U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SCIENTIFIC INVESTIGATIONS MAP 2804

Table 2.—Summary of drill-hole data in the Big Spring quadrangle, Missouri.

[There are no logs for the upper parts of most of the drill holes. Og, Gasconade Dolomite; Ce, Eminence Dolomite; Ep, Potosi Dolomite. Datum is mean sea level]

Drill-hole no.	Location	Collar elevation, in feet	Contact elevation, in feet	Bottom elevation, in feet
Drill-hole data on file with Missouri Department of Natural Resources, Geological Survey and Resource Assessment Division				
223	Center of NW1/4 Sec. 16, T. 27 N., R. 2 E.	8307	4607 Ce-Ep	375
3130	Center of N1/2 Sec. 6, T. 26 N., R. 1 E.	461	at Ce	211
14375	NW1/4SW1/4 Sec. 6, T. 26 N., R. 1 E.	473	443 Og-Ce	333
20313	NW1/4NE1/4 Sec. 6, T. 26 N., R. 1 E.	460	275 Ce-Ep	-15
22445	SE1/4SE1/4 Sec. 27, T. 27 N., R. 1 E.	604	519 Og-Ce	404
26660	SE1/4NW1/4 Sec. 6, T. 26 N., R. 1 E.	492	302 Ce-Ep	-28

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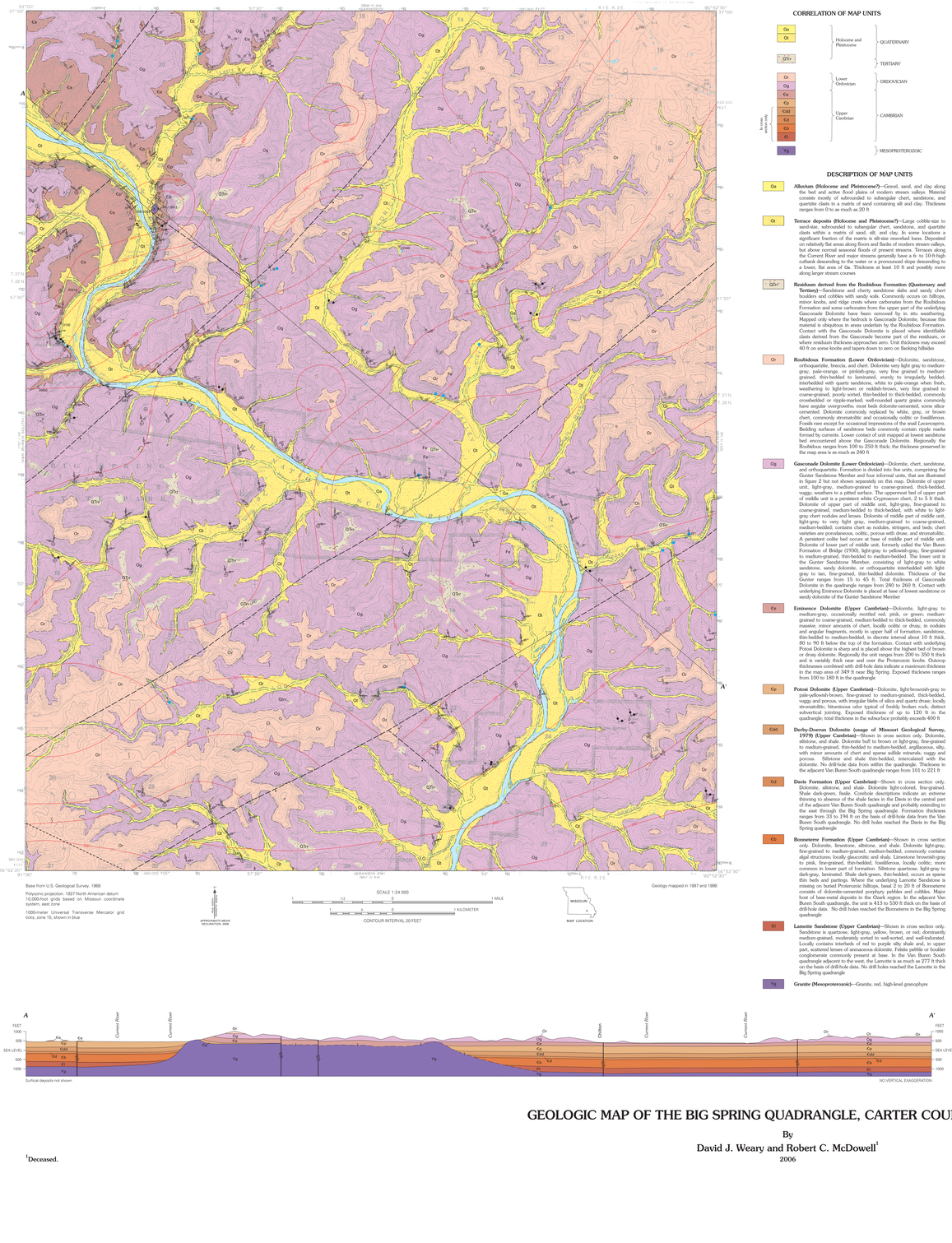

