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

SCIENTIFIC INVESTIGATIONS MAP 2847
Version 1.0

GEOLOGIC MAP OF THE HASTY QUADRANGLE, BOONE AND NEWTON COUNTIES, ARKANSAS

By

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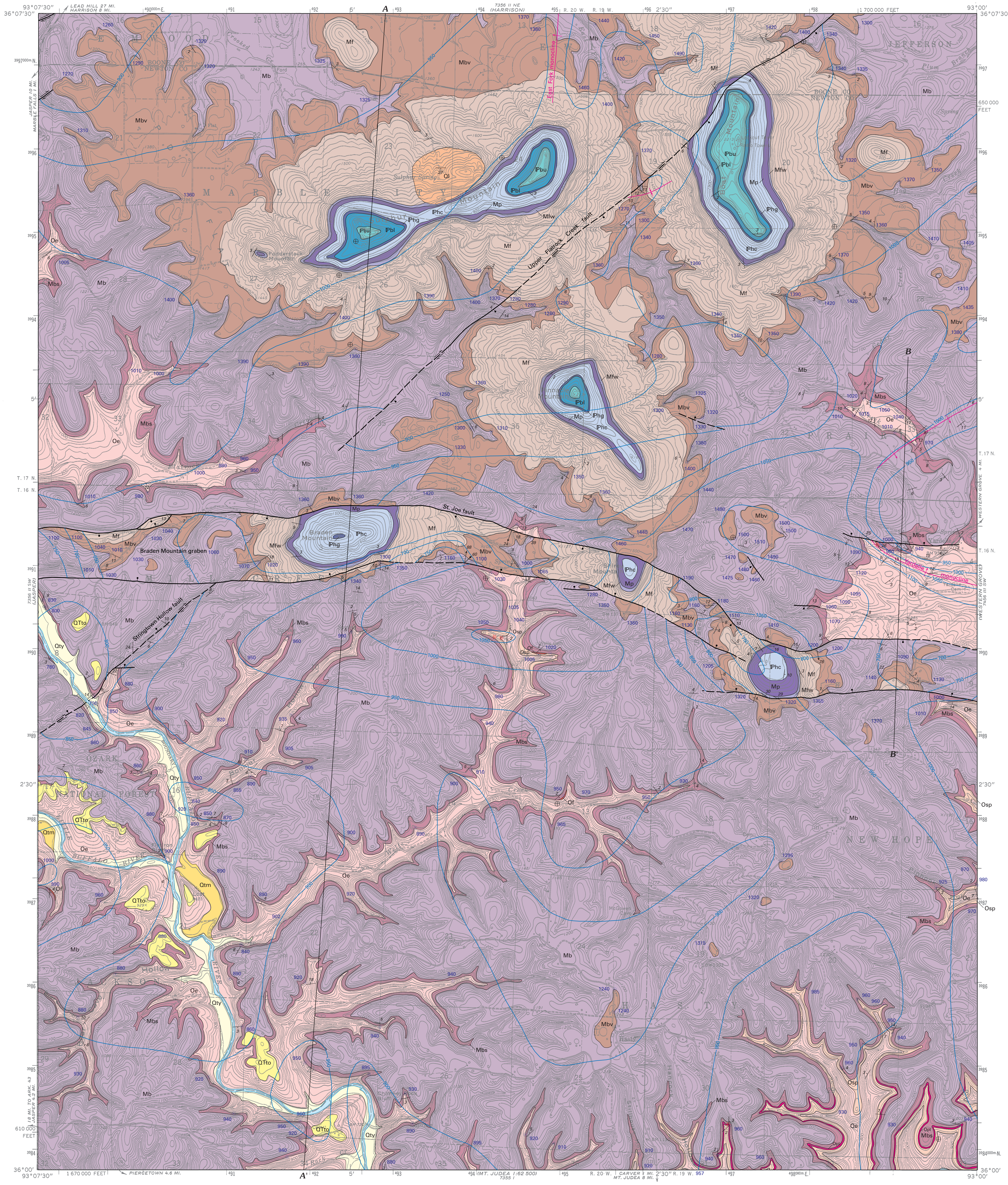
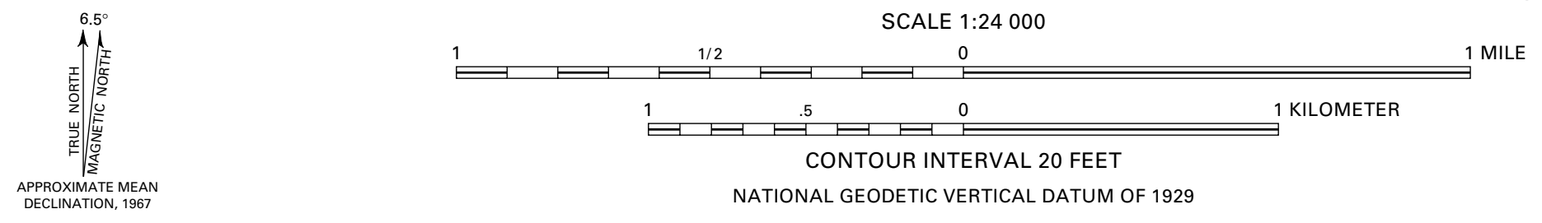
2004



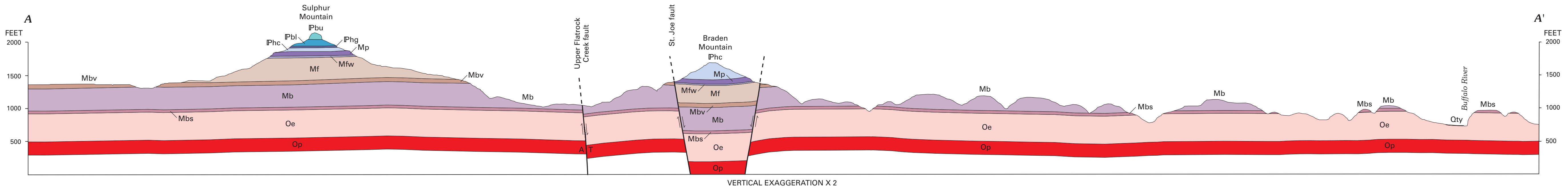
Base from U.S. Geological Survey, 1967
Projection and 10,000-foot grid ticks: Arkansas coodinate system, north zone
1000-meter Universal Transverse Mercator grid, zone 15
1927 North American Datum

