U.S. DEPARTMENT OF THE INTERIOR
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SCIENTIFIC INVESTIGATIONS MAP 2921
Version 1.0

GEOLOGIC MAP OF THE WESTERN GROVE QUADRANGLE, NORTHWESTERN ARKANSAS

By
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2006

Base from U.S. Geological Survey, 1967
Projection and 10,000-foot grid ticks: Arkansas
coodinate system, north zone
1000-meter Universal Transverse Mercator grid, zone 15
1927 North American Datum

Geology mapped by M.R. Hudson, 2001–2003
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SCALE 1:24 000
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

INTRODUCTION

This map summarizes the geology of the Western Grove 7.5-minute quadrangle (fig. 1) in northern Arkansas on the southern flank of the Ozark dome, a regional uplift centered in southeastern Missouri. Physiographically, the map area is part of the Ozark Plateaus region and is within the Springfield Plateau, a land surface underlain by gently dipping Mississippian cherty limestone (Purdue and Miser, 1916). A segment of the Buffalo River loops through the southern part of the quadrangle, and the river and adjacent lands form part of Buffalo National River, a park administered by the U.S. National Park Service. The U.S. National Park Service supported preparation of this map in collaboration with their dye-tracer studies to better understand natural resources of the Buffalo River watershed, particularly the hydrogeologic framework of springs.

The exposed bedrock of this map area comprises approximately 1,000 ft of Ordovician and Mississippian carbonate and clastic sedimentary rocks (fig. 2) that have been mildly folded and broken by faults. The geology of the Western Grove quadrangle was first mapped by McKnight (1935) at 1:125,000 scale. This study confirms much of his mapping but also identifies additional structures and revises the distribution of stratigraphic units.

The area was mapped by field inspection of stratigraphic and structural features at numerous sites that were located with the aid of a global-positioning satellite receiver and a barometric altimeter that was frequently calibrated at points of known elevation.

Contacts and structural features were compiled on a 1:24,000 scale-stable topographic base. Beds dipping less than 2° were considered to be horizontal. Structure contours showing the base of the St. Joe Limestone Member of the Boone Formation were hand drawn by visual inspection of control-point elevations that were either directly measured in the field or calculated from field measurements of upper-contact elevations of the Boone Formation. Samples of Ordovician carbonate rocks were collected for conodont analysis and were analyzed by J.E. Repetski at U.S. Geological Survey facilities in Reston, Va. Samples of unconsolidated terrace deposits for paleomagnetic analysis were collected in oriented plastic cubes and were analyzed by M.R. Hudson at the U.S. Geological Survey Rock Magnetism Laboratory in Denver, Colo.

DESCRIPTION OF MAP UNITS

Alluvial deposits (Quaternary)—Unconsolidated channel and valley-fill deposits of Clear Creek. Channel deposits are subangular to rounded gravel of Paleozoic chert and sandstone and lesser sand and silt; small areas of unmapped bedrock are interspersed in the channel. Alluvial deposits filling valley bottom are composed of reddish-brown fine sand, siltstone, and claystone and contain subrounded to subangular fragments of weathered chert and sandstone. Valley-fill deposits underlie smooth land surfaces that are 10–15 ft above base-flow level of creek. Deposits are as thick as 15 ft

Younger terrace and channel alluvial deposits (Quaternary)—Unconsolidated sand and gravel of Buffalo River. Terrace deposits are principally light-brown fine sand and have smooth upper surfaces that are about 20 ft above the base-flow level of river. Channel gravel is subangular to rounded and composed of Paleozoic sandstone, chert, dolostone, and limestone; unmapped bedrock exposures are interspersed along channel. Deposits are as thick as 20 ft

