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

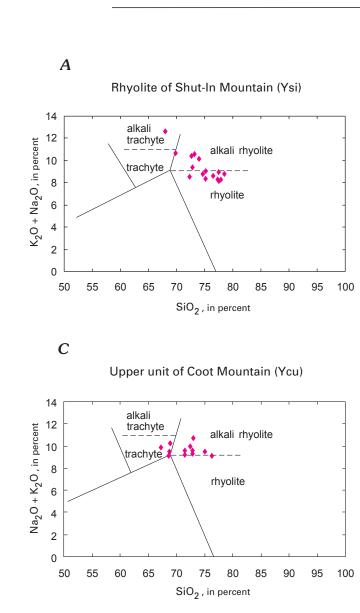
Table 1.—Major-oxide analyses of Middle Proterozoic volcanic rocks in the Powder Mill Ferry quadrangle, Missouri.

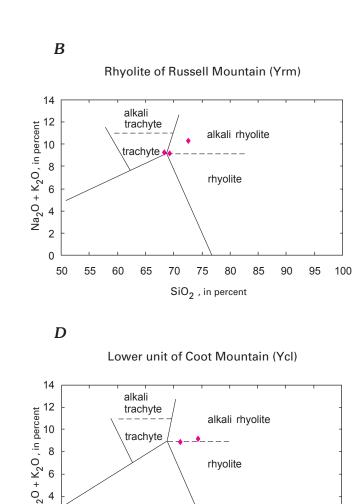
Sample no.	Unit	Location	SiO <sub>2</sub>	AI <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	MgO	MnO	CaO	TiO <sub>2</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	LOI	Total
P1	Ysi	NW1/4,NE1/4 sec. 2, T. 28 N., R. 3 W.	72.66	11.99	3.18	<0.01	0.02	0.36	0.19	0.2	10.2	0.01	0.55	99.36
P2	Ysi	SW1/4,NW1/4 sec. 1, T. 28 N., R. 3 W.	78.44	10.14	2.88	<.01	.03	.02	.18	.18	8.64	<.01	.13	100.64
P3	Ysi	SW1/4,SW1/4 sec. 25, T. 29 N., R. 3 W.	77.37	10.64	2.97	.06	.02	.06	.23	1.37	6.87	<.01	.46	100.05
P4	Ysi	SW1/4,NW1/4 sec. 19, T. 29 N., R. 2 W.	77.75	9.64	2.09	.02	.01	.04	.16	.3	7.99	.02	.36	98.38
P5	Ysi	SE1/4,NE1/4 sec. 24, T. 29 N., R. 3 W.	69.83	11.89	3.79	.01	.01	.38	.19	.2	10.46	.07	.46	97.29
P6	Ysi	NW1/4,NW1/4 sec. 5, T. 28 N., R. 2 W.	72.33	11.55	2.66	.16	.03	.22	.19	2.49	6.07	.02	1.13	96.85
P7	Ysi	SW1/4,SE1/4 sec. 30, T. 29 N., R. 2 W.	74.01	11.73	1.99	.03	.01	.01	.19	.3	9.82	.02	1.19	99.3
P8	Ysi	SE1/4,SE1/4 sec. 30, T. 29 N., R. 2 W.	74.65	11.67	2.38	.04	.03	.04	.19	2.43	6.4	.02	.84	98.69
P9	Ysi	NW1/4,NE1/4 sec. 31, T. 29 N., R. 2 W.	75.18	11.13	2.5	.02	.02	<.01	.18	.94	8.12	1.27	.71	100.07
P10	Ysi	NW1/4,SW1/4 sec. 36, T. 29 N., R. 3 W.	67.99	15.03	3.02	.07	.03	.01	.22	.21	12.4	.02	1.17	100.17
P11	Ysi	SE1/4,SE1/4 sec. 36, T. 29 N., R. 3 W.	72.81	12.31	2.77	.1	.02	.01	.2	.86	8.55	.02	1.15	98.8
P12	Ysi	SE1/4,SE1/4 sec. 36, T. 29 N., R. 3 W.	75.17	11.08	2.43	.08	.01	<.01	.17	.28	8.1	.09	1.17	98.58
P13	Ysi	SW1/4,NW1/4 sec. 33, T. 29 N., R. 2 W.	77.56	11.22	2.05	.04	<.01	.02	.13	.16	8.81	.02	.74	100.75
P14	Ysi	SW1/4,SE1/4 sec. 29, T. 29 N., R. 2 W.	77.42	9.46	2.39	.02	<.01	.02	.15	.23	7.95	.01	1.41	99.06
P15	Ysi	SE1/4,SE1/4 sec. 36, T. 29 N., R. 3 W.	76.56	11.22	2.44	.1	.01	.01	.18	.5	8.08	<.01	1.3	100.4
P16	Ysi	NW1/4,NE1/4 sec. 32, T. 29 N., R. 2 W.	75.12	12.33	2.54	.09	.01	.03	.2	1.73	7.31	.07	1.27	100.7
P17	Ycu	SW1/4,SE1/4 sec. 14, T. 29 N., R. 3 W.	72.92	11.64	4.5	.07	.01	.21	.3	1.74	7.52	.04	.44	99.39
P18	Ycu	SE1/4,SW1/4 sec. 14, T. 29 N., R. 3 W.	68.58	13.03	5.75	.48	.07	1.09	.62	3.12	5.98	.15	1.49	100.36
P19	Ycu	SE1/4,SW1/4 sec. 14, T. 29 N., R. 3 W.	72.96	12.45	3.3	.02	.02	.15	.21	.2	10.5	.01	.54	100.36
P20	Ycu	SE1/4,SE1/4 sec. 1, T. 29 N., R. 3 W.	75.1	11.95	3.4	.07	.02	.07	.28	1.53	7.99	.06	.45	100.92
P21	Ycu	SW1/4,SE1/4 sec. 11, T. 29 N., R. 3 W.	72.86	11.47	3.47	.04	.02	.11	.34	1.03	8.6	.07	.35	98.36
P22	Ycu	NE1/4,NE1/4 sec. 14, T. 29 N., R. 3 W.	76.31	10.3	2.06	<.01	.01	.03	.14	.68	8.47	.02	.27	98.29
P23	Ycu	SW1/4,NW1/4 sec. 12, T. 29 N., R. 3 W.	71.44	12.15	5.86	.18	.03	.11	.59	.54	8.69	.08	.92	100.59
P24	Ycu	SW1/4,NW1/4 sec. 12, T. 29 N., R. 3 W.	72.4	12.47	4.29	.06	.02	.13	.36	2.07	7.89	.04	.46	100.19
P25	Ycu	NE1/4,NE1/4 sec. 12, T. 29 N., R. 3 W.	68.84	12.87	4.22	.09	.05	1.21	.42	1.37	8.87	.1	1.59	99.63
P26	Ycu	NW1/4,SE1/4 sec. 12, T. 29 N., R. 3 W.	67.28	13.46	5.99	.19	.04	.25	.6	1.75	8.1	.16	1.43	99.25
P27	Ycu	SW1/4,NE1/4 sec. 12, T. 29 N., R. 3 W.	68.78	12.46	5.66	.13	.02	.23	.41	1.29	8.22	.09	2.13	99.42
P28	Ycu	SE1/4,SE1/4 sec. 2, T. 29 N., R. 3 W.	71.46	12.4	3.87	.13	<.01	.03	.27	.24	9.36	.05	1.18	98.99
P29	Ycl	NE1/4,NW1/4 sec. 23, T. 29 N., R. 3 W.	74.33	11.18	5.67	.06	.01	.1	.41	.53	8.63	.05	.46	101.43
P30	Ycl	NE1/4,NW1/4 sec. 23, T. 29 N., R. 3 W.	71.21	12.47	6.34	.23	.02	.16	.6	2.05	6.8	.12	1.01	101.01
P31	Yrm	NW1/4,SE1/4 sec. 34, T. 29 N., R. 2 W.	72.56	12.06	3.67	.04	.03	.06	.27	.55	9.74	.06	.87	99.91
P32	Yrm	SE1/4,SW1/4 sec. 35, T. 29 N., R. 2 W.	69.29	12.63	4.89	.41	.04	.18	.39	1.23	7.94	.09	1.75	98.84
P33	Yrm	NE1/4,NW1/4 sec. 2, T. 28 N., R. 2 W.	68.3	13.22	6.61	.33	.04	.27	.59	3.05	6.22	.16	1.35	100.14
P34	Yrm	SE1/4,SW1/4 sec. 20, T. 29 N., R. 2 W.	73.1	12.27	3.5	.02	.02	.01	.29	.16	10.46	.05	.83	100.71