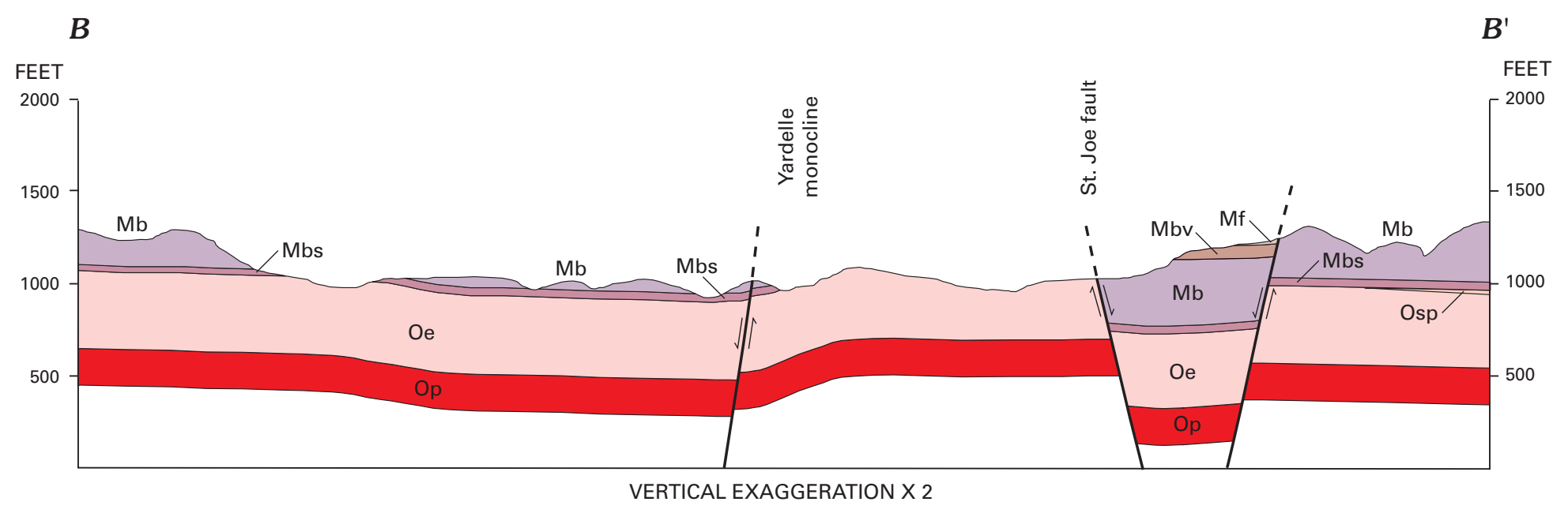


CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

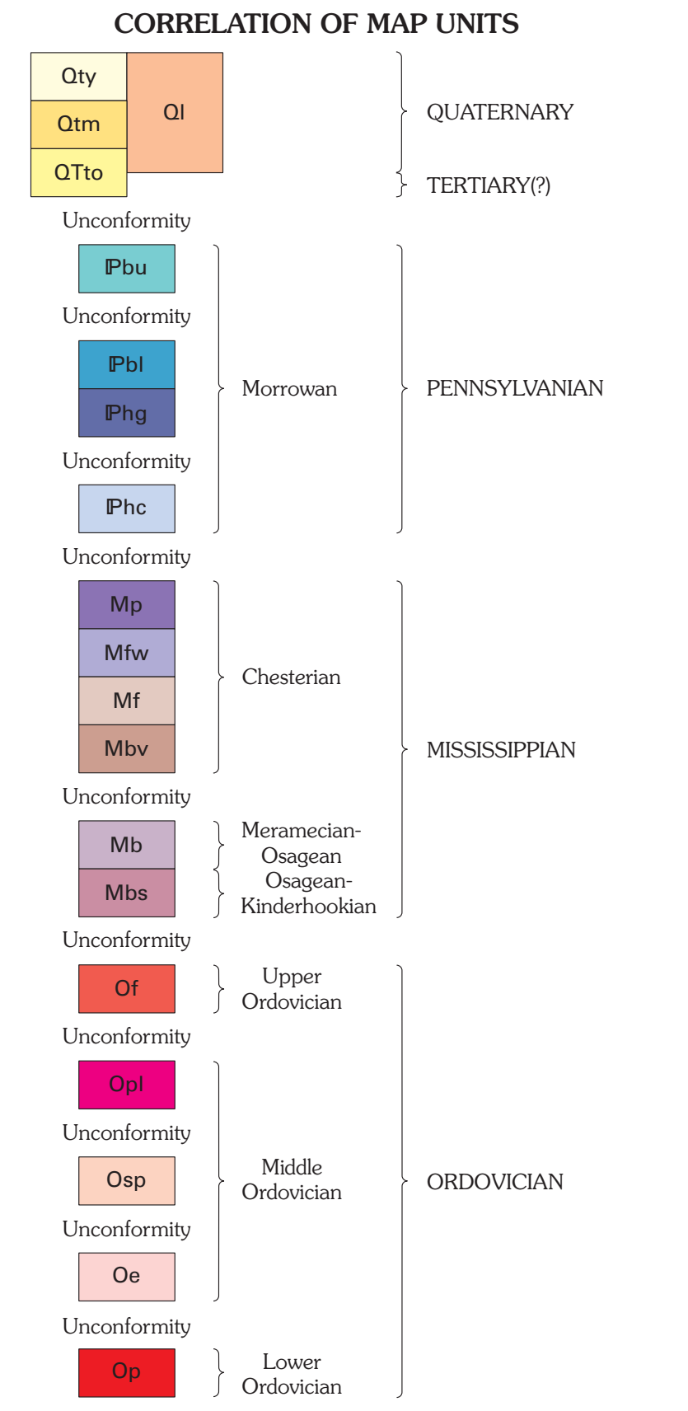
Geology mapped by M.R. Hudson intermittently from 1996 to 2003