Older terrace and alluvial deposits (Quaternary and Tertiary(?))— Unconsolidated gravel, sand, and silt deposits adjacent to Buffalo River. Deposits are principally a lag of brown-weathered, subrounded to rounded cobbles of Paleozoic sandstone and chert in a reddish-brown sandy to silty matrix. Fine sand, silt, and clay locally overlie cobble deposits. Deposits are 80–120 ft above base-flow level of river. Deposits are as thick as 20 ft

Batesville Sandstone (Upper Mississippian, Chesterian)—Fine-grained to very fine grained, light- to medium-brown, calcite-cemented sandstone. Thin to medium beds are parallel laminated, and low-angle crossbeds are common. Sandstone commonly displays burrows on bedding surfaces. Sandstone locally contains 2- to 10-mm-diameter oxidized pyrite framboids that weather to reddish-brown spheres. Sandstone breaks into thin, flat blocks. The Batesville surface may display sinkholes formed by collapse into dissolution cavities in underlying Boone Formation. Batesville Sandstone is chiefly preserved within Mill Creek graben. Thickness is 40–60 ft

Boone Formation (Upper to Lower Mississippian)—Thick sequence of limestone and cherty limestone of main body that grades downward into basal St. Joe Limestone Member. Boone Formation is a common host of caves and sinkholes. Total thickness of the formation is 380–405 ft

Main body (Upper to Lower Mississippian, Meramecian to Osagean)— Medium- to thick-bedded, cherty bioclastic limestone. Limestone is light to medium gray on fresh surfaces, generally coarsely crystalline, and contains interspersed crinoid ossicles.

A 1- to 3-ft-thick bed of oolitic limestone is present locally in the upper 10 ft of Boone Formation. Beds of dense, fine-grained limestone are present in upper one-third of the unit. Beds typically have planar to wavy boundaries; shallow channel fills are present locally in lower part. Chert forms lenticular to anastomosing lenses typically 2–20 in. long that are light to medium gray on fresh surfaces. Chert content varies within main body of Boone Formation but is commonly greater than 50 percent. Most chert-rich intervals are poorly exposed but are identifiable by abundant float of white-weathered, angular chert fragments on hill slopes. Thickness is 350–375 ft

St. Joe Limestone Member (Lower Mississippian, Osagean to Kinderhookian)—Thin-bedded bioclastic limestone containing ubiquitous 3- to 6-mm-wide crinoid fragments in a finely crystalline matrix. Limestone is commonly pink to red on fresh surfaces due to hematite in matrix, but color varies depending on hematite concentration. Thin beds are typically wavy. Lenticular red to pink chert nodules are locally present but uncommon. Contact with overlying main body of Boone Formation is gradational and marked by increase in chert and thicker beds upward. Middle to lower part of St. Joe Limestone Member contains greenish-gray shale interbeds; shale interval is well exposed in footwall of St. Joe fault adjacent to Hurricane Cave (sec. 7, T. 16 N., R. 18 W.). Base of St. Joe is a 0.3- to 0.6-ft-thick, fine-grained tan sandstone, or limestone locally, containing phosphate pebbles. Base of unit is an important unconformity that variably truncates Fernvale Limestone, Plattin Limestone, St. Peter Sandstone, or upper part of the Everton Formation in various parts of quadrangle. Total thickness of member is approximately 30–50 ft

Fernvale Limestone (Upper Ordovician)—Medium- to thick-bedded, coarsely crystalline bioclastic limestone. Limestone is light gray to pink on fresh surfaces and contains abundant 3- to 10-mm-wide cylindrical to barrel-shaped crinoid ossicles in a coarsely crystalline matrix. Unit is discontinuous and limited to thin lenses less than 10 ft thick mapped only where observed beneath St. Joe Limestone Member of Boone Formation

