DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1568-A
PAMPHLET

MINERAL RESOURCE POTENTIAL OF THE FOSSIL SPRINGS ROADLESS AREA, YAVAPAI, GILA, AND COCONINO COUNTIES, ARIZONA

By

Gordon W. Weir and L. Sue Beard, U. S. Geological Survey
and
Clarence E. Ellis, U. S. Bureau of Mines

STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness", "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Fossil Springs Roadless Area (U.S. Forest Service number 03046), Coconino National Forest, Yavapai, Gila, and Coconino Counties, Ariz. The Fossil Springs Roadless Area was classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

The mineral resource potential of the Fossil Springs Roadless Area, central Arizona, is low. Light-gray conglomerate and carbonaceous shale in the Supai Formation, near the central part of the roadless area, contain discontinuous, spotty copper mineralization, and coaly layers within the shale are radioactive. Analyses obtained during the study show unresolved geochemical anomalies in the area; the anomaly suites suggest possible barite vein deposits and contamination from an unknown ultramafic source. Construction materials present within the roadless area—chiefly basalt, sandstone, limestone, and dolomite—are readily available in abundance in adjacent areas. The oil and gas potential is low; the only producing wells in Arizona tap formations not present in the Fossil Springs Roadless Area.

INTRODUCTION

During 1980 and 1981 the U.S. Geological Survey and the U.S. Bureau of Mines conducted field investigations to evaluate the mineral resource potential of the Fossil Springs Roadless Area. Field studies included general reconnaissance, geological mapping (Weir and Beard, in press), geophysical studies (Davis and Weir, in press), geochemical sampling (Beard and Weir, in press), and a survey of prospects and mineralized areas. T. G. Lovering provided valuable assistance in the evaluation of analytical data. M. K. Weisman assisted the authors in sample collecting.

Geographic setting

The Fossil Springs Roadless Area includes about 14,090 acres of plateau and canyons in the Coconino National Forest (fig. 1). Elevations range from about 6,900 ft on the east edge of the roadless area to about 3,700 ft in the canyon of Fossil Creek at the southwest edge of the roadless area.

The principal access to the canyons is by a jeep trail that branches off the Strawberry-Camp Verde road about 2.5 mi west of Strawberry. A private, unimproved road that leads from the Irving Powerplant to a dam about 0.2 mi west of Fossil Springs borders some of the western part of the roadless area. The plateau is locally accessible by rough logging trails and by unimproved roads leading to stock ponds. All these roads and trails are generally impassable in wet weather. Within the roadless area the principal trail is along Fossil Creek. Much of the area is of difficult access even by foot.

No permanent residents are within the roadless area. The nearest towns are Strawberry and Pine (fig. 1), which together have an estimated permanent population of about 1,200, probably increasing to about 4,000 during the summer months. The principal supply point for western Gila County is the town of Payson (1980 population was 5,085), about 15 mi south of Pine. A few families reside year-round at the Irving Powerplant.