GEOLOGIC MAP OF THE BIG SPRING QUADRANGLE, CARTER COUNTY, MISSOURI

By
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2006

[1]Deceased.

CORRELATION OF MAP UNITS

DESCRIPTION OF MAP UNITS

Qa

Alluvium (Holocene and Pleistocene?)—Gravel, sand, and clay along the bed and active flood plains of modern stream valleys. Material consists mostly of subrounded to subangular chert, sandstone, and quartzite clasts in a matrix of sand containing silt and clay. Thickness ranges from 0 to as much as 20 ft

Qt

Terrace deposits (Holocene and Pleistocene?)—Large cobble-size to sand-size, subrounded to subangular chert, sandstone, and quartzite clasts within a matrix of sand, silt, and clay. In some locations a significant fraction of the matrix is silt-size reworked loess. Deposited on relatively flat areas along floors and flanks of modern stream valleys, but above recent flood plains. At present erosion. Terraces along the Current River and major streams generally have a 6- to 10-ft-high cutbank descending to the water or a protruding gravel bar according to a lower, flat area of Qa. Thickness at least 10 ft and possibly more along large streams

QTrr

Residuum derived from the Roubidoux Formation (Quaternary and Tertiary)—Sandstone and cherty sandstone slabs and sandy chert boulders and cobbles with sandy soils. Commonly occurs on hilltops, minor knobs, and ridge crests where carbonates from the Roubidoux Formation and any cherty residuum from the upper part of the underlying Gasconade Dolomite have been removed by in situ weathering. Mapped only where the bedrock is Gasconade Dolomite, because this material is ubiquitous in areas underlain by the Roubidoux Formation. Contact with the Gasconade Dolomite is placed where identifiable clasts derived from the Gasconade become part of the residuum, or where residuum thickness approaches 20 ft. Unit thickness may exceed 40 ft on some knobs and tapers down to zero on flanking hillsides

Or

Roubidoux Formation (Lower Ordovician)—Dolomite, sandstone, orthoquartzite, breccia, and chert. Dolomite very light gray to medium-gray, pale-orange, or pinkish-gray, very fine grained to medium-grained, thin-bedded to laminated, evenly to irregularly bedded, interbedded with quartz sandstone, white to pale-orange when fresh, weathering to light-brown or reddish-brown; very fine grained to coarse-grained, poorly sorted, thin-bedded to thick-bedded, commonly crossbedded or ripple-marked, well-rounded quartz grains commonly have angular overgrowths; most beds dolomite-cemented, some silica-cemented. Dolomite commonly replaced by white, gray, or brown chert, commonly stromatolitic and occasionally oolitic or fossiliferous. Fossils rare except for occasional impressions of the snail *Lecanospira*. Bedding surfaces of sandstone beds commonly contain ripple marks formed by currents. Lower contact of unit mapped at lowest sandstone bed encountered above the Gasconade Dolomite. Regionally the Roubidoux ranges from 100 to 250 ft thick; the thickness preserved in the map area is as much as 240 ft