### Table 2.—Summary of drillhole data on Federal land in the Powder Mill Ferry quadrangle, Missouri. [All drillhole numbers are from Missouri Division of Geology and Land Survey file numbers. Og, Gasconade Dolomite; OCe, Eminence Dolomite; £p, Potosi Dolomite; £dd, Derby-Doerun Dolomite (usage of Anderson, 1979); £d, Davis Formation; £b, Bonneterre

Formation; €I, Lamotte Sandstone; Y, Middle Proterozoic rocks. Datum is mean sea level]

Drillhole no.	Location	Collar elevation, in feet	Contact elevation, in feet	Bottom elevation, in feet
4185	SE1/4,SE1/4 sec. 14, T. 29 N., R. 3 W.	665	None (O€e)	505
4195	NE1/4,SW1/4 sec. 14, T. 29 N., R. 3 W.	650	None (O€e)	550
7099	SE1/4,SW1/4 sec. 13, T. 29 N., R. 3 W.	725	No data	
14151	SW1/4,SW1/4 sec. 8, T. 29 N., R. 2 W.	590	385 O€e–€p	120
14168	SE1/4,SE1/4 sec. 4, T. 29 N., R. 2 W.	650	550 O€e–€p	190
17514	NW1/4,SW1/4 sec. 2, T. 29 N., R. 2 W.	890	525 Og–O€e	205
17515	SE1/4,SE1/4 sec. 35, T. 30 N., R. 2 W.	916	691 Og–O€e	106
21516	SE1/4,SE1/4 sec. 11, T. 29 N., R. 2 W.	1000	815 Og–O€e 490 O€e–€p 62 €p–€dd -77 €dd–€d -265 €d–€b -616 €b–Y	-675
21591	NE1/4,SW1/4 sec. 23, T. 29 N., R. 2 W.	957	432 O€e–€p 37 €p–€dd -125 €dd–€d -276 €d–€b -658 €b–€l -720 €I–Y	-743
25627	SE1/4,SW1/4 sec. 9, T. 29 N., R. 2 W.	644	499 O€e–€p	349
28079	NE1/4,NE1/4 sec. 21, T. 29 N., R. 2 W.	600	425 O€e–€p	300