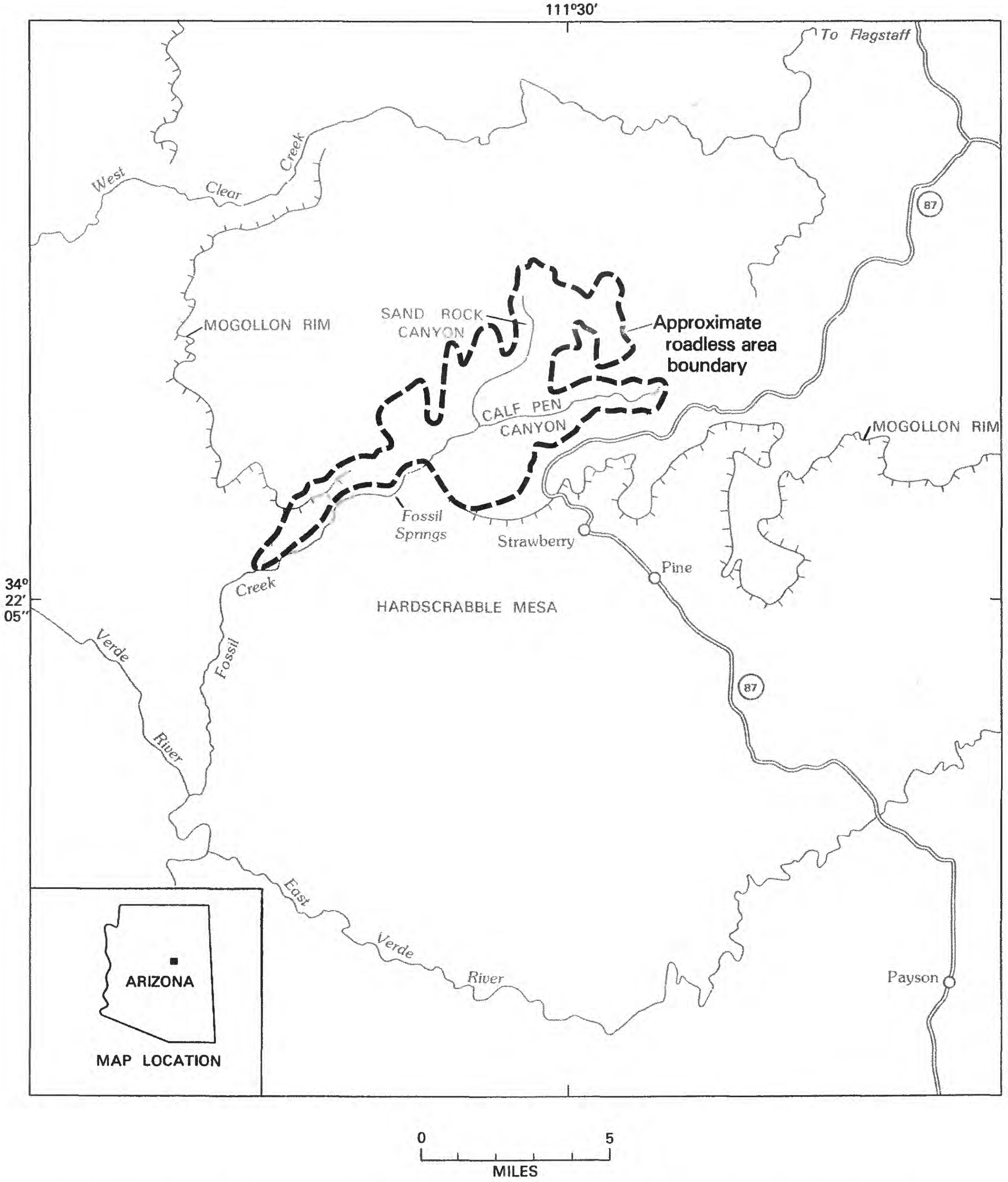

Figure 1.--Index map showing location of the Fossil Springs Roadless Area (U.S. Forest Service number 03046), Yavapai, Gila, and Coconino Counties, Ariz.

Geologic setting

The Fossil Springs Roadless Area is near the southern boundary of the Colorado Plateaus (the Mogollon Rim). This part of the Plateaus is characterized by steep-walled canyons cut into a high tableland of relatively flat-lying Paleozoic sedimentary rocks, veneered locally with Tertiary volcanic rocks.

Mining activity

No mining has been done in or near the roadless area except for quarrying in Paleozoic sandstone and in Tertiary basalt. The quarries were inactive in 1980 and early 1981. Four bulldozer cuts, orginally made during coal prospecting and later utilized for copper and uranium exploration in Permian rocks, are included in a block of claims located in 1962 and 1969 in the central part of the roadless area. The prospects were dormant in 1980 and early 1981.

GEOLOGY

Rocks of Paleozoic and Cenozoic age, totaling about 3,000 ft in thickness, crop out in the Fossil Springs Roadless Area (Weir and Beard, in press). Characteristics of the exposed rock units are listed in table 1. Generalized geology is shown in figure 2. Grayish-red, brownish-red, and gray sandstone, shale, and minor limestone of the Supai Formation (Pennsylvanian and Permian) and grayish-yellow sandstone of the Coconino Sandstone (Permian) make up the bulk of the outcrops in the canyon walls in the northeastern part of the roadless area (fig. 1). Coconino Sandstone forms most of the plateau top in the northern and northeastern parts of the roadless area. In the northwestern part of the roadless area the plateau is covered by Tertiary volcanic rocks, a few tens to a few hundreds of feet thick. South of Fossil Springs the volcanic rocks, chiefly dark-gray basalt and yellowish-gray tuff, thicken abruptly to more than 2,000 ft against an ancestral Mogollon Rim (Twenter, 1962) cut into the Paleozoic section by prevolcanism erosion. Preserved locally beneath the volcanics are Tertiary gravel deposits containing clasts of lower Paleozoic and Precambrian lithologies. A potassium-argon age of 10.16 ± 0.22 m.y. for a basalt flow about 1,250 ft above the floor of the Fossil Creek canyon (Peirce and others, 1979) gives a minimum age of formation of the ancestral Mogollon Rim and subsequent deposition of the gravels. A unique feature of the area is a deposit of travertine (Pleistocene and Holocene) that forms a conspicuous bench above Fossil Springs. Thin sheets of colluvium and masses of landslide blocks obscure much of the outcrop throughout the roadless area.