Og

Gasconade Dolomite (Lower Ordovician)—Dolomite, chert, sandstone, and orthoquartzite. Formation is divided into five units, comprising the Gunter Sandstone Member and five informal units, that are illustrated in figure 2 but not shown separately on this map. Dolomite of upper part of middle unit is pinkish-gray, fine-grained to coarse-grained, thin-bedded to thick-bedded, commonly cherty, and contains abundant fossils, including the snail *Maclurites*, the cephalopod *Rhynchorthoceras*, and the conodont *Oistodus lanceolatus*. Dolomite of upper part of middle unit, light-gray, fine-grained to coarse-grained, poorly sorted, thin-bedded to thick-bedded, commonly crossbedded or ripple-marked, well-rounded quartz grains commonly have angular overgrowths; most beds dolomite-cemented, some silica-cemented. Dolomite commonly replaced by white, gray, or brown chert, commonly stromatolitic and occasionally oolitic or fossiliferous. Fossils rare except for occasional impressions of the snail *Leconospira*. Bedding surfaces of sandstone beds commonly contain ripple marks formed by currents. Lower contact of unit mapped at lowest sandstone bed encountered above the Gasconade Dolomite. Regionally the Roubidoux ranges from 100 to 250 ft thick; the thickness preserved in the map area is as much as 240 ft

Ce

Eminence Dolomite (Upper Cambrian)—Dolomite, light-gray to medium-gray, occasionally mottled red, pink, or green; medium-grained to coarse-grained, medium-bedded to thick-bedded, commonly massive; minor amounts of chert. Chert, locally oolitic or cherty, in nodules and angular fragments, mostly in upper half of formation; sandstone, thin-bedded to medium-bedded, in discrete interval about 10 ft thick, 80 to 90 ft below the top of the formation. Contact with underlying Potosi Dolomite is placed at the base of lowest bed of coarse sand or thick or druse dolomite. Regionally the unit ranges from 200 to 350 ft thick and is variably thick near and over the Proterozoic knobs. Observed thicknesses combined with drill-hole data indicate a maximum thickness in the map area of 349 ft near Big Spring. Exposed thickness ranges from 100 to 180 ft in the quadrangle

Cp

Potosi Dolomite (Upper Cambrian)—Dolomite, light-brownish-gray to pale-yellowish-brown, fine-grained to coarse-grained, thick-bedded, vuggy and porous, with irregular blebs of silica and quartz druse; locally stromatolitic; bituminous odor when fresh. Chert, white to gray, in subvertical jointing. Exposed thickness of up to 120 ft in the quadrangle; total thickness in the subsurface probably exceeds 600 ft

Cdd

Derby-Doerun Dolomite (usage of Missouri Geological Survey, 1979) (Upper Cambrian)—Shown in cross section only. Dolomite, siltstone, and shale. Dolomite light-brown or light-gray, fine-grained to medium-grained, thin-bedded to medium-bedded, argillaceous, silty, with minor amounts of chert and sparse oolitic, vuggy, and porous. Siltstone and shale thin-bedded, intercalated with the dolomite. No drill-hole data from within the quadrangle. Thickness in the adjacent Van Buren South quadrangle ranges from 101 to 221 ft

Cd

Davis Formation (Upper Cambrian)—Shown in cross section only. Dolomite, siltstone, and shale. Dolomite light-colored, fine-grained. Shale dark-green, flinty. Conchule descriptions indicate an extreme thinning to absence of the shale facies in the Davis in the central part of the adjacent Van Buren South quadrangle and probably extending to the east through the Big Spring quadrangle. Formation thickness ranges from 33 to 194 ft on the basis of drill-hole data from the Van Buren South quadrangle. No drill holes reached the Davis in the Big Spring quadrangle

Cb

Bonneterre Formation (Upper Cambrian)—Shown in cross section only. Dolomite, limestone, siltstone, and shale. Dolomite light-gray, fine-grained to medium-grained, thin-bedded, commonly cherty; contains algal structures, locally glauconitic and shaly. Limestone brownish-gray to pink, fine-grained, thin-bedded, fossiliferous, locally oolitic, more common in lower part of formation. Siltstone quartzose, light-gray to dark-gray, laminated. Shale dark-green, fine-bedded; occurs as seams in thin beds and partings. Where the underlying Lamotte Sandstone is missing on buried Proterozoic hilltops, basal 2 to 20 ft of Bonneterre consists of dolomite-cemented porphyry pebbles and cobbles. Major host of base-metal deposits in the Ozark region. In the adjacent Van Buren South quadrangle, the unit is 413 to 530 ft thick on the basis of drill-hole data. No drill holes reached the Bonneterre in the Big Spring quadrangle