Manuscript approved for publication August 6, 2004





CORRELATION OF MAP UNITS



INTRODUCTION

This map summarizes the geology of the Hasty 7.5-minute quadrangle (fig. 1) in the Ozark Plateaus region of northern Arkansas. Geologically, the area lies on the southern flank of the Ozark dome, an uplift that exposes oldest rocks at its center in Missouri. Physiographically, the Hasty quadrangle lies within the Springfield Plateau, a topographic surface generally held up by Mississippian cherty limestone (Purdue and Miser, 1916). The quadrangle also contains isolated mountains (for example, Sulphur Mountain) capped by Pennsylvanian rocks that are erosional outliers of the higher Boston Mountains plateau to the south. Segments of the Buffalo and Little Buffalo Rivers flow through the southeastern part of the map area; these have enhanced bedrock erosion. Exposed bedrock of this region comprises an approximately 1,600-ft-thick sequence of Ordovician, Mississippian, and Pennsylvanian carbonate and clastic sedimentary rocks (fig. 2) that have been mildly deformed by a series of faults and folds. The Hasty quadrangle includes part of Buffalo National River, a park encompassing the Buffalo River and adjacent land that is administered by the National Park Service.

The geology of the Hasty quadrangle was first mapped by Purdue and Miser (1916) at 1:125,000 scale. The current map confirms many features of this previous study but it also identifies new structures and uses a revised stratigraphy. A preliminary map of the northeastern part of the quadrangle was previously presented by Hudson (1998) at 1:24,000 scale.

Mapping for this study was conducted by field inspection of numerous sites and was compiled on a 1:24,000 scale-stable topographic base. Locations and elevations of contacts or other sites were determined with the aid of a global positioning satellite receiver and a hand-held barometric altimeter that was frequently recalibrated at points of known elevation. Orthophotos and a hill-shade relief image derived from a U.S. Geological Survey 10-m digital elevation model were used to help trace ledge-forming units between field traverses within the Upper Mississippian and Pennsylvanian part of the stratigraphic sequence. Strike and dip of beds were typically measured along stream drainages or at well-exposed ledges to avoid loose rock affected by slope creep. Beds dipping less than 2° are shown as horizontal. Structure contours constructed on the base of the Boone Formation were hand drawn based on elevations of control points on both lower and upper contacts of the Boone Formation as well as other limiting information on their maximum or minimum elevations.

DESCRIPTION OF MAP UNITS

Qty **Younger terrace and active-channel alluvial deposits (Quaternary)**—Unconsolidated sand and gravel of Buffalo River. Terrace deposits are principally composed of light-brown, fine sand; smooth upper surfaces are about 20 ft above base-flow level of river. Active-channel gravel deposits are composed of subangular to rounded Paleozoic rock clasts of mixed lithology along drainages, and they are interspersed with bedrock exposures (not mapped). As thick as 20 ft

Qtm **Medial terrace and alluvial deposits (Quaternary)**—Unconsolidated sand deposits adjacent to Buffalo River. Deposits are poorly exposed and are principally brown-weathered, fine sand as high as 40 ft above base-flow level of river. Includes deposits within abandoned channel of Buffalo River east of Lost Hill. Thickness uncertain but probably as much as 20 ft

QTto **Older terrace and alluvial deposits (Quaternary and Tertiary (?))**—Unconsolidated gravel and sand deposits adjacent to Buffalo River. Deposits are poorly exposed and are principally a lag of brown-weathered, subrounded to rounded Paleozoic rock clasts of mixed lithology in a sandy matrix 140–180 ft above base-flow level of river. Thickness uncertain but probably no more than 5 ft

Ql **Landslide (Quaternary)**—Large slide blocks of limestone, sandstone, and shale derived from the Pitkin Limestone (Mp) and the Wedington Sandstone Member (Mfw) and main body of the Fayetteville Shale (Mf); generally back tilted into hillside on north side of Sulphur Mountain. Blocks moved over middle and lower parts of the Fayetteville Shale

Bloyd Formation (Lower Pennsylvanian, Morrowan)—Interbedded sequence of sandstone, siltstone, shale, and thin limestone beds separated into lower and upper intervals. As much as 300 ft thick

Pbu **Upper part**—Prominent crossbedded sandstone that forms cliffs as tall as 60 ft capping Sulphur, Boat, and Pinnacle Mountains. Sandstone is white to light-brown, fine- to medium-grained quartz arenite and is commonly a composite of several 1- to 3-ft-thick tabular and trough crossbed sets. Sandstone has a sharp erosional base and contains concentrations of white quartz pebbles and, locally, casts and molds of wood fragments. Rocks of the upper Bloyd Formation were originally assigned to the Winslow Formation by Purdue and Miser (1916). Zachry (1977) concluded that the basal sandstone was a time-equivalent unit with the Woolsey Member of the Bloyd Formation farther west and designated it the "middle Bloyd sandstone." Maximum preserved thickness 160 ft

Pbl **Lower part**—Sequence of predominantly dark-gray to black shale and siltstone with thin beds of sandstone and limestone; forms moderate to steep slopes, but is poorly exposed. Fine-grained, planar-bedded, olive-brown sandstone beds, 5–10 ft thick, are locally exposed as ledges. Coarse bioclastic limestone is reddish gray and weathers dark brown but is poorly exposed and mostly observed as loose blocks in lower part of sequence. Thickness 90–120 ft

Hale Formation (Lower Pennsylvanian, Morrowan)—Interbedded sequence of sandstone, siltstone, shale, and thin limestone. Thickness 100–180 ft