Paleozoic strata dip gently to the north or northeast. This dominant homoclinal structure is broken into several fault blocks in which the strata dip westerly or southerly. Dips are commonly moderate to steep (10°–40°) in rocks near the faults. All the faults in the roadless area are high-angle normal faults that have minimum displacements commonly ranging from about 50 to 400 ft. The Tertiary volcanic rocks, which rest unconformably on the Paleozoic strata, are flat-lying in the northern part of the roadless area. South of Fossil Springs the volcanic rocks appear to dip gently southwestward. Most of the faults that cut Paleozoic strata also appear to cut the volcanic rocks, but because of poor exposures and lack of lithologic contrasts on the plateau top, few of the faults can be traced in the volcanics far from the canyon rims.

AEROMAGNETICS

The aeromagnetic map (Davis and Weir, in press) of the Fossil Springs Roadless Area shows no evidence of subsurface metallic mineral deposits. The variations in total magnetic intensity of the roadless area are related to magnetic property contrasts in the volcanic rocks and to magnetic contrasts between the basalts and the sedimentary rocks. There is no evidence of any magnetic lows that represent zones of alteration in which metallic mineral deposits may occur along fault zones, and the low amplitude of the anomalies argues against a large deposit of magnetite lying at shallow depths.

GEOCHEMISTRY

Sampling and analytical techniques

A total of 94 samples from within and near the Fossil Springs Roadless Area was collected in 1980-82. Thirty-five stream-sediment samples were collected along Fossil Creek and its tributaries. At 16 of the sample sites panned concentrates of the stream sediments were also obtained. Thirty-two samples of bedrock units were collected to check the general background of the roadless area. In addition, 11 samples of mineralized rock were collected from copper-uranium prospects in the Permian and Pennsylvanian Supai Formation (Beard and Weir, in press).

Semiquantitative spectrographic analyses of the silt fraction (less-than-80 mesh) of the stream sediments, panned concentrates (nonmagnetic fraction), and rocks were made by D. E. Detra using the six-step method for 30 elements (Au, Ag, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, La, Mg, Mn, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, Ti, V, W, Y, Zn, and Zr). The spectrographic data were reported to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1 * * *, which represents approximate midpoints of grouped data on a geometric scale. The radioactivity of the samples of mineralized rock was measured in terms of eU by J. C. Negri. The data for all samples are stored in the RASS (Rock Analysis and Storage System) files of the U.S. Geological Survey. Anomaly minimums (tables 2-5) for all analyses were determined either by comparison with published average or median values for similar rock types (Levinson, 1974; Siegal, 1974; Krauskopf, 1979; and Rose and others, 1979) or by setting the minimum at about two standard deviations above the mean.

Evaluation of analytical data

Geochemical analyses of the samples of stream sediments and rocks yielded two separate anomaly suites that remain geologically unresolved (tables 2-5). One suite of anomalies is found in panned-concentrate samples (table 3) containing levels of chromium, cobalt, and nickel expected in ultramafic rocks. These samples were generally taken from the