Cr

Lamotte Sandstone (Upper Cambrian)—Shown in cross section only. Sandstone is quartzose, light-gray, yellow, brown, or red, dominantly medium-grained, moderately sorted to well-sorted, and well-indurated. Locally contains interbeds of red to purple silty shale and, in upper part, scattered lenses of arenaceous dolomite. Feldsparic or basaltic conglomeratic units commonly present at base. In the Van Buren South quadrangle adjacent to the west, the Lamotte is as much as 277 ft thick on the basis of drill-hole data. No drill holes reached the Lamotte in the Big Spring quadrangle

Yg

Granite (Mesoproterozoic)—Granite, red, high-level granophyre

EXPLANATION OF MAP SYMBOLS

Contact—Dashed where approximately located; dotted where concealed

Fault—Long-dashed where approximately located; short-dashed where inferred; dotted where concealed. Bar and ball on downthrown side; arrows (in cross section) show relative direction of vertical movement. Only the vertical component of offset was observed; however, similar faults exposed in mines in nearby quadrangles have strike-slip displacement

Structure contour—Drawn on base of Roubidoux Formation; projected where above land surface. Contour interval 20 ft

PLANAR FEATURES

Strike and dip of beds

Inclined

Horizontal

Strike and dip of joints—Point of observation at intersection of multiple symbols. Apertures are narrow (<0.5 in), except where noted by w (solutionally widened)

Throughgoing, vertical

Widely spaced (> 6 ft)

Moderately spaced (2–6 ft)

Throughgoing, inclined

Widely spaced (> 6 ft)

Non-throughgoing, vertical

Widely spaced (> 6 ft)

Moderately spaced (2–6 ft)

Closely spaced (< 2 ft)

Non-throughgoing, inclined

Widely spaced (> 6 ft)

Moderately spaced (2–6 ft)

Closely spaced (< 2 ft)

OTHER FEATURES

Drill hole—Number refers to well records from Missouri Department of Natural Resources; see table 2 for summary of well data

Sample locality—Mesoproterozoic intrusive rocks; see table 1 for geochemical analyses

Slickensides or cataclastic deformation bands in sandstone float

Spring

Large sinkhole—Greater than or equal to 100 ft in diameter

Small sinkhole—Less than 100 ft in diameter

Iron mineralization or prospect pit

DISCUSSION

INTRODUCTION

The Big Spring 7.5-minute quadrangle is located in south-central Missouri within the Salem Plateau region of the Ozark Plateaus physiographic province (Fenneman, 1938; Bretz, 1965) (fig. 1). Much of the land within the quadrangle bounding both banks of the Current River is administered by the Ozark National Scenic Riverways of the National Park Service. Other areas are privately owned and are used mostly for agriculture, growing timber, and hunting. The map area has topographic relief of about 600 feet (ft), with elevations ranging from about 390 ft in the southeast corner of the quadrangle to about 990 ft in the north-central part. The most prominent physiographic feature of the quadrangle is the valley of the Current River, which bisects the quadrangle from northwest to southeast.