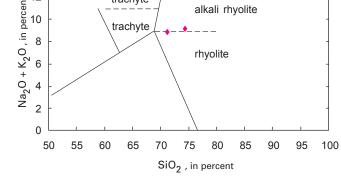
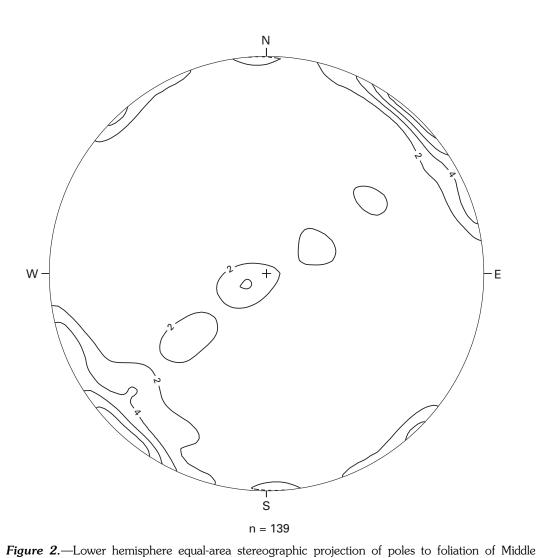
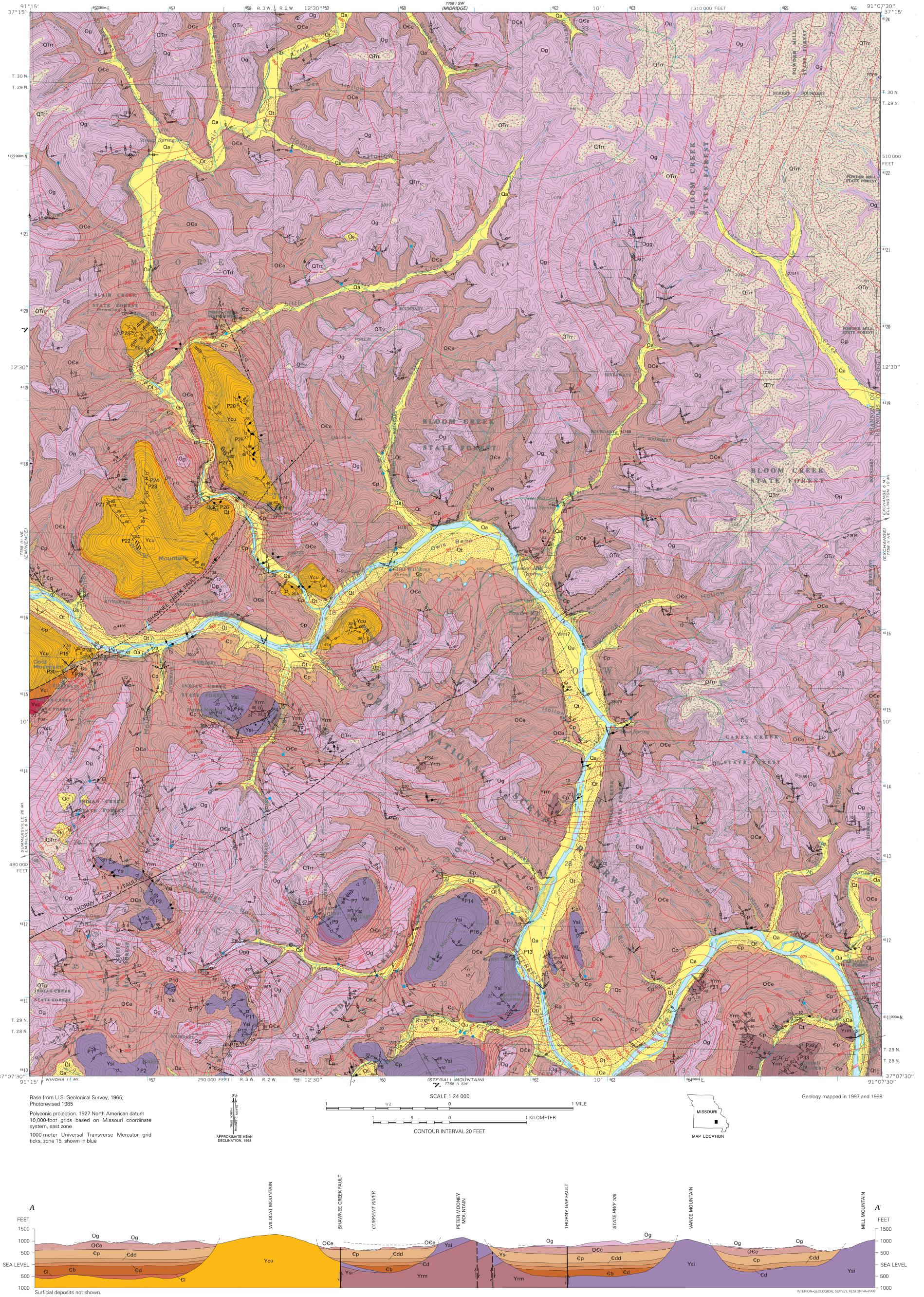
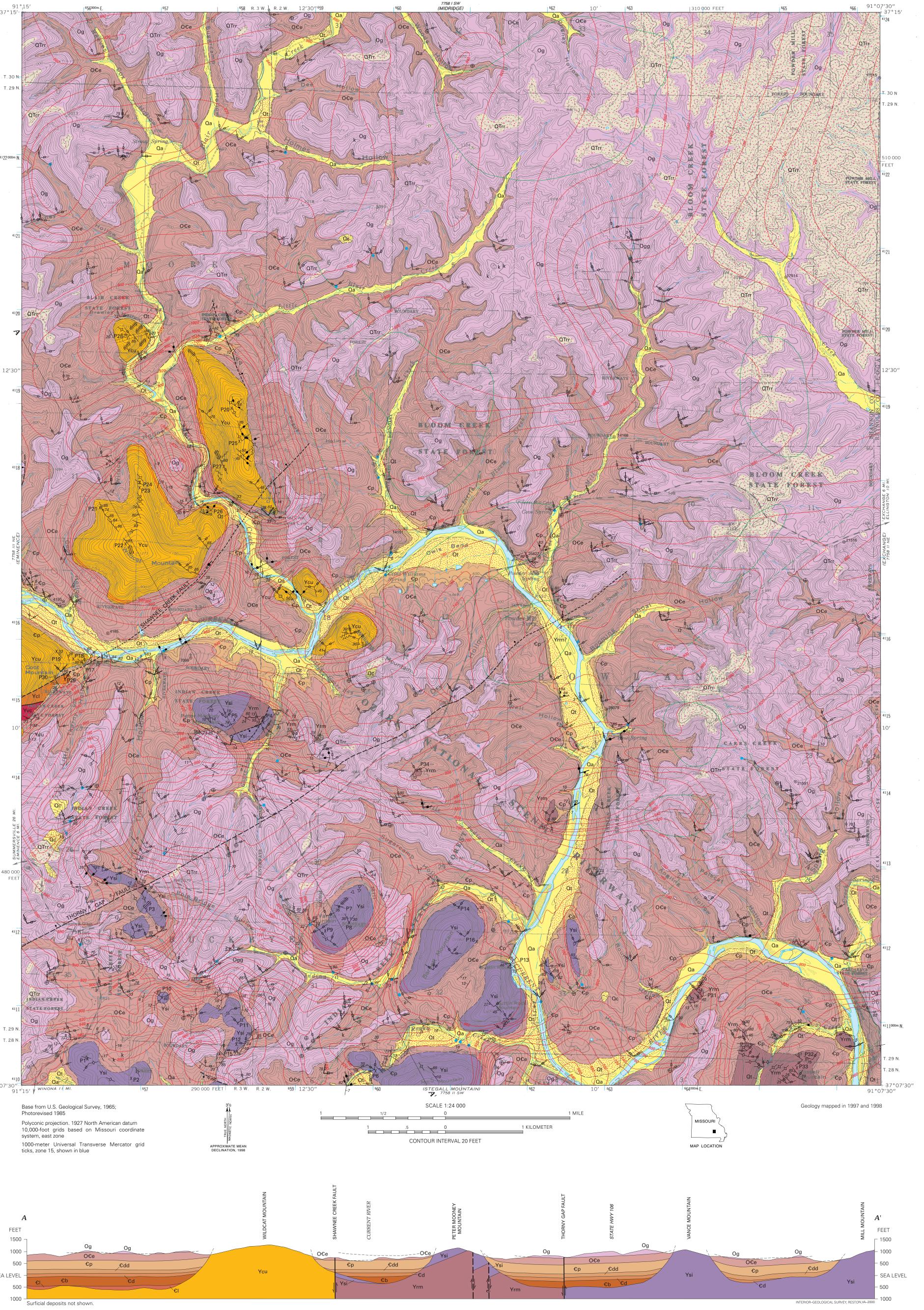


Figure 1.—Total alkali versus silica diagrams for Middle Proterozoic volcanic rocks of the Powder Mill Ferry quadrangle. A, Rhyolite of Shut-In Mountain (Ysi); B, Rhyolite of Russell Mountain (Yrm); C, Upper unit of Coot Mountain (Ycu); D, Lower unit of Coot Mountain (Ycl).



