivided)

The West Baden Group consists of five named formations described in descending order. The Elwren Formation is variably composed of sandstone, shale, siltstone, and mudstone. The sandstone is horizontally to cross-bedded, fine-grained to very fine-grained. The shale is often bioturbated, and the siltstone and mudstone is massive to lenticular bedded. Predominant lithology can be sandstone, siltstone, or shale. Sandstones are shades of gray, siltstones are dark gray, and shales are dark gray to greenish-gray to maroon. Thickness ranges from 40 to greater than 50 feet from limited measurements. The Redsville Limestone is discontinuous, consisting of approximately an equal amount of brown- to green-gray lime-mudstone-clast breccias and pinkish-gray oolitic grainstone. Thickness is three feet. The Sample Formation is dominantly a wavy- to cross-bedded, fine-grained to very fine-grained sandstone that can also be ripple-bedded or massive. Color is often orange to yellowish-gray or tanish-gray that weathers to a dark purple. Cross-bedded sandstones are generally slightly coarser up to medium-grained sand. Remainder of formation is a variable combination of orangish-brown to dark gray shale and a dark gray siltstone. Sandstones generally occur in upper part of unit with finer grained rocks in lower third of the unit. Thickness ranges from 33 to greater than 53 feet. The Beaver Bend Limestone consists of fossiliferous grainstone to packstone with occasional argillaceous limestone beds. Recognizable fossils include crinoids and occasional bryozoans and brachiopods. It may be locally oolitic in part. Color is variable from yellow-tan-gray to medium pinkish-gray to dark brown-gray or dark gray. Thickness ranges from five to 15 feet. The Beech Formation is dominantly either dark gray to black shale, containing occasional thin sandstone laminae and scattered small pyrite nodules or dark gray to black, bioturbated siltstone lenticular to interlaminated with very fine-grained sandstone. Wavy- or ripple-bedded to cross-bedded, fine-grained to very fine-grained sandstone forms about one-third to one-quarter of the unit, generally, in the upper part, but occasional heavily cross-bedded fine-grained sandstones can also be found near the base. Sandstones range from light to dark gray. Massive and occasionally bioturbated mudstone can be locally prominent. A thin coal was present at the top of the unit at one locality. Thickness varies from 15 to 37 feet (Keith and others, 2014).

Blue River Group (Mississippian, Chesterian, Valmeyeran)

Psali Limestone

Dominantly buff to medium pinkish-gray fossiliferous packstone to grainstone that is variably oolitic in the upper part. Fossils include crinoids and brachiopods. Occasional one to two thin limestone-clast breccia beds are present in addition to minor lime mudstone, fossiliferous wackestone, siltstone, and quartz sandstone. Thickness varies from 13 to greater than 23 feet (Hasenmueller and others, 2008; Keith and others, 2014).

Ste. Genevieve Limestone

The overall thickness of Ste. Genevieve in the Bedford quadrangle ranges between 25 and 149 feet, and can be informally divided into four units, two of which are probably equivalent to named members in the subsurface of Indiana. A discontinuous yellowish- to greenish-gray limestone-clast breccia bed is found at some locations ranging from a few inches to two feet in thickness. Where present, the breccia is found at the top of the Ste. Genevieve and is referred to as the 'Bryozoanite Breccia Bed' (Malott, 1952; Shaver and others, 1986). The next unit is a dominantly massive to cross-bedded oolitic to fossiliferous grainstone. Additional beds of fossiliferous packstone, wackestone, and lime mudstone are present in variable proportions. At a few localities the grainstone is a minor constituent and instead a massive fossiliferous packstone or fossiliferous wackestone is dominant. Recognizable fossils are crinoids and brachiopods. All lithologies range in color from light tanish-gray to light gray (Keith and others, 2014). This unit is probably equivalent to the Karnak Member and is highly variable in thickness from 18 to 75 feet (Hasenmueller and others, 2008). The next lower unit is a generally light to medium gray horizontal- to cross-bedded grainstone with abundant rounded quartz grains. Thickness of the unit ranges from 4 to 17 feet. The lowermost unit of the Ste. Genevieve Limestone is dominantly a massive fossiliferous packstone to grainstone with brachiopods, crinoids, and occasional goniatites. Where a grainstone is present it is often cross-bedded. Wackestone, lime mudstone, and argillaceous limestone can be locally abundant. Color is generally light to medium gray. Thicknesses range from 9 to 49 feet but is generally between 20 and 30 feet. This unit is probably equivalent to the Fredonia Member (Hasenmueller and others, 2008; Keith and others, 2014).

St. Louis Limestone

The upper unit of the St. Louis Limestone is dominantly a horizontal-bedded fossiliferous packstone to wackestone. Occasional dolomite and lime mudstone beds are present. Scattered light gray to dark gray chert nodules occur in the lower half of the unit, although at some localities chert can be found near the top of the unit. Color varies from light to medium gray (Hasenmueller and others, 2008; Keith and others, 2014). Near the base of the upper unit is a persistent thin horizon a few inches thick containing silicified ngonite corals, *Arayastris proliferum* (Keith and others, 2014). This unit is probably equivalent to the St. Louis Member and is highly variable in thickness from 28 feet to 56 feet. The lower unit generally consists of variable lithologies that are typically dominated by a horizontal- to massive-bedded fossiliferous packstone or a bioturbated argillaceous limestone. Dolomitic packstone to mudstone can also be prominent at some localities. Occasional thin breccia beds and mudstone also occur. Dark gray chert nodules are present at some localities. Overall color is light to medium brown-gray to medium gray. This lower unit ranges in thickness from 76 to 94 feet (Hasenmueller and others, 2008; Keith and others, 2014).