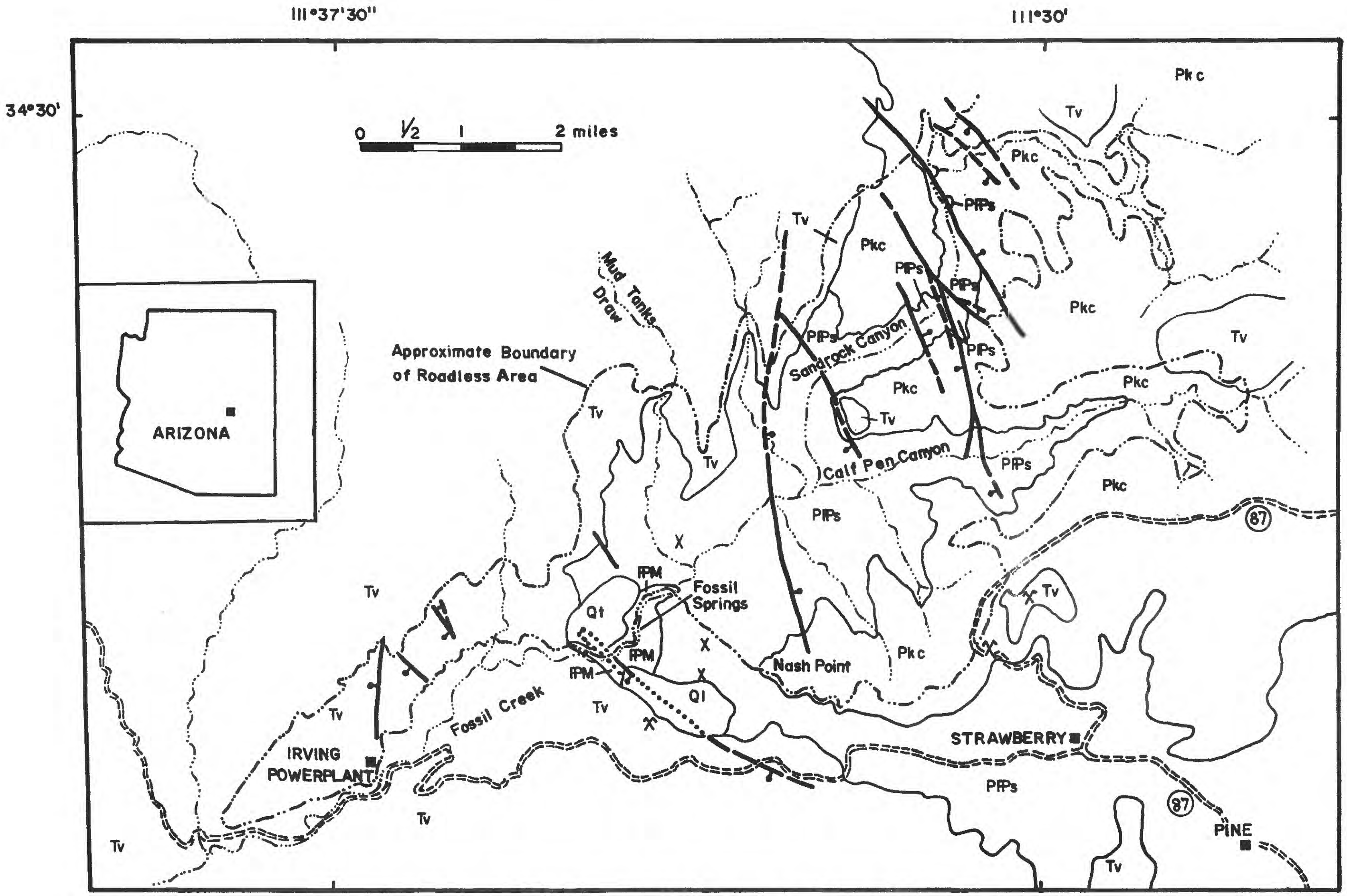

Figure 2.--Map showing generalized geology of the Fossil Springs Roadless Area, Yavapai, Gila, and Coconino Counties, Ariz. The entire roadless area has low mineral resource potential.

EXPLANATION

×	PROSPECT—Copper-uranium, in Supai Formation
⚒	QUARRY
	BOUNDARY OF ROADLESS AREA
	CONTACT
	FAULT—Ball and bar on downthrown side; dashed where approximately located, dotted where concealed

LIST OF MAP UNITS

Ql	LANDSLIDE DEPOSITS (QUATERNARY)
Qt	TRAVERTINE (QUATERNARY)
Tv	VOLCANIC ROCKS (TERTIARY)
Pkc	KAIBAB LIMESTONE AND COCONINO SANDSTONE (PERMIAN)
P IPs	SUPAI FORMATION (PERMIAN AND PENNSYLVANIAN)
IPM	NACO FORMATION (PENNSYLVANIAN) AND REDWALL LIMESTONE (MISSISSIPPIAN)

Figure 2.--Continued

Table 1.--Generalized stratigraphic section of the Fossil Springs Roadless Area, Yavapai, Gila, and Coconino Counties, Arizona