Plattin Limestone (Middle Ordovician)—Thin- to medium-planar-bedded, fine-grained, dense limestone locally interbedded with calcarenite. Characteristically thin-bedded, dense, very fine grained, medium-gray limestone that breaks with conchoidal fracture and weathers to very light gray, thin, tabular blocks. Locally in upper parts there are interbeds of laminated, tan to light-gray, fine-grained to very fine grained, limey to dolomitic calcarenite as thick as 10 ft; calcarenite has fetid odor when freshly broken. Where the Plattin is thickest in south-central part of area, lower parts are medium-gray, moderately fossiliferous, finely crystalline limestone. Thickness ranges from 70 ft in south-central part of area to absent in northern and western parts due to pre-Mississippian erosion beneath unconformity at base of St. Joe Limestone Member of Boone Formation

St. Peter Sandstone (Middle Ordovician)—Very fine grained, grayish-yellow sandstone interbedded with blue-green siltstone and shale. Sandstone is calcite-cemented arenite containing well-rounded quartz grains. Upper part of unit, as thick as 25 ft, is blue-green shale and siltstone interbedded with sandstone; shale and siltstone are poorly exposed, but interval is locally marked by zone of slumped sandstone blocks on hill slopes. Main part of unit contains a sequence of 1- to 2-ft-thick sandstone beds overlying a massive basal sandstone ledge as thick as 15 ft. Bioturbation is common in most sandstone beds and includes cylindrical burrows (*skolithos*) perpendicular to bedding that weather to distinctive straw-like forms. Basal sandstone is crossbedded, contains inclined fractures, and discordantly overlies laminated sandy dolomite in upper part of Everton Formation at local recesses; basal unit thins westward and eventually disappears. Unit thins to nothing to north and west due to pre-Mississippian erosion beneath unconformity at base of St. Joe Limestone Member of Boone Formation. Thickness ranges from 0 to 100 ft

Everton Formation (Middle Ordovician)—Interbedded dolostone, limestone, and sandstone sequence, divided into upper and lower parts. Unit is 300–400 ft thick

Upper part—Interbedded dolostone, sandstone, and limestone. Limestone is finely crystalline, light gray, thick bedded, and locally fossiliferous, and is present in intervals as thick as 20 ft. Dolostone is light to dark gray, finely to medium crystalline, laminated, and medium to thick bedded commonly containing sandstone stringers. Sandstone is arenite composed of well-sorted, well-rounded, fine to medium quartz grains. Sandstone is light tan to white in planar, medium to thick beds and is variably cemented by dolomite or calcite; sandstone locally grades into sandy dolostone or limestone. Limestone interbedded with limy sandstone and lesser dolostone at top of unit comprises Jasper Member of Glick and Frezon (1953). Jasper Member is 50–70 ft thick in southern part of quadrangle (Glick and Frezon, 1953) but is absent in northern part of quadrangle due to pre-Mississippian erosion beneath unconformity at base of St. Joe Limestone Member of Boone Formation. Dolostone and dolomitic sandstone underlying Jasper Member make up most of upper part of Everton. Base of upper part of Everton is marked by Newton Sandstone Member (McKnight, 1935), a planar, medium-bedded quartz arenite composed of well-sorted, well-rounded, fine to medium quartz grains. Newton Sandstone Member is 10–15 ft thick. Upper part of Everton Formation is 110–200 ft thick

Lower part—Interbedded dolostone, sandstone, and limestone. Limestone is restricted to upper part of unit and is interbedded with dolostone and sandstone. Limestone is light gray, finely crystalline, thin to medium bedded, and commonly laminated, and contains scattered stromatolite hemispheres as large as 1 ft in diameter. Dolostone, present throughout unit, is light gray to grayish brown, finely to medium crystalline, thin to thick bedded, and commonly laminated, and it commonly contains stromatolites. Sandstone is light-tan to white quartz arenite, composed of well-sorted, well-rounded, fine to medium quartz grains, variably cemented by dolomite or calcite. Sandstone intervals, composed of planar, thin to medium beds as thick as 6 ft, are present throughout unit. Sandstone also forms lenses and stringers within limestone and dolostone intervals. Light- to dark-brownish-gray dolostone and sandy dolostone interspersed with sandstone are predominant in lower part of unit. Basal contact with Powell Dolomite is unconformable and locally marked by a 0.5-ft-thick conglomerate containing clasts of Powell in finely crystalline dolomite matrix. Unit is 250 ft thick where fully exposed near Mt. Hersey near Buffalo River in south-central part of area Yellowish gray on fresh surfaces. Weathers to thin, platy blocks. As much as 65 ft of Powell is exposed along Buffalo River where it eroded upthrown side of Cane Branch monocline near Mt. Hersey (Glick and Frezon, 1953). Regionally, formation thickness ranges from 40 to 200 ft (McFarland, 1988)