Sanders Group (Mississippian, Valmeyeran)

Salem Limestone

The Salem Limestone is dominantly a cross-bedded to horizontal- and massive-bedded fine-grained fossiliferous grainstone. Horizontal-bedded fossiliferous packstones and argillaceous limestones can form one-third to one-quarter of the unit in places. Occasional dolomite beds can be present. Fossils include bryozoans, crinoids, brachiopods, corals, and foraminifera. Coated grains can be locally abundant in the uppermost grainstones. Color ranges from light tan-gray or light gray to medium and dark gray. Dolomite is commonly medium tan-brown (Hasenmueller and others, 2008; Keith and others, 2014). Thickness ranges from 56 to 86 feet (Hasenmueller and others, 2008).

Harrodsburg Limestone and Ramp Creek Formation (undivided)

The Harrodsburg Limestone is dominantly a horizontal- to cross-bedded fossiliferous grainstone with variable amounts of fossiliferous packstone and argillaceous limestone becoming more prominent toward the lower part. Bryozoans are the dominant fossil in the upper part of the unit, and crinoids and brachiopods are more abundant in the lower part. Color varies from light tanish-gray to light gray and medium gray. Geodes are sometimes present near the base in transition to Ramp Creek Formation (Hasenmueller and others, 2008; Keith and others, 2014). The Harrodsburg Limestone thickness ranges from 30 to 60 feet (Hasenmueller and others, 2008). The Ramp Creek Formation is marked by interbedded lithologies of horizontal- to massive-bedded fossiliferous grainstone to occasional packstone and horizontal-bedded bioturbated siltstone. Siltstone beds resemble rocks of the underlying Borden Group. Limestone beds vary from three to five in number in the area and contain crinoids, brachiopods, and bryozoans fragments. They also often contain glauconite pellets giving them a greenish-gray color, and the siltstones are medium to dark brownish-gray (Hasenmueller and others, 2008; Keith and others, 2014). Thickness ranges from 26 to 36 feet (Hasenmueller and others, 2008).

Borden Group (Mississippian, Valmeyeran)

Edwardsville Formation

Predominately a tan to light brown sandstone, siltstone, and sandy shale fining down section, containing vertical and horizontal burrows, interbedded with occasional light brown silty limestone or dolomite. Siliceous geodes have been observed on occasion in the lower part of the Edwardsville Formation. Body fossils are locally abundant in impure limestone lenses and consist almost entirely of disarticulated echinoderms and brachiopods. Occasionally, the discontinuous two- to three-foot-thick Floyd Knob Limestone Member is present at the base of the Edwardsville Formation and marks the separation between the Spickert Knob Formation and Edwardsville Formation. The Floyd Knob Limestone Member is a brick-red ferruginous fossiliferous limestone containing ooids, disarticulated brachiopods, and bryozoan fragments. Thickness of the Edwardsville Formation ranges from 90 to 130 feet.

Spickert Knob Formation

A siltstone with ubiquitous burrows that contain red siderite nodules several inches in diameter arranged in layers separated by one to two feet. Exposures appear massive with a few projecting tan sandy siltstone ledges two to three feet thick. Fresh exposures are gray, blue-gray, or olive-gray. Clay mineral is present and becomes more abundant down section. Thicknesses range from 225 to 275 feet, thinning in a southward direction away from the belt of outcrop exposures to where it becomes indiscernible from the Edwardsville Formation and New Providence Shale below the surface in southwestern Indiana (Rexroad and Lane, 1984; Shaver and others, 1986).

Project funded collected data	Archive data	Water well
☐ IGWS core (SDH 498)	☐ IGWS core	☐ Petroleum well
☐ Field observation	☐ Geophysical log	☐ Other data (quarry, literature, test borings)
☐ INDOT borehole	☐ Outcrop archive	

- +— Anticline – Identity and existence certain, location approximate.
- Contact – Identity and existence certain, location approximate.
- Seissor fault, normal-slip offset – Identity and existence certain, location inferred. Rectangles on downthrown block
- Normal fault – Identity and existence certain, location approximate. Ball and bar on downthrown block

ACKNOWLEDGMENTS AND DISCLAIMER

This geologic map was funded in part through the STATEMAP Program supported by the U.S. Geological Survey under Cooperative Agreement No. G20AC00375. The cooperative agreement requires the following statements: "this map and explanatory information is submitted for publication with the understanding that the United States Government is authorized to reproduce and distribute reprints for governmental use," and "the views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government."

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SUGGESTED CITATION

Tripp, D. C., Eldridge, J. R., and Burgess, S. A., Bedrock geology of the northern half of the Bedford 30- X 60-minute quadrangle, Indiana: Indiana Geological and Water Survey, Indiana Journal of Earth Sciences, v. 3, scale 1:100,000, DOI: 10.14434/ijes.v3i1.33299