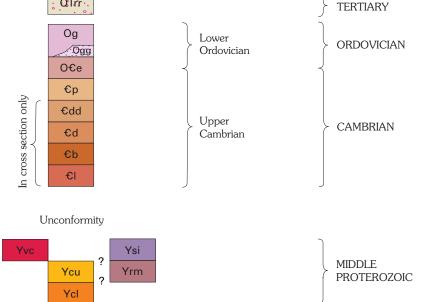
Proterozoic volcanic rocks in the Powder Mill Ferry quadrangle. Contour intervals at 2, 4, 6, 8, and 10 percent of 1 percent area. n, number of measurements.





GEOLOGIC MAP OF THE POWDER MILL FERRY QUADRANGLE, SHANNON AND REYNOLDS COUNTIES, MISSOURI

Robert C. McDowell and Richard W. Harrison



CORRELATION OF MAP UNITS

Holocene and

Pleistocene

QUATERNAR

DESCRIPTION OF MAP UNITS

Alluvium (Holocene)-Silt, clay, sand, and gravel that form unconsolidated flood plain and streambed deposits; occurs along most streams; shown where thickest and most extensive. As much as 30 ft thick along the Current River, thinner along tributaries. Gravel composed of rounded to subangular pebbles and cobbles of chert, sandstone, and quartzite as much as 8 in. in longest dimension Colluvium (Holocene and Pleistocene)-Boulders, cobbles, and pebbles of sandstone derived from weathering of the Roubidoux Formation, forms gravity-creep deposits a few feet thick on steep slopes in the upper part of the Gasconade Dolomite below Roubidoux residuum. Widely distributed, common on steep slopes; shown on map only where thickest and most extensive

Terrace deposits (Holocene and Pleistocene)—Silt, sand, and gravel along the sides of stream valleys; consist of older, dissected alluvium and locally younger deposits of intermittent major floods; deposit in southwestern corner of map includes loess. Probably as much as 40 ft thick

Residuum derived from Roubidoux Formation (Quaternary and **Tertiary**)—Sand, clay, sandstone, and chert that form unconsolidated deposits on the crests of hills and ridges; formed by removal of dolomite beds by weathering processes. Contains angular to subangular boulders and cobbles of sandstone and chert as much as 10 ft in longest dimension. Sandstone commonly crossbedded, ripple-marked; locally preserved in irregular, near-coherent layers. Chert includes oolitic, banded, and porcelaneous varieties. Unit ranges in thickness from a few feet on isolated hilltops to as much as 160 ft in northeastern part of quadrangle

Gasconade Dolomite (Lower Ordovician)—Dolomite, chert, and sandstone. Dolomite, light- to medium-gray, locally pinkish-gray, fine- to coarse-grained, thin- to thick-bedded; contains nodules, beds, and stringers of chert, generally white to light gray, mostly porcelaneous, locally oolitic; most abundant in lower part of unit, the Van Buren Formation of Bridge (1930); nodules as much as 3 in thick, beds 1 ft thick. Stromatolitic chert bed 2 to 3 ft thick about 125 to 130 ft above base of formation. Gunter Sandstone Member (Ogg), locally mapped separately where it forms valley floor, at base of formation; composed of interbedded sandstone, orthoquartzite, sandy dolomite, dolomite, and minor amounts of chert. Sandstone, light-yellowish-gray to medium-gray, medium- to coarse-grained, weathers brownish to reddish gray or light gray; ripple marks, crossbeds, and mud cracks common. Orthoquartzite, very light gray, medium- to coarse-grained. Dolomite, light- to medium-gray, medium- to coarse-grained, sandy in part, in bedding sets as much as 5 ft thick. Chert, light gray, in nodules or thin beds in dolomite. Gunter best exposed on Cardareva Bluff in southeastern corner of guadrangle. Member 10 to 50 ft thick, thickest in southeastern part of map area; formation 200 to 280 ft thick. Basal contact placed at

Eminence Dolomite (Lower Ordovician and Upper Cambrian)— Dolomite, chert, and sandstone. Dolomite, light-gray to light yellowish-gray, medium-gray, tan, or pink, fine- to coarse-grained, thin- to medium-bedded; commonly mottled with rust-colored spots; some beds slightly calcareous; generally weathers to a pitted surface; upper beds locally form pinnacles. Chert, light-gray, in part oolitic, in sparse stringers and nodules. Sandstone, light-gray to tan, medium-grained, in bed 2 to 5 ft thick, in lower part of formation in south-central and southeastern part of quadrangle. Thickness ranges from 125 to 325 ft; thinnest near knobs underlain by Middle Proterozoic rocks; may also be thinned locally by erosion before deposition of the Gasconade. Unit well exposed in bluffs along the Current River. Base characterized by interbedding of light-gray dolomite with brownish-gray, fetid dolomite with drusy chert typical of underlying Potosi Dolomite; contact placed at top of highest brownish-gray, fetid, vuggy dolomite bed; locally marked by a 3- to 6ft-thick chert bed

base of lowest sandstone or orthoquartzite bed

Potosi Dolomite (Upper Cambrian)—Dolomite and chert. Dolomite, pale-yellowish-gray, grayish-orange, or brownish-gray, very fine to coarse-grained, thick-bedded, vuggy; darker beds commonly fetid when broken. Some beds pelletal. Contains angular granules to cobbles of rhyolite in lower few feet of unit where in contact with underlying Middle Proterozoic rocks. Chert, light-gray, in nodules, stringers, and large botryoidal masses; cavities in chert drusy. Unit well exposed at base of bluffs along Current River. Base of unit not exposed; as much as 125 ft thick in outcrops along Little Blair Creek; 428 ft reported in drill hole 21516 (table 2) Derby-Doerun Dolomite (usage of Anderson, 1979) (Upper