System	Series	Stratigraphic unit	Approximate thickness (feet)	Approximate thickness (meters)	Description
Quaternary	Holocene	Alluvium	0-30	0-10	Clay, silt, sand, and gravel consisting mostly of pebble- to boulder-size clasts of basalt-and sandstone; near Fossil Springs includes pebbles and cobbles of dolomite and limestone.
		Colluvium	0-60	0-20	Rubble locally derived chiefly from Coconino Sandstone and from basalt of Tertiary volcanics; in sheetlike masses mantling slopes.
	Holocene and Pleistocene	Landslide deposits	0-100	0-30	Irregular masses of volcanic rocks, commonly moved downslope hundreds of feet; mostly on west or northwest-facing slopes; forms hummocky topography; grades into colluvium.
		Travertine deposits	0-200	0-60	Yellowish-gray travertine, in part cavernous; forms thick, irregularly tabular body above Fossil Springs, smaller sheetlike bodies on slopes, and lenses in or near Fossil Creek bed; of several generations; base of oldest deposit about 200 ft above creek, base of youngest deposits at creek level. At base of thick tabular body is conglomerate, as much as 20 ft thick, consisting chiefly of boulders of dolomite and sandstone derived from the Supai and Naco Formations.
		Unconformity			
Tertiary	Pliocene and Miocene	Volcanic rocks	0-2,000+	0-600+	Chiefly flows of dark-gray olivine basalt; contain minor but conspicuous layers of light-yellowish-gray pyroclastic dacitic rock; a few basalt dikes and rare basalt-agglomerate dikes; probably includes some vent deposits in southwestern part of roadless area. Thickens abruptly west of Fossil Springs, where base is not exposed.
		Unconformity			
	Miocene(?) or older	Canyon gravel	0-200+	0-60+	Weakly cemented conglomerate consisting mainly of pebble- to cobble-size clasts of granite, gneiss, diabase, and fine-grained metamorphic rocks in a medium- to coarse-grained quartzose matrix; clasts derived from Precambrian terrane, probably south of roadless area. Poorly exposed in scattered outcrops southwest of dam in Fossil Creek bed and as much as 200 ft above bed; cut out locally by Quaternary alluvial gravels; apparently overlain by travertine and by basalt; cut locally by basalt dikes; base not exposed; probably overlies Paleozoic rocks; maximum thickness unknown. Relation to rim gravel uncertain; probably canyon gravel is younger deposit having similar provenance, but possibly is derived from rim gravel or is downfaulted remnant of rim gravel.
		Rim gravel	0-60	0-20	Weakly cemented conglomerate consisting mainly of pebbles and cobbles of resistant Precambrian rocks, including quartzite, granite, gneiss, diabase, and fine-grained metamorphic rocks, in medium- to coarse-grained quartzose matrix; poorly exposed below basalt flows in canyon walls, about 1,000 ft above Fossil Creek and in small areas, less than 50 ft long, north-northwest and southeast of Fossil Springs.
		Unconformity			
Permian		Kaibab Limestone	0-60	0-20	Light-gray and grayish-yellow, very fine grained to fine-grained limestone and dolomite; in part sandy and cherty; locally contains abundant brachiopods near base; top eroded; locally overlain by Tertiary basalt; caps plateau in northern and eastern parts of roadless area.
		Coconino Sandstone	0-1,000	0-300	Light-grayish-orange, very fine to fine-grained, crossbedded sandstone; contains some horizontally bedded layers of sandstone and reddish-brown siltstone near base; forms massive cliffs.
Permian and Pennsylvanian		Supai Formation	1,500	450	Mostly reddish-brown siltstone, sandstone, conglomerate, and shale; gray limestone-pebble conglomerate common near top of lower third. Fine-grained, rarely fossiliferous, gray limestone in a few layers 2-40 ft thick; form conspicuous ledges in upper third. Unit forms steep slopes.
Pennsylvanian		Naco Formation	400	120	Reddish-brown dolomite, limestone, siltstone, and shale; chert-pebble conglomerate at base.
		Unconformity			
Mississippian		Redwall Limestone	80+	24+	Light-gray limestone; in part fossiliferous, chiefly foraminifers; poorly exposed below dam on Fossil Creek; base covered.

Table 2.--Anomalous concentrations shown by spectrographic analyses of silt fraction of stream sediments (less-than-80 mesh) from the Fossil Springs Roadless Area, Yavapai, Gila and Coconino Counties, Arizona

[Analyses by D. E. Detra; concentrations reported in parts per million; leaders (--) indicate value below anomaly minimum]