STRATIGRAPHY

Mesoproterozoic Rocks

Mesoproterozoic granite is exposed in one small area of the Big Spring quadrangle, on a hillside adjacent to the Current River in the central part of the boundary between sections 29 and 32, T. 27 N., R. 1 E. The granite is a red, high-level granophyre having anorogenic, within-plate and rift-related granitic signatures (Harrison and others, 2000). See table 1 for major-oxide analysis of three samples from this granite. The outcrop in this quadrangle is the northernmost exposure in Missouri of a Mesoproterozoic granite–rhyolite terrane, which is extensive in the Midcontinent region. Additional outcrops of this granite occur in the Van Buren North, Stegall Mountain, Powder Mill Ferry, and Eminence quadrangles to the northwest and in the Saint Francois Mountains (fig. 1) to the north and northeast. Typically, however, these rocks are encountered only in deep (1,000–2,000-ft) exploration drill holes, but none of these holes reached those depths (table 2). Uranium-lead isotopic analyses yielded radiometric ages of (1) 1,461.8±5.5 Ma for the granite exposed in the Big Spring quadrangle (Harrison and others, 2000), (2) 1,473±15 Ma for granite from a corehole in the Van Buren South quadrangle to the west, (3) 1,480±42 Ma for granite from a corehole in the Winona quadrangle to the northwest (Van Schmus and others, 1993), and (4) 1,473±15 Ma for granite from a corehole in the Round Spring quadrangle to the northwest (Bickford and others, 1981). A uranium-lead age of 1,470.4±2.7 Ma was obtained from the "Rhyolite of Shut-In Mountain" in the Stegall Mountain quadrangle to the northwest (Harrison and others, 2002).

These granites and their surrounding volcanic deposits were subjected to uplift and erosion throughout Late Proterozoic time. The regional relief on this buried erosional surface has been reported to be as much as 2,000 ft (Kisvarsanyi, 1979). Structure contours drawn by Kisvarsanyi (1979) indicate that a northeast- to southwest-trending ridge underlies the northern part of the Big Spring quadrangle. The exposure along the Current River is the highest point along this buried ridge.

Paleozoic Stratigraphy

The Big Spring quadrangle is underlain by 1,000 to 2,000 ft of lower Paleozoic marine strata, chiefly dolomite, chert, sandstone, and orthoquartzite. From oldest to youngest, these units are the Upper Cambrian Lamotte Sandstone, Bonneterre Formation, Davis Formation, Derby-Doerun Dolomite (usage of Missouri Geological Survey, 1979), Potosi Dolomite, and Eminence Dolomite and the Lower Ordovician Gasconade Dolomite and Roubidoux Formation. Only the last four units crop out in the quadrangle. The stratigraphic column (fig. 2) summarizes the general lithologies and thickness of the Paleozoic strata that crop out in the Big Spring quadrangle.

During Late Cambrian time, the Ozark region was flooded by an extensive epicontinental sea that covered most of the midwestern part of the United States. Because of topographic relief on the Mesoproterozoic paleosurface, initially only low areas were covered by the sea, and high areas remained above water as islands. In the map area, the basal Cambrian unit, the Lamotte Sandstone, onlaps the flanks of the basement high located in the northern part of the quadrangle. On the basis of drill-hole data, the Lamotte is as much as 277 ft thick in the Van Buren South quadrangle, adjacent to the west. No drill holes reached the Lamotte in the Big Spring quadrangle (table 2).

During deposition of the Bonneterre Formation, algal reefs developed along the flanks of the remnant islands of Mesoproterozoic rocks in the Late Cambrian sea (Lyle, 1977). These reefs, especially to the north along the Viburnum Trend (fig. 1), later became the focus of deposition of Mississippi Valley-type (MVT) base-metal deposits (Thacker and Anderson, 1977). Most of the islands in the region, with the exception of the highest areas of basement rocks, such as the granite outcrop in the northwestern part of the Big Spring quadrangle, were entirely buried near the end of deposition of the Bonneterre. However, they have affected depositional patterns even after they were completely buried through differential compaction of sediments deposited on and around their flanks. The Bonneterre is 413 to 530 ft thick in the adjacent Van Buren South quadrangle on the basis of drill-hole data. No drill holes reached the Bonneterre in the Big Spring quadrangle (table 2).