Phg **Prairie Grove Member**—Brown to reddish-brown, fine- to medium-grained, thick-bedded, calcite-cemented sandstone. Locally contains quartz pebbles in its base. Beds are planar or crossbedded, and crossbeds may have bi-directional dips. Weathered sandstone forms rounded surfaces. Sandstone forms steep slopes but is commonly covered by slope debris from overlying units. Thickness 10–20 ft

Phc **Cane Hill Member**—Interbedded sequence of shale, siltstone, and sandstone. Upper part is poorly exposed and composed of dark-gray shale and thin-bedded siltstone that form gentle to moderately steep slopes. Lower part is a 10- to 20-ft-thick sandstone interval of reddish-brown, medium- to thick-bedded, very fine grained to medium-grained sandstone with trough crossbeds. Lower sandstone changes upward to olive-brown, very fine grained to fine-grained, thin-bedded sandstone with ripple cross-lamination or parallel lamination. Basal sandstone locally contains casts of wood fragments and conglomerate lenses with quartz pebbles and angular to subrounded clasts of shale, siltstone, and sandstone. Unit unconfomably overlies the Pitkin Limestone. Thickness varies from 80 ft to as much as 260 ft at Braden Mountain

Mp **Pitkin Limestone (Upper Mississippian, Chesterian)**—Generally medium- to dark-gray, fetid limestone. Limestone texture varies from micritic to coarse grained and is locally oolitic. Limestone beds may contain abundant crinoids, brachipods, corals, and bryzoan *Archimedes*. Basal contact with the Fayetteville Shale is conformable, although rarely exposed. The Pitkin generally forms a prominent ledge or cliff. Thickness 40–100 ft

Fayetteville Shale (Upper Mississippian, Chesterian)—Fine-grained sandstone and siltstone of the Wedington Sandstone Member that grades downward into main body of black, slope-forming shale. Thickness varies from 250 to 370 ft

Mfw **Wedington Sandstone Member**—Brown, well-indurated, calcite-cemented sandstone and siltstone. The Wedington caps a steep slope and is separated from the overlying Pitkin Limestone by thin black shale that commonly forms a bench. Sandstone is fine grained to very fine grained and is present in thick to thin planar beds with internal parallel laminations and locally developed low-angle crossbeds. Sandstone grades downward into siltstone beds that are ripple cross-laminated and bioturbated. The Wedington grades downward into main body. Thickness 25–33 ft

Mf **Main body**—Below the Wedington Sandstone Member, the middle part of the Fayetteville Shale is black shale that is rarely exposed; local topographic flats in this interval suggest the presence of more resistant rock, like a thin sandstone that is exposed about 100 ft below the Wedington Sandstone Member on east side of Pinnacle Mountain. The lower part of the Fayetteville crops out along stream gullies, where it consists of black fissile shale that may contain medium- to light-gray, fetid septarian concretions as large as 2 ft in diameter. The Fayetteville Shale is susceptible to landslides. Thickness varies from 230 to 350 ft

Mbv **Batesville Sandstone (Upper Mississippian, Chesterian)**—Fine-grained to very fine grained, light- to medium-brown, calcite-cemented sandstone with sparse interbedded limestone. Thin to medium beds are typically parallel laminated; low-angle crossbeds common in upper part of unit. Sandstone commonly contains burrows on bedding plane surfaces. Sandstone breaks into thin flat blocks. One or more discontinuous, 1- to 3-ft-thick, medium- to dark-gray, fetid, fossiliferous limestone beds are locally interbedded with sandstone; limestone beds are fossiliferous and contain crinoids and brachiopods. Both sandstone and limestone beds may contain 2- to 10-mm-diameter oxidized pyrite framboids that weather to reddish-brown spheres. The Batesville commonly forms a topographic ledge that forms small waterfalls along streams. Where stripped of the overlying Fayetteville Shale, the top of the Batesville is typically a topographic flat. Unit commonly hosts sinkholes formed by collapse into dissolution cavities in the underlying Boone Formation. Thickness 40–60 ft

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

Mb **Main body (Upper to Lower Mississippian, Meramecian to Osagean)**—Medium- to thick-bedded, chert-bearing bioclastic limestone. Limestone is light to medium gray on fresh surfaces and generally coarsely crystalline with interspersed crinoid ossicles. A 1- to 3-ft-thick bed of oolitic limestone is common in upper 10 ft of the Boone Formation. Dense, fine-grained beds of limestone are present in upper one-third of unit. Beds are typically parallel planar to wavy, but channel fills are locally present in lower part of unit. Chert content varies vertically and laterally within the Boone and is greatest in the southeastern part of map area. Chert forms lenticular to anastomosing lenses. Chert-rich horizons are generally poorly exposed but produce abundant float of white-weathered chert on hill slopes. Chert in uppermost part of unit contains prominent brachiopod molds. Thickness 310–375 ft

Mbs **St. Joe Limestone Member (Lower Mississippian, Osagean to Kinderhookian)**—Thin-bedded, coarse-crystalline bioclastic limestone with ubiquitous 3- to 6-mm-wide crinoid fragments. Limestone is commonly pink to red on fresh surfaces due to hematite in matrix, but its color and hematite concentrations vary with location. Thin beds are typically wavy in form. Chert nodules are uncommon but, where present, are tabular and reddish. Contact with the overlying main body of the Boone Formation is gradational. Middle to lower part of the St. Joe Limestone Member may contain shaly limestone interval that is best developed in eastern part of map area. Base of unit is a sequence of phosphate-pebble-bearing tan sandstone and overlying greenish-gray shale that is typically 0.5–3 ft thick but thickens to as much as 10 ft where it is exposed along the Davis Creek drainage in northwestern part of sec. 33, T. 17 N., R. 19 W. Thickness approximately 30–50 ft

Of **Fernvale Limestone (Upper Ordovician)**—Medium- to thick-bedded, coarse-crystalline bioclastic limestone. Limestone is light to medium gray on fresh surfaces and contains abundant 3- to 10-mm-wide cylindrical to barrel-shaped crinoid ossicles. Distribution is discontinuous and limited to three thin lenses less than 10 ft thick that are mapped where locally recognized in central and southwestern parts of map area beneath unconformity at base of the St. Joe Limestone Member of the Boone Formation (Mbs)