Element (Lower limit of detection)	Ag (0.5)	B (10)	Ba (20)	Co (5)	Cr (10)	Cu (5)	Ni (5)	Pb (10)	Sr (100)	V (10)	Y (10)	Zr (10)	
Anomaly minimum	0.5	150	500	20	100	70	50	20	300	100	30	700	
Sample No.	Ag	B	Ba	Co	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Remarks
Mostly sedimentary terrane													
FC1S	--	--	--	20	100	--	70	--	--	--	--	700	Calf Pen Canyon, 3.4 mi east of Fossil Creek.
FC3S	--	--	--	20	--	--	50	--	--	--	--	--	Calf Pen Canyon, 2.7 mi east of Fossil Creek.
FC4S	--	150	--	--	--	--	50	--	--	--	--	--	Calf Pen Canyon, 1.7 mi east of Fossil Creek.
FC6S	--	--	--	--	--	--	50	--	--	--	--	--	Calf Pen Canyon, 1.8 mi east of Fossil Creek.
FC7S	--	150	--	--	--	--	--	--	--	--	30	--	Calf Pen Canyon, 1.2 mi east of Fossil Creek.
FC50S	0.5	--	500	50	150	70	100	--	--	--	--	--	Sandrock Canyon, 0.3 mi south of Horsetank Wash.
FC51S	--	--	--	20	150	--	50	--	--	--	--	--	Sandrock Canyon, 0.5 mi south of Horsetank Wash.
FC52S	0.7	--	--	--	--	--	--	20	--	100	--	--	Sandrock Canyon, 0.8 mi south of Horsetank Wash.
FC58S	--	--	500	50	--	--	--	--	--	--	--	--	Sandrock Canyon, 1.0 mi north of Calf Pen Canyon.
FC59S	--	--	700	70	200	70	200	--	--	150	30	--	Fossil Cr., 0.4 mi north of Fossil Springs.
FC60S	--	--	--	--	100	--	50	--	--	--	--	--	Fossil Cr., 0.5 mi north of Fossil Springs.
FC61S	--	--	--	--	--	100	--	--	--	--	--	--	Fossil Cr., 0.7 mi north of Fossil Springs.
FC62S	--	--	700	50	200	70	150	--	300	--	30	--	Fossil Cr., 1.0 mi northeast of Fossil Springs.
FC63S	--	--	--	--	--	--	--	--	--	--	--	700	Fossil Cr., 1.4 mi northeast of Fossil Springs.
FC64S	--	--	--	20	--	--	--	--	--	--	--	700	Fossil Cr., 1.8 mi northeast of Fossil Springs.
FC65S	--	--	--	--	--	--	--	--	--	--	--	700	Fossil Cr., 2.0 mi northeast of Fossil Springs.
FC66S	--	--	--	--	--	--	--	--	--	--	--	700	Fossil Cr., 0.6 mi southwest of Calf Pen Canyon.
FC67S	--	--	500	50	200	--	100	--	--	--	--	--	Fossil Cr., 0.2 mi southwest of Calf Pen Canyon.
FC70S	--	--	--	--	--	--	--	20	--	--	--	700	Confluence of Calf Pen and Sandrock Canyons.
Mostly volcanic terrane													
Element (Lower limit of detection)	Ag (0.5)	B (10)	Ba (20)	Co (5)	Cr (10)	Cu (5)	Ni (5)	Pb (10)	Sr (100)	V (10)	Y (10)	Zr (10)	
Anomaly minimum				100	500	200	200	30	700	200			
FC71S	--	--	--	--	--	--	--	--	--	200	--	--	Unnamed gully, 0.5 mi north of powerplant.
FC72S	--	--	--	100	700	200	300	30	--	200	--	--	Unnamed gully, 1.0 mi northeast of powerplant.
FC73S	--	--	--	--	500	200	200	30	--	200	--	--	Unnamed gully, 1.3 mi northeast of powerplant.
FC74S	--	--	--	100	700	--	200	30	--	200	--	--	Unnamed gully, 1.5 mi northeast of powerplant.
FC75S	--	--	--	--	500	--	--	--	700	--	--	--	Unnamed gully, 1.7 mi northeast of powerplant.
FC76S	--	--	--	--	500	--	200	50	--	--	--	--	Unnamed gully, 1.8 mi northeast of powerplant.

Table 3.--Anomalous concentrations shown by spectrographic analyses of panned concentrates (nonmagnetic fraction) of stream sediments from the Fossil Springs Roadless Area, Yavapai, Gila, and Coconino Counties, Arizona

[Analyses by D. E. Detra; concentrations reported in parts per million; > = greater than concentration shown; leaders (--) indicate value below anomaly minimum]