Cambrian) (shown in cross section only)—Dolomite, interbedded with siltstone and shale. Dolomite, buff or brown to light-gray, fineto medium-grained, thin- to medium-bedded, argillaceous, silty, with minor amounts of chert and sparse sulfide minerals. Siltstone and shale, thin-bedded. Glauconite is present in lower 40 to 50 ft of formation. Thickness about 140 to 160 ft Davis Formation (Upper Cambrian) (shown in cross section

only)— Interbedded shale and limestone with minor amounts of dolomite. Shale, dark-green, fissile, thin- to thick-bedded; as much as 50 percent of formation. Limestone, light-gray, fine-grained to cryptograined, dense; locally glauconitic. Thickness about 150 to

Bonneterre Formation (Upper Cambrian) (shown in cross section only)—Dolomite and minor amounts of interbedded limestone, siltstone, and shale. Dolomite, light-gray, fine- to medium-grained, medium-bedded; commonly contains algal structures; locally glauconitic and shaly; sparse sulfide minerals. Limestone, brownishgray to pink, fine-grained, thin-bedded, fossiliferous, locally oolitic; more common in lower part of formation. Siltstone, quartzose, lightto dark-gray, laminated. Shale, dark-green, thin-bedded; occurs as sparse thin interbeds and partings. Thickness about 350 to 380 ft Lamotte Sandstone (Upper Cambrian) (shown in cross section only)—Sandstone, quartzose, light-gray, yellow, brown, or red, medium-grained, moderately to well-sorted, well indurated; locally contains interbeds of red to purple silty shale and, in upper part, scattered lenses of arenaceous dolomite. Felsite pebble or boulder conglomerate is present locally at base. Overlies Middle Proterozoic rocks. Regional thickness ranges from a few feet to 500 ft; absent in drillhole 21516 (table 2)

Volcaniclastic conglomerate and breccia (Middle Proterozoic)—Interbedded volcaniclastic conglomerate and breccia. Conglomerate consists of subrounded cobbles 3 to 5 in. in diameter and large pebbles of rhyolite of the upper unit of Coot Mountain (Ycu) and unidentified volcanic rocks. Matrix strongly altered, greenish, fine-grained volcaniclastic material. Conglomerate is overlain by strongly silicified volcanic breccia, possibly an autobrecciated flow, that consists of aphanitic pink rhyolite and quartz clasts in a quartz matrix. Mapped only from float on the southeastern side of Coot Mountain

Rhyolite of Shut-In Mountain (Middle Proterozoic)-Named for xposures on and around Shut-In Mountain (secs. 2 and 11, T. 28 N., R. 3 W.) in the Stegall Mountain quadrangle to the south. Massive rhyolite to alkali trachyte lava (Orndorff and others, 1999); moderately crystal-rich, containing 15 to 20 percent phenocrysts of pink feldspar (10 to 20 percent) and quartz (5 to 10 percent) in a dark maroon matrix. When present, flow layering is poorly developed and typically contorted. Magnetite content is from 1 to 3 percent, relatively low compared to other volcanic units; pods and disseminations of fluorite are sporadic but common. Unit locally autobrecciated; in places intruded by small breccia dikes a few fractions of an inch to a few inches wide; locally contains xenoliths of aphanitic rock. This unit is interpreted as representing a coalesced rhyolite dome field. Probably, in part, the same as the Stegall Rhyolite of Tolman and Robertson (1969, p. 14–15)

Rhyolite of Russell Mountain (Middle Proterozoic)-Ash-flow tuff, moderately crystal-rich with 10 to 20 percent phenocrysts of pink feldspar, locally altered to a pale-green color, and sparse to no quartz; typically densely welded and displays well-developed flow layering, although locally massive with poorly developed or no layering; contains 5 to 10 percent magnetite. Interpreted as consisting of multiple flows of both simple and compound cooling units. Unit may be correlative with upper unit of Coot Mountain (Ycu)

Upper unit of Coot Mountain (Middle Proterozoic)—Ash-flow tuffs and minor lavas, dominantly alkali rhyolite; generally less than 10 percent phenocrysts of pink feldspar, locally altered to a pale-green color, and sparse or no quartz; contains 4 to 10 percent disseminated magnetite grains; dominantly densely welded with well-developed flow layering, although locally massive with poorly developed or no flow layering; massive intervals commonly contain aggregates and large (as much as 0.4 in across) phenocrysts of feldspar; contains sporadic but common disseminations and pods of fluorite. Interpreted as consisting of multiple flows of both simple and compound cooling units. Approximately the same as upper unit of Coot Mountain of Fisher Lower unit of Coot Mountain (Middle Proterozoic)-Interbedded ash-

rhyolite to rhyolite to trachyte (Orndorff and others, 1999); mostly massive and dense with poorly developed to no flow layering; locally flow layering is moderately well developed; 5 to 25 percent phenocrysts of pink feldspar and sparse to no quartz in a dark maroon matrix; contains 4 to 10 percent disseminated magnetite grains. Quartz veinlets and areas of silicification are common. Interpreted as consisting of multiple flows of both simple and compound cooling units. Ash-fall tuffs approximately the same as middle unit of Coot Mountain of Fisher (1969). Air-fall tuffs, rhyolite; aphanitic; massive to thinbedded; typically silicified; contains disseminated pyrite grains. Petrographically consists of feldspar microlites and devitrified glass. Air-fall tuffs approximately same as lower unit of Coot Mountain of Fisher (1969)

### EXPLANATION OF MAP SYMBOLS

— Contact—Dashed where approximately located; dotted where concealed Gasconade Dolomite; projected where above land surface. Generally not shown above or adjacent to Middle Proterozoic volcanic rocks. Contour interval 20 ft **Fault**—Long-dashed where approximately located; short-dashed where inferred; dotted where concealed. Bar and ball on downthrown side; arrows show relative direction of movement Strike and dip of beds-Symbols in Qa represent small bedrock outcrops in streambed Inclined Horizontal Strike and dip of flow layering in Middle Proterozoic rocks Inclined Vertical Strike and dip of joints—Point of observation at intersection of multiple symbols. Apertures are narrow (<0.5 in) except where noted by w. Symbols in Qa represent small bedrock outcrops in streambed Throughgoing, vertical Widely spaced (>6 ft) Moderately spaced (2–6 ft) --- Closely spaced (<2 ft) Throughgoing, inclined Widely spaced (>6 ft) Moderately spaced (2–6 ft) Closely spaced (<2 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) Structural and textural features in Middle Proterozoic rocks Shear Dextral shear Sinistral shear ← Flow lineation And Quartz veinlet Zone of hydrothermal alteration △△ Breccia Basement topographic high indicated by aeromagnetic contour ——— Prominant aeromagnetic gradient Small sinkhole  $\circ^{23250}$  **Drillhole**—Number refers to Missouri Division of Geology and Land Survey well records; see table 2 for summary of well data Abandoned mine or prospect pit x<sup>P33</sup> Sample locality for geochemistry of Middle Proterozoic rocks