Opl **Plattin Limestone (Middle Ordovician)**—Thin- to medium-planar-bedded, fine-grained, dense limestone that typically breaks with conchoidal fracture. Limestone is medium gray on fresh surfaces but weathers to white to light-gray tabular blocks. Distribution is restricted to southeastern part of quadrangle where thickness reaches 10 ft

Osp **St. Peter Sandstone (Middle Ordovician)**—Fine-grained to very fine grained, tan sandstone and interbedded blue-green siltstone and shale. Sandstone is calcite-cemented quartz arenite with rounded grains; commonly strongly bioturbated. In central part of map area, unit consists mainly of interbedded blue-green shale, siltstone, and sandstone that are locally exposed along roadside. Thickness varies from 0 to 40 ft

Oe **Everton Formation (Middle Ordovician)**—Interbedded sandstone, dolostone, and limestone sequence. Sandstone is quartz arenite with well-sorted, well-rounded, and fine to medium quartz grains. Sandstone is present in medium to thick planar beds and is light tan to white and cemented by dolomite and (or) calcite. Poorly cemented sandstone breaks with sugary texture. Upper part of the Everton Formation contains 3- to 20-ft-thick, light- to dark-gray limestone and dolostone beds that are commonly interbedded with sandstone. Middle part is a sandstone interval, the Newton Sandstone Member of the Everton of McKnight (1935). Lower part contains 3- to 6-ft-thick limestone and dolostone beds interbedded with sandstone. Carbonate beds in both upper and lower parts of unit are typically finely crystalline and sparsely fossiliferous, and commonly display crinkly laminations. Exposed thickness along Little Buffalo River as much as 200 ft, but base not exposed

Op **Powell Dolomite (Lower Ordovician)**—Shown in cross sections only. Argillaceous brownish-gray dolostone. Regionally, thickness varies from 40 to 200 ft (McFarland, 1988)

Contact

88 60 **Normal fault**—Showing fault dip (arrow) and rake (diamond-headed arrow) where known. Bar and ball on downthrown side. Dashed where approximately located

Normal, right-lateral, strike-slip fault—Bar and ball on downthrown side. Dashed where approximately located. In cross section ***A–A'***, A, movement away from viewer; T, movement toward viewer

Strike-slip fault, right-lateral offset

Syncline

Monocline

900 **Line of equal elevation drawn on base of Boone Formation**—Contour interval 50 ft

⊕ **Horizontal bedding**

2 **Inclined bedding**—Showing strike and dip

Conodont sample locality

1240 ⊙ **Control point showing elevation (in feet) on lower or upper contact of Boone Formation**

STRATIGRAPHY

The study area preserves a 1,600-ft-thick record of early and late Paleozoic deposition on what is now the southern margin of the North American continent. Stages for Pennsylvanian and Mississippian units are from McFarland (1988).

The Middle Ordovician Everton Formation is a heterogeneous sandstone and carbonate unit that Suhm (1974) interpreted to have been deposited in barrier island and tidal flat depositional environments. The Everton Formation is discontinuously overlain by the Middle Ordovician St. Peter Sandstone and Plattin Limestone and the Upper Ordovician Fernvale Limestone. Identification of an inlier of St. Peter Sandstone within the central part of the quadrangle is based principally on the local roadside exposure of blue-green shale, which is interpreted to be equivalent to the shale-rich middle interval of the St. Peter Sandstone described farther to the east and south (McKnight, 1935; Glick and Frezon, 1953). Sparse conodonts retrieved from a site (lat 36°3.458' N., long 93°3.826' W.) in this blue-green shale indicate a Middle Ordovician Mohawkian age and have morphologies that are more like those of overlying formations than those in the Everton Formation, thus supporting a St. Peter identification (J.E. Repetski, written commun., 2003). Limestone from a site (lat 36°3.451' N., long 93°3.771' W.) about 40 ft lower in elevation than this shale horizon yielded conodonts that indicate a Middle Ordovician Whiterockian age and have conodont species that are typical of the Jasper Member (Suhm, 1974) of the upper Everton Formation (J.E. Repetski, written commun., 2003). A sample from the Plattin Limestone mapped in the southeastern corner of the quadrangle (lat 36°0.295' N., long 93°1.96' W.) yielded latest Whiterockian to late Mohawkian age range conodonts that are typical for the formation and that are consistent with a Middle Ordovician age (J.E. Repetski, written commun., 2003).

The Mississippian Boone Formation is the most widespread unit at the surface within the quadrangle. The phosphate-nodule-bearing sandstone at the base of the St. Joe Limestone Member is persistent throughout much of northern Arkansas (McKnight, 1935). This sandstone was probably deposited as a transgressive lag during sea-level rise in Late Devonian time (Horner and Craig, 1984). On the eastern side of the quadrangle, the lower part of the St. Joe Limestone Member directly above the basal sandstone is greenish-gray fossiliferous shale that yielded conodonts at a site (lat 36°4.057' N., long 93°0.767' W.) that indicate a late Kinderhookian age (J.E. Repetski, written commun., 2003). The contact of the main body of the Boone Formation with the St. Joe Limestone Member is gradational and is based on the change to thin bedding and the generally chert-free lithology of the St. Joe Limestone Member. Near the top of the formation an oolite interval as thick as 3 ft is common. Braden and Ausbrooks (2003) also recognized this facies in areas to the south and correlated this interval with the Short Creek Oolite Member of the Boone Formation, which is present in Missouri and Kansas (McKnight and Fischer, 1970).