Element (Limit of detection)	Ag (1)	B (10)	Ba (20)	Be (1)	Co (5)	Cr (20)	Cu (10)	La (20)	Mo (5)	Ni (5)	Pb (10)	Sc (5)	Sn (10)	Sr (200)	V (10)	Y (10)	Zr (10)	
Anomaly minimum	0.5	1,000	10,000	30	100	2,000	300	300	5	150	150	100	10	1,000	500	1,000	2,000	
Sample No.	Ag	B	Ba	Be	Co	Cr	Cu	La	Mo	Ni	Pb	Sc	Sn	Sr	V	Y	Zr	Remarks
FC1P	--	--	>10,000	50	100	2,000	1,000	500	--	150	--	--	--	--	--	--	>2,000	Calf Pen Canyon, 3.4 mi east of Fossil Creek.
FC2P	--	--	>10,000	70	--	--	300	--	--	--	--	--	--	--	--	--	>2,000	Calf Pen Canyon, 3.3 mi east of Fossil Creek.
FC3P	--	--	--	50	--	--	--	--	--	--	--	--	--	--	--	--	>2,000	Calf Pen Canyon, 2.7 mi east of Fossil Creek.
FC4P	--	--	>10,000	50	--	--	2,000	--	--	--	--	--	20	--	--	--	>2,000	Calf Pen Canyon, 2.7 mi east of Fossil Creek.
FC5P	--	--	>10,000	70	--	2,000	--	--	15	--	--	--	--	--	--	1,000	>2,000	Calf Pen Canyon, 2.9 mi east of Fossil Creek.
FC8P	--	--	10,000	30	150	5,000	5,000	--	--	300	--	100	--	--	--	--	>2,000	Calf Pen Canyon, 0.5 mi east of Fossil Creek.
FC13P	--	--	--	--	--	--	--	--	--	150	--	--	--	--	--	--	>2,000	Unnamed gully, 1.5 mi northeast of powerplant.
FC50P	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	>2,000	Sandrock Canyon, 0.3 mi south of Horsetank Wash.
FC52P	--	2,000	--	--	--	--	1,000	--	10	--	200	--	--	--	500	--	>2,000	Sandrock Canyon, 0.8 mi south of Horsetank Wash.
FC55P	--	--	--	50	--	--	--	--	--	--	--	--	--	--	--	--	--	Sandrock Canyon, 2.0 mi north of Calf Pen Canyon.
FC59P	--	--	--	--	200	5,000	--	--	--	300	--	100	--	--	500	--	>2,000	Fossil Creek, 0.4 mi north of Fossil Springs.
FC60P	--	--	>10,000	--	100	3,000	--	--	--	150	--	--	--	1,000	--	--	>2,000	Fossil Creek, 0.5 mi north of Fossil Springs.
FC61P	--	--	>10,000	--	100	3,000	15,000	--	--	150	--	--	--	--	--	--	--	Fossil Creek, 0.7 mi northeast of Fossil Springs.
FC62P	--	--	--	--	150	7,000	500	--	--	300	--	100	--	--	--	--	>2,000	Fossil Creek, 1.0 mi northeast of Fossil Springs.
FC63P	10	--	>10,000	30	150	3,000	--	--	--	300	--	100	--	--	--	--	>2,000	Fossil Creek, 1.4 mi northeast of Fossil Springs.
FC66P	--	1,000	>10,000	100	--	--	--	--	--	--	--	--	--	--	--	1,000	>2,000	Fossil Creek, 0.6 mi southwest of Calf Pen Canyon.

Table 4.--Anomalous concentrations shown by spectrographic and radiometric analyses of rock samples from outcrops in and near the Fossil Springs Roadless Area, Yavapai, Gila, and Coconino Counties, Arizona

[Spectrographic analyses by D. E. Detra; radiometric analyses by J. C. Negri; concentrations reported in parts per million; and leaders (--) indicate value below anomaly minimum]

Element (Limit of detection)		Mn (10)	Ag (0.5)	B (10)	Ba (20)	Be (1)	Cd (20)	Co (5)	Cr (10)	Cu (5)	La (20)	Mo (5)	Nb (20)	Ni (5)	Pb (10)	Sc (5)	Sr (100)	Y (10)	Zn (200)	Zr (10)	eU (20)
Anomaly minimum	Limestone	*	*	*	*	*	1.0	10	30	10	*	*	*	*	20	*	*	*	200	*	*
	Sandstone	10	0.1	*	300	*	*	*	*	*	*	*	*	5	*	*	*	*	*	*	*
	Intermediate volcanics	*	*	30	1,000	5	10	50	100	200	100	5	50	100	30	30	1,000	50	*	100	20
	Basalt	*	*	20	3,000	*	*	100	700	200	50	*	50	300	20	100	1,000	50	*	200	20
	Precambrian clasts	*	*	*	1,500	*	*	*	*	*	*	5	50	*	*	*	*	*	*	*	*