# DISCUSSION

# INTRODUCTION

The Powder Mill Ferry 7.5-min quadrangle covers an area of about 60 mi<sup>2</sup> in Shannon County and a very small portion of Reynolds County, south-central Missouri, in the southern part of the Salem Plateau of the Ozark Plateaus province. It is underlain by flat-lying to gently dipping Upper Cambrian and Lower Ordovician strata, mostly dolomite, and by scattered knobs of Middle Proterozoic volcanic rocks. The Paleozoic strata, as much as 1,800 ft thick, overlie an irregular buried basement surface of Middle Proterozoic rhyolite and granite, and are overlain themselves by unconsolidated surficial materials of Tertiary and Quaternary age. The terrain is a dissected karst plain with abundant sinkholes, caves, springs, and losing streams. Altitudes range from about 510 ft on the Current River in the southeastern corner of the map to 1,273 ft on the crest of Wildcat Mountain. The area is predominantly forested. About one half of the quadrangle lies within the Ozark National Scenic Riverways and as much as a third of the remainder of the quadrangle is State Forest

Spring

The Powder Mill Ferry quadrangle was first mapped in detail by Bridge (1930) at a scale of 1:62,500, and the general geologic setting is shown on the Rolla 1°x2° quadrangle at a scale of 1:250,000 (Pratt and others, 1992) and on the geologic map of Missouri at a scale of 1:500,000 (Anderson, 1979). Orndorff and others (1999) mapped the adjacent Eminence quadrangle at 1:24,000. The present investigation was begun in the Winter of 1997 and completed in the Spring of 1998. Geologic mapping included the use of a Paulin altimeter and locally global positioning system instrumentation for location of field stations. Structural contours, derived from outcrop data, were used to plot the formational contacts of the Paleozoic rocks. In addition to the outcrop data, drillhole locations from well records, sample localities, abandoned mineral workings, sinkholes, and springs not shown on the base map also are plotted.

### STRATIGRAPHY

Exposed bedrock in the quadrangle includes Middle Proterozoic volcanic rocks, informally subdivided into five stratigraphic units, and three Paleozoic sedimentary formations of Late Cambrian and Early Ordovician age. The exposed Paleozoic strata, which range from about 520 to 700 ft in thickness, are, from oldest to youngest, the Potosi Dolomite, the Eminence Dolomite, and the Gasconade Dolomite. The Potosi overlies subsurface Upper Cambrian strata, as much as 1,200 ft thick, as shown in drillholes in this and adjacent guadrangles. These subsurface formations are, from oldest to youngest, the Lamotte Sandstone (locally absent), the Bonneterre Formation, the Davis Formation, and the Derby-Doerun Dolomite (usage of Anderson, 1979). The Paleozoic strata, which are included in the Sauk sequence of Sloss (1982, p. 30), were deposited as sediments in shallow epicontinental seas upon a paleotopography of scattered islands composed of Middle Proterozoic volcanic rocks, which were eventually buried. The higher of these buried volcanic rocks were later exposed by erosion, forming knobs that now protrude through the younger Paleozoic rocks. These strata are generally thinner near the knobs underlain by Middle Proterozoic rocks, and all of the units below the Eminence are locally absent because of erosion or nondeposition over the basement topographic highs. Bedrock units are locally overlain by mapped surficial deposits of Quaternary and Tertiary age. The Middle Proterozoic volcanic rocks, mapped as rhyolite porphyry by Bridge

(1930), have been characterized as chiefly rhyolitic ash-flow tuffs (Pratt and others, 1979). In the Powder Mill Ferry quadrangle the rhyolites were subdivided and mapped at a scale of 1:20,000 by Fisher (1969), and they were shown by Pratt and others (1979) as alkali rhyolites assigned to a three-member stratigraphic sequence. They are presumed to be correlative with the volcanic rocks of the St. Francois Mountains to the northeast (Kisvarsanyi, 1979), which have been assigned a radiometric age of about 1,500 Ma (Bickford and Mose, 1975). This age assignment is supported by granite from a corehole in the Round Spring quadrangle nearby to the northwest, which yielded a U-Pb age of 1.473±15 Ga (Bickford and others, 1981), and by a preliminary U-Pb age of 1.47 Ga recently obtained for a sample of rhyolite of Shut-In Mountain from the Stegall Mountain quadrangle, adjacent to the south (Dan Unruh, oral commun., 1999). In this report, the five informal units of the volcanic rocks were subdivided on the basis of mineralogy, texture, and chemical composition. These are the lower and upper units of Coot Mountain (YcI and Ycu) (Orndorff and others, 1999), rhyolite of Russell Mountain (Yrm), rhyolite of Shut-In Mountain (Ysi), and

unknown

flow tuffs and lesser amounts of air-fall tuffs. Ash-flow tuffs, alkali

of rhyolite and trachyte (fig. 1). The rhyolitic rocks form seventeen large knobs (>1.000 ft in longest dimension) in the quadrangle and also are found in ten smaller outcrops, one of which (1/4 mi east of Peter Mooney Mountain) is newly reported herein. The volcanic rock exposures are restricted to the western and southern parts of the quadrangle. Drillholes east of these exposures in this and adjacent quadrangles encountered Middle Proterozoic granites (for example, drillholes 21516 and 21591; see table 2). The nature of the contact between the volcanic rocks and granites is