The onset of Morrowan deposition reflects sea-level rise following a terminal Mississippian sea-level drop (Sutherland, 1988). The variable nature of the basal sandstone interval of the Cane Hill Member of the Hale Formation as well as its content of conglomerate and wood fragments suggests that this interval contains nonmarine valley-fill fluvial deposits. The study area lies at the northeastern margin of the distribution of thick Prairie Grove Member of the Hale Formation (Sutherland, 1988). The Prairie Grove Member in the study area is represented by indistinct planar-bedded or crossbedded, calcite-cemented sandstone, 10–20 ft thick, which forms a rounded ledge above the Cane Hill Member and below the capping cliff-former of the middle sandstone of the Bloyd Formation. Pennsylvanian sandstone and shale of the upper part of the Bloyd Formation were originally called Winslow Formation by Purdue and Miser (1916), with the basal Greenland Sandstone Member of the Atoka Formation (Henbest, 1953) representing the prominent cliff-forming crossbedded sandstone. Zachry (1977), however, concluded that the cliff-forming sandstone was a time-equivalent unit with the Woolsey Member of the Bloyd Formation farther west and designated it with the informal term "middle Bloyd sandstone."

Unconsolidated sediments are preserved as terrace deposits adjacent to the Buffalo and Little Buffalo Rivers at several elevations. The relative age of the deposits can be determined from their height above the river, but there are no constraints on their absolute age. The youngest deposits are almost certainly Quaternary in age, but the oldest deposits, which are 140–180 ft above the river, could potentially be as old as Tertiary (>1.8 Ma).

STRUCTURAL GEOLOGY

Rocks within the map area were mildly deformed by a system of faults and folds. Structure contours on the base of the Boone Formation illustrate the location of structures and their vertical offset. The structure contours conform to elevations at 263 control points located at both lower and upper contacts of the Boone Formation, as well as other information limiting maximum or minimum elevations. A 390-ft thickness for the Boone Formation (including the St. Joe Limestone Member) was used to project the elevation of the basal contact from points on the upper contact, based on the average of five traverses across stratigraphic sections near the Buffalo River (Hudson, 1998) whose thicknesses range from 380 to 405 ft. The vertical offset of structures can be estimated from the elevation difference of formation contacts across the structures, but lateral offset is difficult to measure due to the lack of appropriate markers. Kinematic data indicating fault slip directions are sparse within the quadrangle, but elsewhere in the Buffalo River region (Hudson, 2001) kinematic data indicate that east- to east-southeast-striking faults typically have normal slip whereas northeast-striking faults have oblique slip, with both right-lateral and normal components of offset.

The dominant structural feature of the Hasty quadrangle is a graben system that extends from east to west across the center of the quadrangle. Purdue and Miser (1916) mapped the eastern and western parts of this system as separate grabens. This study illustrates that the northern bounding fault is continuous across the area, with a curvilinear map trace. McKnight (1935) called the eastern extension of this northern fault the St. Joe fault and that name is adopted here. The southern boundary of the graben system within the quadrangle is formed by two normal faults that partly overlap in sec. 7, T. 16 N., R. 19 W. Where observed, the main planes of faults forming the graben system dip steeply (72°–83°); where slip striations have been preserved on these faults or nearby smaller faults, they mostly have high rake angles that indicate a predominant normal sense of slip (fig. 3*A*). Strata within the graben system reach their maximum depth beneath and just west of Braden Mountain, and they rise to shallower levels both to the east where the southern boundary faults overlap and to the west where the graben merges with the northeast-striking Carlton fault zone on the adjacent Jasper quadrangle (Hudson and others, 2001). The western part of the graben system was called the Braden Mountain graben by Hudson (1998). The 260-ft thickness of the Cane Hill Member of the Hale Formation preserved within the graben at Braden Mountain is much thicker than its 80–140 ft thickness preserved elsewhere in the quadrangle, suggesting that the graben was active as a growth structure during Early Pennsylvanian deposition of the Cane Hill Member.

The northeast-striking Stringtown Hollow fault and Upper Flatrock Creek fault have throws that are down to the northwest and southeast, respectively, but it is likely that these faults have components of right-lateral strike slip movement in addition to vertical movement. The down-to-the-northwest sense of throw on the Stringtown Hollow fault where it crosses the Buffalo River is the opposite of its sense on the Jasper quadrangle to the southwest (Hudson and others, 2001), but it is common for fault zones with dominant strike-slip displacement to change sense of throw along their length (Sylvester, 1988). The main fault plane for the Stringtown Hollow fault was not directly observed within the quadrangle, but small left-lateral faults with northwest strike that were observed at one location within the fault zone (lat 36°3.23' N., long 93°6.92' W.) are interpreted to be antithetic shears to the main, right-lateral fault zone. The Upper Flatrock Creek fault has consistent down-to-the-southeast throw as great as 100 ft. It is at least 5 mi long and it continues to the northeast off the edge of the quadrangle. The southwest extension of the Upper Flatrock Creek fault is uncertain past sec. 35, T. 17 N., R. 20 W. Where the Upper Flatrock Creek fault crosses Davis Creek, a syncline is developed within Batesville Sandstone on the downthrown, southeastern side of the fault.

The structure contours also illustrate the effects of several broad domes and monoclinal folds, across which the Boone Formation varies as much as 200 ft in elevation. The Yardelle monocline on the eastern edge of the quadrangle has the greatest relief and is expressed by consistent north to north-northeast dips of as great as 27°. Just to the north, a northeast-trending monocline exposes Everton Formation on its upthrown, northwestern side along Davis Creek. The East Fork monocline continues northward at least 2 mi beyond the north edge of the quadrangle (Hudson, 1998).

Away from monocline limbs, dips of bedding measured throughout the quadrangle 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 rock units.

Joints measured within the map area (405 total) are near vertical and distributed in several sets (fig. 3*B*). The dominant sets strike north and northeast. Less prominent joint sets strike west-northwest and northwest. Joint planes within limestone and dolostone formations, such as the Boone Formation, are commonly enlarged due to dissolution.