Contact

Normal fault—Showing fault dip (arrow) and rake (diamond-headed arrow) where known. Bar and ball on downthrown side. Dashed where approximately located

Anticline
Monocline
Line of equal elevation showing base of Boone Formation—Contour interval 50 ft
Horizontal bedding
Inclined bedding—Showing strike and dip
Conodont sample locality
Paleomagnetism sample locality
Control point showing elevation (in feet) on lower or upper contact of Boone Formation

STRATIGRAPHY

The study area exposes a 1,000-ft-thick record of discontinuous middle Paleozoic deposition of shallow-water sediments that became limestone, dolostone, and sandstone on the southern margin of the North American continent. Stages for Mississippian units are from McFarland (1988).

Powell Dolomite was originally identified by McKnight (1935) in the area adjacent to the Buffalo River near Mt. Hersey. A sample processed for conodonts from site 11954-CO (table 1) near the Buffalo River yielded a single species, *Diaphorodus delicatus*. This species, together with abundant insoluble residue from this sample (expected for an argillaceous dolostone), are consistent with an identification of Powell Dolomite of latest Early Ordovician (late Ibexian) age (table 1).

The Middle Ordovician Everton Formation is a heterogeneous unit of intermixed sandstone and carbonate that Suhm (1974) interpreted as having been deposited in barrier island and tidal flat depositional environments. Glick and Frezon (1953) and Suhm (1974) measured a series of stratigraphic sections in the Everton Formation along the 130-mi length of the Buffalo River, and they documented a change from an eastern, carbonate-rich facies to a western, more sand-rich facies. The sand-rich nature of the western facies is demonstrated by the presence of the Newton Sandstone Member as thick as 100 ft which can be mapped as a separate unit in the Ponca quadrangle (fig. 1, Hudson and Murray, 2003). In the Western Grove quadrangle, the carbonate-rich facies of the Everton is predominant and the Newton Sandstone Member is only 10–15 ft thick and not easily distinguished from other sandstone intervals within the Everton. During mapping, recognition of the Newton Sandstone Member was based on its position above limestone containing distinctive stromatolite hemispheres near the top of the lower part of the Everton Formation.

The massive basal sandstone of the St. Peter Sandstone unconformably overlies sandy dolostone of the upper part of the Everton Formation in the south-central part of the quadrangle. To the north and northwest, the basal sandstone pinches out and, in the absence of shale outcrops in thicker sections, thin sandstone beds of the St. Peter are difficult to distinguish from sandstone in the upper part of the Everton Formation.