The oldest exposed Paleozoic bedrock, the Potosi Dolomite (£p), was originally named by Winslow (1894) for exposures in and near Potosi, Washington County, Missouri. In the Powder Mill Ferry quadrangle it is generally a brown to gray, fetid, vuggy, massive dolomite with drusy chert masses, and is found along the major drainages where it commonly crops out at the base of steep slopes and bluffs. The full thickness of the Potosi reported in drillholes in the area is about 400 ft, of which only the upper 100 ft or less is exposed in most places, although about 125 ft is exposed on Little Blair Creek as a result of local faulting. Ulrich (1911) named the overlying Eminence Dolomite  $(O \in e)$  for exposures near Eminence, 7 mi west of the Powder Mill Ferry quadrangle. The contact between the Potosi and Eminence Dolomites is gradational, marked by alternating beds of light-gray and brownish-gray dolomite. The base of the Eminence is placed at the top of the highest brownish-gray, fetid, vuggy dolomite, which locally is overlain by a 3- to 6-ft-thick chert bed. The Eminence is a light- to medium-gray, fine- to coarse-grained dolomite with minor amounts of chert. A 2- to 5-ft-thick light-gray sandstone bed that closely resembles sandstone beds in the Gunter Sandstone Member of the Gasconade Dolomite occurs near the base of the formation in the southern part of the quadrangle. The Eminence is found on middle and lower slopes throughout most of the quadrangle. It is the youngest formation in contact with the Middle Proterozoic rhyolite in this quadrangle. The youngest bedrock exposed in the quadrangle, the Gasconade Dolomite (Og), was named Gasconade Limestone by Nason (1892, p. 115) for beds exposed along the Gasconade River in central Missouri. It is a light- to medium-gray, fine- to coarsegrained dolomite with irregular chert interbeds and nodules, which are particularly abundant in the lower part. The Gasconade is exposed on upper slopes and ridge tops throughout the quadrangle. The base of the formation is a sequence of interbedded orthoquartzite, sandstone, sandy dolomite, dolomite, and minor amounts of chert a few feet to as much as 50 feet thick, named the Gunter Sandstone Member of the Gasconade (Ogg) by Ball and Smith (1903) for exposures at Gunter (Hahatonka Springs), central Missouri. The base of the Gunter, a distinctive, readily mappable contact, is apparently slightly unconformable on dolomite beds of the Eminence Dolomite (Thompson, 1991, p. 29; Orndorff and others, 1999). Because the Gunter

is too thin to show on the map except in a few places where it forms valley floors, its position is generally represented by the contact at the base of the Gasconade. Holes drilled for mineral exploration provide limited data on subsurface Paleozoic formations (table 2). These units are shown only on the cross section. The Lamotte Sandstone (€I) is reported in only one (21591) of the two drillholes reaching basement. The Bonneterre Formation (cb) is mostly dolomite but includes siltstone, shale, and limestone; it is the host of the lead and zinc mineralization in the Viburnum ore trend a few miles to the north of the quadrangle. The Davis Formation (€d) is dominantly shale with lesser amounts of limestone and dolomite. The Derby-Doerun Dolomite (usage of Anderson, 1979) (€dd), the youngest of the subsurface formations, is mainly thin-bedded to laminated dolomite. The Davis and Derby-Doerun together form a confining bed for groundwater aquifers. Descriptions of these subsurface units are taken from drill logs and from Thompson (1995). Surficial deposits mapped in the quadrangle include residuum (QTrr) derived from

the Roubidoux Formation, colluvium (Qc), alluvium (Qa), and terrace deposits (Qt). Inasmuch as outcrops are relatively sparse, virtually the entire area is covered with these deposits or with unmapped thin soil, colluvium, or residuum. Residuum derived from the Roubidoux is presumably the oldest surficial material present. It is widespread on the higher hilltops and ridge crests, particularly in the northeastern area of the quadrangle. It is marked by abundant large sandstone float blocks and sandy and cherty soil. The unit is derived from the intensive weathering of the interbedded sandstone and dolomite of the Roubidoux Formation, which succeeds the Gasconade in the Paleozoic sequence of the region. No outcrops of Roubidoux bedrock were found in the Powder Mill Ferry guadrangle. The mapped colluvial deposits formed by downslope slumping or creep of these residual deposits. Alluvial deposits have been laid down by streams; terrace deposits are higher remnants of earlier deposits that have been dissected by the down-cutting streams, but may have continued to accumulate sediments during infrequent major floods. Minor amounts of wind-blown loess probably occur throughout the quadrangle; it has been recognized principally in the southwestern corner of the map, where it has been reworked into a terrace deposit along highway H.

# STRUCTURE

The principal bedrock structures in the quadrangle include joints, faults, and broad, gentle folds. These are superimposed on a regional dip of about 20 ft/mi to the south-southeast, as shown by structure contours on the base of the Roubidoux Formation (McCracken, 1971). Draping of the Paleozoic strata over and around the knobs underlain by Middle Proterozoic rocks, probably as a result of post-depositional compaction of the sediments, has resulted in local moderately to steeply dipping beds. Most exposures of the Middle Proterozoic rocks exhibit compositional layering (flow layering) that generally strikes northwest-southeast and dips steeply to both northeast and southwest (fig. 2), suggesting that these rocks have been folded, as for example in a northwest-trending synform on Wildcat Mountain. Evidence from the Stegall Mountain 7.5 min quadrangle, south of the Powder Mill Ferry quadrangle, indicates that these steep dips are synvolcanic and the result of eruption-related collapse. The volcanoes that produced the volcanic rocks may have been structurally controlled by an axial accommodation zone along the rift system defined by the Missouri Gravity Low, a 75- to 100-mi-wide linear feature that extends from southeastern Nebraska to northwestern Tennessee (Guinness and others, 1982). Mapping of joints included the observation of orientation (azimuth and dip), spacing, and persistence (throughgoing or non-throughgoing). Joints spaced 6 ft or more apart were characterized as widely spaced; those 2 ft or less as closely spaced; and between 2 and 6 ft as medium spaced. In order to represent the actual amount of joints present in delineating the trends shown in fig. 3, closely spaced joints were weighted by a factor of three, and medium spaced joints were weighted by a factor of two. Joints measured in the exposed Paleozoic strata occur in two distinct trends

centering on approximately N. 75° E. and N. 10° W. (fig. 3A). Joints in the rhyolites show somewhat more scatter, but also exhibit two principal trends, about N. 45° E. and N. 45° W. (fig. 3B). Joints in the sedimentary rocks are generally normal to bedding and thus are vertical, except locally near knobs underlain by Middle Proterozoic rocks where beds commonly have dips of 5 to 10 degrees or more. Joints in rhyolite commonly have a wide range of dips. Joints in the larger outcrops encountered were considered to be throughgoing if they persisted through the entire outcrop, cutting through all beds. Most joints, however, were found to be nonthroughgoing