ACKNOWLEDGMENTS

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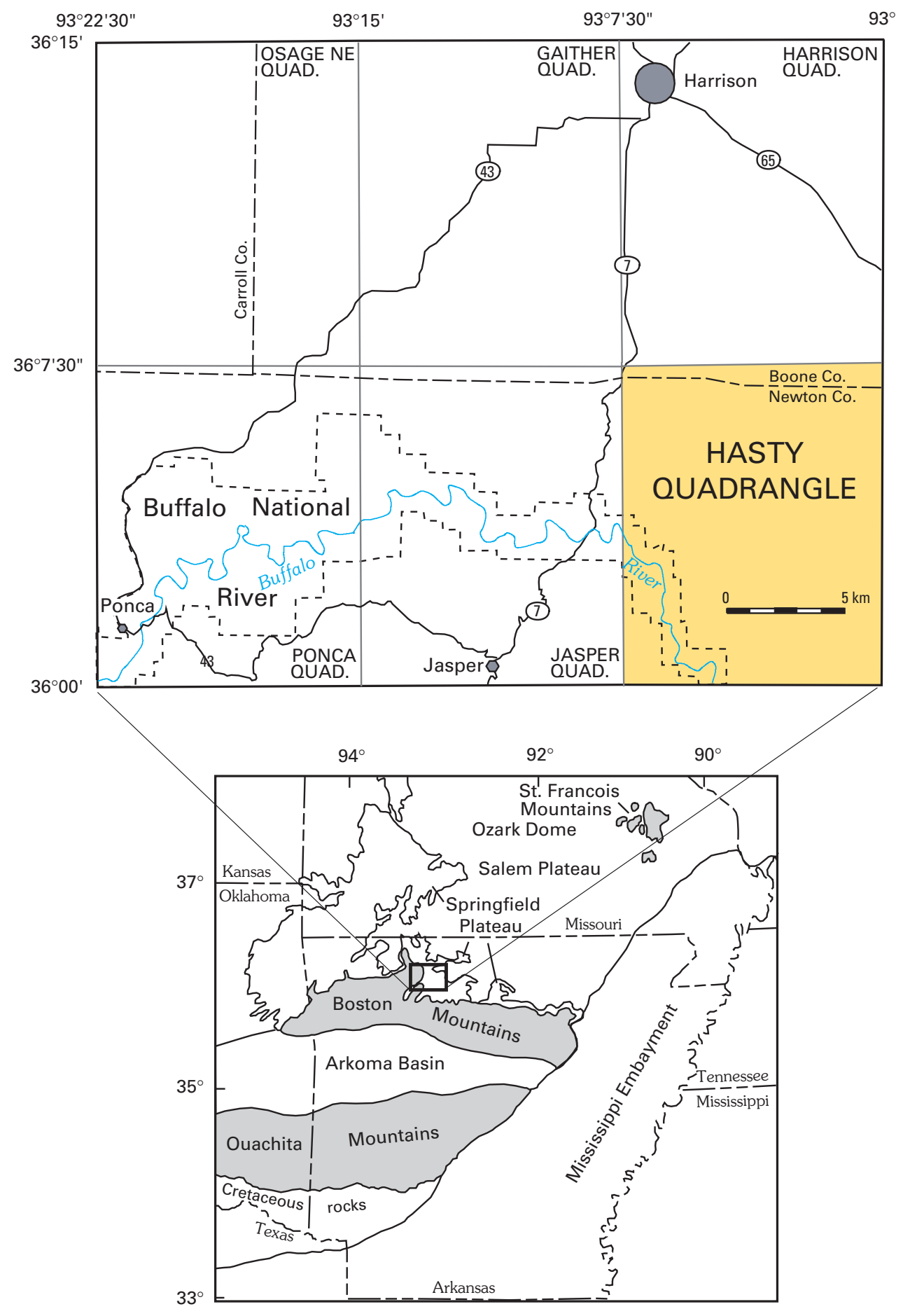

Figure 1. Location of study area within northern Arkansas, adjacent to the western part of Buffalo National River. Lower regional map illustrates geological and selected physiographic provinces of Arkansas and adjacent areas.