The Davis Formation probably was named for exposures on Davis Creek, St. Francois County, Mo. (Buehler, 1907). The Davis Formation conformably overlies the Bonneterre Formation and typically comprises shale, siltstone, sandstone, dolomite, and limestone conglomerate. Conchule descriptions indicate an extreme thinning to absence of the shale facies in the Davis in the central part of the Van Buren South quadrangle and probably extending to the east through the Big Spring quadrangle (Weary and Schindler, 2004). This same pattern occurs in the Wilderness and Handy quadrangles to the southwest (Harrison and McDowell, 2003). The Davis in the central part of the Van Buren South quadrangle comprises light-colored, fine-grained dolomite, siltstone, and thin shale and locally contains traces of galena, sphalerite, and chalcopyrite. Shales within the Davis have low primary permeability and act as an aquitard (part of the St. Francois confining unit) between the underlying St. Francois aquifer and the overlying Ozark aquifer (Kleeschulte and Seeger, 2000). The Davis is reported to have a maximum thickness of 225 ft but is commonly about 170 ft thick (Thompson, 1995). The formation ranges from 33 to 194 ft thick in the adjacent Van Buren South quadrangle on the basis of drill-hole data. No drill holes reached the Davis in the Big Spring quadrangle (table 2).

The Derby-Doerun Dolomite was originally two separate formations described from outcrops near mines operated by the Derby Lead Co. and the Doe Run Lead Co. in St. Francois County, Mo. (Thompson, 1995). The formation comprises thin-bedded to medium-bedded dolomite intercalated with thin-bedded siltstone and shale. Thompson (1995) reported a thickness of 0 to 250 ft for the unit. In the adjacent Van Buren South quadrangle, the thickness ranges from 101 to 221 ft on the basis of drill-hole data. No boreholes reached the Derby-Doerun in the Big Spring quadrangle (table 2).

The Upper Cambrian Potosi Dolomite is the oldest Paleozoic unit exposed in the Big Spring quadrangle. Outcrops occur at the base of bluffs along the Current River in the northwest corner of the quadrangle. The name Potosi was originally used by Winslow (1894) in a much broader sense for rocks exposed near the town of Potosi in Washington County, Mo. Dake (1930) reviewed, revised, and redefined the Potosi as used presently. The Potosi is a vuggy, fine-grained to medium-grained, light-brownish-gray to pale-yellowish-brown dolostone having siliceous druses as a replacement of the dolomite or as vug linings. A fetid smell on freshly broken surfaces is characteristic. In outcrop, the Potosi characteristically is more intensely jointed than the overlying formations. Joints are typically subvertical. Pronounced cavern development (small caves and other solution features) exists at or near the contact between the Potosi and the overlying Eminence Dolomite, suggesting a permeability contrast across that boundary. The Potosi is characteristically unfossiliferous, and at least 120 ft is exposed within the map area. No boreholes in the Big Spring quadrangle reached the lower contact of the Potosi; however, a minimum thickness of 290 ft was penetrated in borehole 20313 (table 2). Boreholes in the adjacent Van Buren South quadrangle record thicknesses of up to 425 ft. The contact with the overlying Eminence Dolomite is sharp and changes elevation relative to the base of the Potosi and top of the Eminence. This suggests that the lithologic difference between the Potosi and Eminence is a secondary alteration of the Potosi that includes dissolution of carbonate, precipitation of silica, and introduction of hydrocarbons.

The Eminence Dolomite was described by Ulrich (1911) from exposures in the vicinity of the town of Eminence, Mo. Most of the exposures in the quadrangle occur in the floor and along the walls of the Current River valley, and are confined to the north half of the map area. The Eminence comprises mostly massive to thick-bedded, medium-grained to coarse-grained, light-gray to medium-gray dolomite and chert; dolomite with a few minor sandstone beds and white chert. Many of the beds are stromatolitic, with ciliti and vugs developed between the laminae, and others are crossbedded. The thick, non-cherty dolomite beds commonly weather into irregular pinnacles, especially beds lying subjacent to sandstone of the Eminence or of the overlying Gunter Sandstone Member of the Gasconade Dolomite.