A few minor faults occur, with vertical displacements of 20 ft or less. The more persistent Thorny Gap fault extends from the vicinity of Powder Mill Ferry southwestward through Thorny Gap. It has been found to continue southwestward through the Eminence quadrangle (Orndorff and others, 1999) into the Winona quadrangle. Stratigraphic displacement appears to be locally as much as 100 ft. Another possibly extensive fault is inferred to extend from Coot Mountain, where it separates the upper and lower rhyolites of Coot Mountain, northeastward to the large rhyolite knob east of Blair Creek. Offsets of Paleozoic contacts, if any, are minor except for the base of the Gunter Sandstone Member of the Gasconade Dolomite on the ridge just east of the knob, where there is a stratigraphic displacement of 10 to 15 ft. North of the knob the base of the Eminence Dolomite is offset as much as 20 ft along a northwest-trending fault. Other faults are restricted to Middle Proterozoic rocks, as on Peter Mooney Mountain and just northeast of Thorny Gap. Thus, some faulting is older than the Paleozoic rocks and some younger, although the latter are possibly reactivated basement faults. In the absence of exposed fault surfaces, fault motion is difficult to determine. Most faults in the quadrangle were identified on the basis of stratigraphic offset, generally indicating vertical (dip-slip) movement; however a significant strike-slip component in some cases is suggested by kinematic indicators such as mullion structures, slickensides, en echelon fractures, and riedel shears exposed in nearby areas, including mines in the Viburnum ore trend. The gentle folds northeast of the knobs of Middle Proterozoic volcanic rocks can be identified and portrayed only by means of structure contours. The folds show no evidence of lateral compression and probably resulted from uneven sediment

# MINERAL RESOURCES AND GEOLOGIC HAZARDS

distribution and compaction over the irregular surface of the basement shown by the

magnetic highs delineated on the map.

Base-metal mineralization has been reported along the northern margin of the quadrangle (Kisvarsanyi, 1977). Mineralization is in the Bonneterre Formation. This occurrence is at the southern end of the Viburnum ore trend, a major source of lead and zinc ore. Remains of a small mine or large prospect pit in limonite ore were found nearly 0.5 mi southwest of Stroup Spring. Grawe (1943, p. 77) reported a manganese prospect along Blair Creek near Brawley Hollow, in a 2-in-wide vein presumably in rhyolite. During mapping, epithermal vein mineralization was found in the rhyolite knob at Brawley Hollow, but has not been assayed. Manganese nodules are found locally in stream gravels along Bloom Creek. Sand and gravel resources are abundant along major streams. Dolomite of the Gasconade and Eminence Dolomites has been guarried in other areas for use as

dimension stone or crushed rock for asphalt stone and agricultural lime. Surface waters are abundant and represent a significant resource in support of agriculture and tourism. Major streams in the quadrangle include the Current River, Blair Creek, Rocky Creek, Indian Creek, Carr Creek, and Bloom Creek, all of which contain abundant, perennial discharge. Springs are numerous; 32 are shown on the map. The largest, Blue Spring, has an average flow of 69,000,000 gal/day and a maximum of 152,000,000 gal/day; Powder Mill Spring, 4,230,000 gal/day; Cove Spring, 2,390,000 gal/day; and Stroup (Gang) Spring, about 500,000 gal/day (Vineyard and Feder, 1982). Blue Spring, the sixth largest in Missouri, has been explored to a depth of 256 ft, and extends an unknown distance farther; it is the deepest explored spring in the State (Vineyard and Feder, 1982, p. 88). Dye tracers injected in Logan Creek, a losing stream several miles to the northeast in the Corridon SE and Exchange quadrangles, were recovered in Blue Spring, having crossed the surface drainage divide between the Black and Current Rivers (Feder and Barks, 1972; Vandike, 1997). Geologic hazards in the quadrangle present only minor risks. They include

flooding, earthquakes, sinkhole collapse, and landslides. Areas mapped as alluvium or terrace deposits are subject to periodic flooding. Alexander (1990) presents a flood analysis of the Powder Mill Spring and Ferry area in which he projects a 100-yr flood level nearly 30 ft above normal flow. The guadrangle lies about 100 mi northwest of the New Madrid Seismic zone. It

would be within Modified Mercalli intensity zone VIII in the event of a recurrence of the earthquake series that took place there in 1811–1812 (Hamilton and Johnston, 1990, fig. 3), and thus within the area of structural damage to buildings. Karst features in the quadrangle include caves, sinkholes, and losing streams. The abundance of sinkholes, some relatively recently developed, and cavernous areas indicates the possibility of local catastrophic collapse of bedrock; inasmuch as historical occurrences of karst collapse in this area are rare and widely dispersed, the likelihood of such an event in any given locality is judged to be remote, however. Many caves have been found in the quadrangle, some of which have been shown to be extensive by exploration and unpublished mapping carried out by the Cave Research Foundation. These caves are commonly conduits for large amounts of water, as indicated by springs issuing from many of them. Water derived from such sources is particularly susceptible to pollution.

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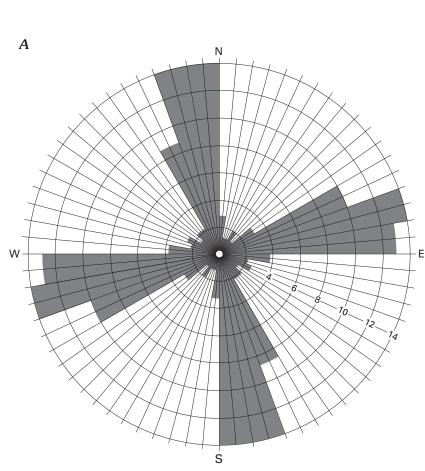
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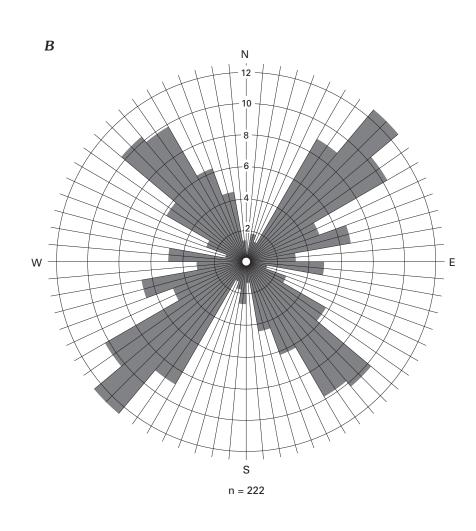


Figure 3.—Compass-rose diagrams of joints in the Powder Mill Ferry quadrangle. n, number of joints. Numbers on diagrams are percent of total. A, Paleozoic rocks; *B*, Middle Proterozoic volcanic rocks. Interval is 5 degrees.



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volcaniclastic conglomerate and breccia (Yvc). Thirty-four samples of Middle Proterozoic volcanic rocks analyzed for major oxides are shown in table 1. Classifications based on the total alkali versus silica diagrams (Le Maitre, 1984) show that the volcanic units in the quadrangle are mostly alkali rhyolite with lesser amounts