Plattin Limestone overlies the St. Peter Sandstone throughout much of the southern part of the quadrangle, and its thickness ranges from zero to 70 ft. The Plattin Limestone is typically gray, dense, fine micritic limestone, but its upper part also locally contains fine-grained calcarenite that is laminated and crossbedded. One conodont sample (11952-CO) from dense limestone near the base of a 70-ft-thick section in a tributary to Cane Branch Creek yielded a single specimen of the conodont species *Erismodus*, a morphotype that indicates a late Middle Ordovician to medial Late Ordovician age, younger than typical limestone of the upper part of the Everton Formation (table 1). Two samples (11951-CO, 11953-CO) from calcarenite near the top of the Plattin interval yielded conodonts that indicate a very late Middle Ordovician to early Late Ordovician age (table 1). McKnight (1935) described an isolated locality in a tributary to Mill Branch (SW 1/4, NE 1/4, sec. 19, T. 16 N., R. 18 W.), containing loose blocks of light-gray sandstone that he correlated to Middle Ordovician Kimmswick Limestone on the basis of echinoderm fauna. No other Kimmswick Limestone outcrops have been identified nearby. We think McKnight (1935) probably miscorrelated a sandstone interbed within the upper calcarenite interval of the Plattin Limestone with the Kimmswick Limestone. Conodont assemblages in the Plattin calcarenite samples (table 1) from the quadrangle are distinct from what have been reported for Kimmswick Limestone where it is well developed about 60 mi farther east in the Batesville district of Arkansas (Craig, 1975).

Fernvale Limestone is preserved only as small, discontinuous lenses beneath the unconformity at the base of the Mississippian Boone Formation. Fernvale lenses were mapped where they were directly observed to be at least 5 ft thick in the quadrangle, but it is likely that other unobserved lenses exist. Fernvale lenses are restricted to the central parts of the quadrangle including (1) beneath a knob east of the southeastern part of Clear Creek, (2) at two locations on the southeast limb of the Shaddock Branch anticline, (3) where Shaddock Branch cuts through the western part of the Mill Creek graben, (4) south of Hurricane Branch in the footwall of the Mill Creek fault, and (5) on a ridge northeast of Davis Creek about 1.5 mi upstream from its confluence with the Buffalo River.

The Mississippian Boone Formation is the most widespread unit exposed within the quadrangle and consists of a thin basal St. Joe Limestone Member and a thicker bedded overlying main body. Throughout much of the quadrangle the lower part of the St. Joe Limestone Member is greenish-gray, fossiliferous shale containing thin limestone beds; the shale interval is 15 ft thick where well exposed in the wall of the commercial parking lot for Hurricane Cave near the center of the quadrangle (sec. 7, T. 16 N., R. 18 W.). The contact of the main body of the Boone Formation with the St. Joe Limestone Member is gradational and picked where thin beds of St. Joe Limestone Member give way upward to thicker, chert-bearing beds. Thin oolitic limestone locally present near the top of the Boone Formation was also recognized by Braden and Ausbrooks (2003a) to the south, and they correlated it with the Short Creek Oolite Member of the Boone Formation in Missouri and Kansas (McKnight and Fischer, 1970).

The relative age of unconsolidated terrace deposits adjacent to the Buffalo River (units Qty and QTto) can be determined from their height above the river; there are no constraints on their absolute age. The deposits of unit Qty are likely Quaternary in age but deposits of unit QTto, which are 80–120 ft above the river, may be as old as Tertiary (> 1.8 Ma). Three samples were collected for paleomagnetic analysis from reddish clay overlying high-level cobbles of unit QTto northwest of the river (lat 35° 0.325' N., long 92° 57.573' W.). The samples yielded a normal polarity magnetization and thus could be as young as the Brunhes chron (< 780 ka), but could also possibly record one of several older normal-polarity subchrons within the Matuyama chron (Berggren and others, 1995).

STRUCTURAL GEOLOGY

Rocks within the map area were mildly folded and faulted. Structure contours showing the base of the Boone Formation highlight the structures and their vertical displacement. The structure contours conform to elevations at 215 control points located at both lower and upper contacts of the Boone Formation. A 390-ft thickness for the Boone Formation (including the St. Joe Limestone Member) was used to project elevations from points on the upper contact to the basal contact. This thickness is based on the average of five stratigraphic sections farther west near the Buffalo River (Hudson, 1998), where thickness ranges from 380 to 405 ft. Structure contour elevations were also limited to be lower than Boone Formation outcrops in valley bottoms, such as where the Hurricane Branch crosses the Mill Creek graben. Upper contacts of the Boone Formation were limited to be higher than Boone outcrops on hilltops.