A conspicuous interval of sandstone and dolomite, about 10 ft thick, occurs in the Eminence between about 80 and 90 ft below the top of the formation. The base of the interval is marked by a quartz sandstone bed, 18 to 28 inches (in) thick, that is overlain by several feet of crossbedded dolomite and sandstone. Sandstone is 1 to 12 in thick. Although Bridge (1930) believed the sandstone in the Eminence to be localized lenses, this sandstone-dolomite interval was observed in most outcrops in the map area, has been reported in the Stegal Mountain 7.5-minute quadrangle to the northwest (Harrison and others, 2002), and occurs in the Van Buren North and Van Buren South 7.5-minute quadrangles to the northwest and west, respectively. Assuming that this interval is correlative across this multi-quadrangle area, it may mark a regressive event similar to, but less widespread than, the regression indicated by the unconformity beneath the basal Gunter Sandstone Member of overlying Gasconade Dolomite. The variation in thickness of the Eminence above the sandstone-dolomite interval is probably due to erosion down into the Eminence prior to deposition of the overlying Gunter Sandstone Member.

Bridge (1930) reported the Eminence to be abundantly fossiliferous, especially with trilobites and gastropods in residual cherts. No such fossils were observed during the course of this study. The exposed thickness of the Eminence in the map area ranges from about 100 to 180 ft. Records from drill holes 20313 and 3130, just north of Big Spring, indicate Eminence Dolomite thicknesses of 180. ft and at least 200 ft, respectively (table 2), interpolating between the elevations of the base of the Eminence in these drill holes and of the top of the Eminence in nearby outcrops yields total Eminence thicknesses of 305 ft and at least 349 ft, respectively. Although Thompson (1995) reported a thickness of up to 350 ft in parts of south-central Missouri, these are exceptional thicknesses compared to Eminence Dolomite outcrops in the immediate area. Variability in thickness is the result of the non-planar transition from the underlying Potosi Dolomite and erosional beveling by the unconformity at the base of the overlying Gasconade Dolomite.

The Eminence Dolomite is the main cave-bearing formation in the map area. Caves typically are concentrated just below the Gunter Sandstone Member of the overlying Gasconade Dolomite and to a lesser extent below the sandstone-dolomite interval within the Eminence. Big Spring, the largest spring in the Ozark National Scenic Riverways, issues from the Eminence and possibly emerges from caverns developed beneath the Eminence sandstone-dolomite interval.

Previous maps produced by the U.S. Geological Survey project placed the Cambrian-Ordovician boundary in the upper part of the Eminence (McDowell, 1998; Orndorff and others, 1999; McDowell and Harrison, 2000; Orndorff and Harrison, 2001; Harrison and others, 2002; Weems, 2002; Harrison and McDowell, 2003). However, recent international agreement on redefinition of this boundary requires that it be placed at the contact between the Eminence and Gasconade Dolomites (Cooper and others, 2001). Bridge (1930) speculated that an important unconformity exists at the base of the Gasconade. Conodont biostratigraphy suggests that there may be multiple unconformities within the basal Gasconade interval and that the basal Gasconade is significantly younger in the area between the towns of Van Buren and Eminence, which are about 1 mile (mi) and 23 mi, respectively, to the northwest of the northeast corner of the Big Spring quadrangle (Repetski and others, 2000).

The Gasconade Dolomite was named by Nason (1892) for exposures along the Gasconade River in Laclede, Pulaski, and Phelps Counties, central Missouri. The basal 15 to 45 ft consists of sandstone, orthoquartzite, and dolomite. Sandstone and dolomite and sandy dolomite named the Gunter Sandstone Member by Ball and Smith (1903) for exposures along the Niangua River at Gunter Spring in Hickory Township, Camden County, central Missouri. The lower part of the Gunter comprises relatively thin quartz sandstones and dolomite and commonly is buried in sandstone float for beds above. The upper part of the Gunter is typically thick-bedded or massive quartz sandstone as much as 15 ft thick, which produces a prominent topographic bench on many of the hillsides. The total thickness of the Gunter varies from about 15 to 45 ft within the map area. No boreholes in the Big Spring quadrangle reached the lower contact of the Potosi; however, a minimum thickness of 290 ft was penetrated in borehole 20313 (table 2). Boreholes in the adjacent Van Buren South quadrangle record thicknesses of up to 425 ft. The contact with the overlying Eminence Dolomite is sharp and changes elevation relative to the base of the Potosi and top of the Eminence. This suggests that the lithologic difference between the Potosi and Eminence is a secondary alteration of the Potosi that includes dissolution of carbonate, precipitation of silica, and introduction of hydrocarbons.

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