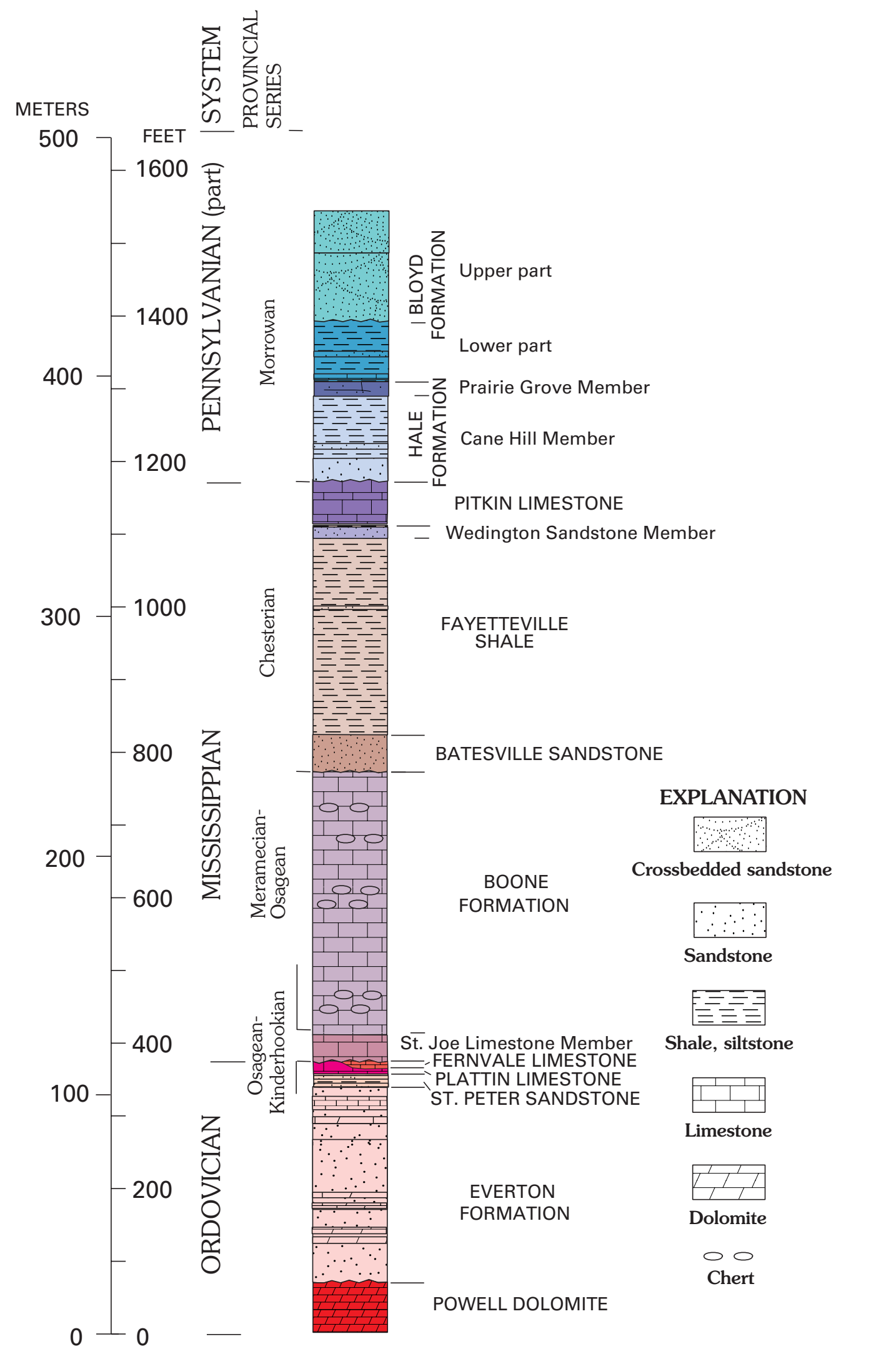

Figure 2. Stratigraphic column for Paleozoic rocks of the map area. Provincial series are from Purdue and Miser (1916) and McFarland (1988).

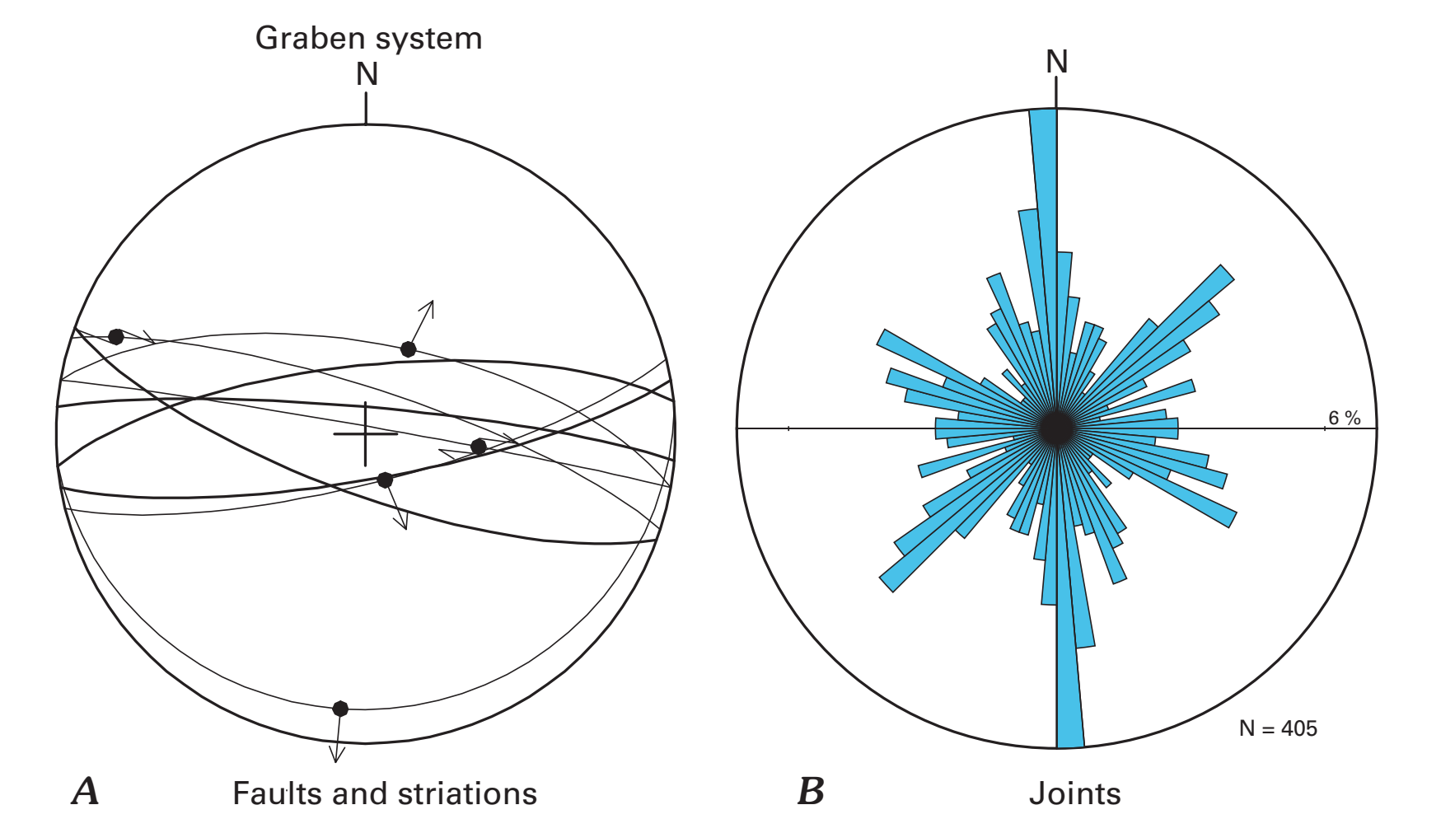

Figure 3. Structural data for the Hasty quadrangle. *A,* Faults associated with the east-west-trending graben system. Great circles and dots are lower hemisphere projections of fault planes and their slip lines, respectively. Arrows show movement sense of hanging wall. Thick lines designate main fault planes of graben system and thin lines designate associated minor fault planes. *B,* Rose diagram of strike frequency of joints recorded within the map area.

CONVERSION FACTORS

Multiply	By	To obtain
inches (in.)	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

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