The predominant structural feature of the Western Grove quadrangle is the Mill Creek graben (McKnight, 1935), which is mapped east-west across the center of the quadrangle. The St. Joe and Mill Creek faults bound the north and south sides of the graben, respectively. The main plane of the St. Joe fault dips 66° S. in the abandoned pit of the Hurricane Mine (lat 36° 3.169' N., long 92° 59.479' W.), and associated fault striations rake 78° E., indicating a predominant normal sense of slip. Whereas McKnight (1935) showed the Mill Creek fault to continue across the quadrangle, we map this fault as dying out in the western part of the quadrangle (sec. 10, T. 16 N., R. 19 W.). A separate north-dipping normal fault begins just to the north and continues to the west beyond the quadrangle. Fault displacements are greatest in the eastern part of the Mill Creek graben, where the Batesville Sandstone is preserved; throw is as much 400 ft on the St. Joe fault and 250 ft on the Mill Creek fault. Throw on the St. Joe fault decreases westward to less than 200 ft northeast of where the Mill Creek fault ends, but farther west throw on the St. Joe fault increases. The graben system continues more than 6 mi beyond the west edge of the quadrangle where it becomes the Braden Mountain graben (Hudson and Murray, 2004).

Several folds and broad domes are evident in the structure contour map. The greatest structural relief in the quadrangle, about 300 ft, reflects folding across the northwest-trending Cane Branch monocline, named by Braden and Ausbrooks (2003b) in the adjacent Eula quadrangle. The base of the Boone Formation reaches its highest elevation on the upthrown side of the Cane Branch monocline southeast of Mt. Hersey. In this area, erosion by the Buffalo River has exposed the oldest stratigraphic unit, the Powell Dolomite. Whereas most folds in the quadrangle are monoclines, both limbs of the northeast-trending Shaddock Branch anticline have significant dip. The northwestern limb of the anticline dips most steeply and merges southwestward with the Yardelle monocline. The north-dipping Yardelle monocline extends about a mile west of the quadrangle (Hudson and Murray, 2004). The Yardelle monocline and Shaddock Branch anticline collectively bring the lower part of the Everton Formation to the surface along Davis Creek north of the St. Joe fault. In the eastern and central part of the quadrangle, strata in the immediate footwall of the St. Joe fault consistently dip north 5°–16°; structural relief on this footwall flank is as much as 150 ft. A broad dome in the northeastern part of the quadrangle raises the base of the Boone Formation above the

1,100-ft elevation, and erosion by Clear Creek on its western flank has exposed the lower part of the Everton Formation.

Away from fold limbs, bedding dips are typically low and variable in direction. These dispersed attitudes can be attributed in part to local subsidence caused by karst dissolution within the abundant limestone and dolostone units.

Joints measured within the map area (441 total) are nearly vertical and distributed in several sets (fig. 3). The predominant sets strike north, northeast, and west-northwest to west. Joint planes within limestone and dolostone formations, such as the Boone and Everton Formations, are commonly enlarged by dissolution.

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Figure 1. Location map of Western Grove quadrangle within northern Arkansas, including part of Buffalo National River. Other U.S. Geological Survey geologic maps in area (Hudson, 1998; Hudson and others, 2001; Hudson and Murray, 2003, 2004) are listed by publication number. Regional map illustrates geological and selected physiographic provinces of Arkansas and adjacent areas. Ozark Plateaus region is composed of Salem and Springfield Plateaus and Boston Mountains.

Figure 2. Stratigraphic column for Paleozoic rocks of the map area. Provincial series are from McFarland (1988) and Ethington and others (1989).

Figure 3. Rose diagram showing strike frequency of joints measured in map area.

Table 1. Conodont data from Ordovician units in the Western Grove quadrangle, Arkansas.

This map was produced on request, directly from digital files, on an electronic plotter
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