Sample No.	Mn	Ag	B	Ba	Be	Cd	Co	Cr	Cu	La	Mo	Nb	Ni	Pb	Sc	Sr	Y	Zn	Zr	eU	Remarks
38R	--	--	--	--	--	--	10	70	--	--	--	--	--	--	--	--	--	--	--	--	Limestone, Naco Formation.
11R	--	--	--	--	--	20	--	--	--	--	--	--	--	50	--	--	--	300	--	--	Limestone, upper Supai Formation.
R6	70	--	--	300	--	--	--	--	--	--	--	--	10	--	--	--	--	--	--	--	Coconino Sandstone.
R7	30	1.0	--	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--	Do.
B1T	--	--	--	--	--	--	70	--	--	--	--	--	150	--	--	1,000	--	--	100	--	Tuff.
B2T	--	--	50	--	--	--	--	--	--	--	5	--	--	30	--	--	--	--	--	--	Do.
B3T	--	--	50	--	--	--	--	--	--	--	--	--	--	50	--	--	--	--	--	--	Do.
B4T	--	--	--	--	--	--	100	--	--	--	--	--	--	--	--	--	--	--	--	--	Tuff, basaltic.
B5T	--	--	--	--	--	--	50	200	--	--	--	--	100	--	--	--	--	--	--	--	Tuff.
B6D	--	--	30	1,000	--	--	--	--	--	100	--	--	--	--	--	1,000	--	--	--	--	Dacite.
B7TU	--	--	--	--	--	--	--	100	--	--	--	--	--	30	--	--	--	--	--	--	Tuff, upper part of layer.
B7TM	--	--	--	--	--	--	50	150	--	--	--	--	100	30	--	--	--	--	--	--	Tuff, middle part of layer.
B7TL	--	--	--	3,000	--	--	--	1,500	200	--	--	--	500	--	50	1,000	--	--	100	--	Tuff, lower part of layer.
B8TU	--	--	--	--	--	--	--	150	--	--	--	--	--	--	--	--	--	--	--	--	Tuff, upper part of layer.
B8TM	--	--	50	--	--	--	--	--	--	--	5	--	--	50	--	--	--	--	--	--	Tuff, middle part of layer.
B8TL	--	--	50	--	--	--	--	200	--	--	--	--	100	30	30	--	--	--	--	--	Tuff, lower part of layer.
R3	--	--	100	--	--	--	--	150	--	--	--	--	--	100	--	--	--	--	--	--	Tuff.
R3a	--	--	100	--	--	--	--	100	--	--	--	--	--	100	--	--	--	--	--	--	Do.
R8a	--	--	100	--	5	--	--	--	--	--	--	--	--	70	--	--	--	--	--	--	Do.
R8m	--	--	100	--	5	--	--	100	--	--	--	--	--	70	--	--	--	--	--	--	Tuff,lithic, matrix.
R8cm	--	--	150	--	5	--	--	--	--	--	--	100	--	100	--	--	--	--	--	--	Tuff, lithic.
FC10R	--	--	20	--	--	--	--	1,000	200	50	--	--	--	--	--	1,000	--	--	--	--	Volcanic breccia from dike.
FC12R	--	--	--	--	--	--	100	1,000	200	--	--	--	300	--	100	--	--	--	--	--	Basalt, Fossil Creek rim.
R1	--	--	20	--	--	--	--	1,000	--	--	--	--	--	--	--	--	--	--	--	--	Basalt, lower.
R2	--	--	--	--	--	--	--	700	--	--	--	--	--	--	--	--	50	--	--	--	Basalt, middle of section.
R4	--	--	20	3,000	--	--	--	700	--	150	--	50	--	30	--	1,000	50	--	200	--	Do.
R5	--	--	--	--	--	--	--	--	--	70	--	50	--	50	--	--	50	--	--	--	Basalt, Fossil Creek rim.
BTD	--	--	--	1,500	--	--	--	--	--	--	7	50	--	--	--	--	--	--	--	--	Precambrian clast from Tertiary gravel.
R8c	--	--	--	1,500	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Precambrian clast from tuff.

*Where no anomaly minimum is given, no anomalous concentrations were found.

Table 5.--Anomalous concentrations shown by spectrographic and radiometric analyses of mineralized rock from the Supai Formation in and near the Fossil Springs Roadless Area, Yavapai, Gila, and Coconino Counties, Arizona

[Spectrographic analyses by D. E. Detra; radiometric analyses by J. C. Negri; concentrations reported in parts per million, except Fe; Fe concentrations in percent; > = greater than concentrations shown; leaders (--) indicate value below anomaly minimum]

	Element (Lower limit of detection)	Fe (0.05)	Mn (10)	Ag (0.5)	As (200)	B (10)	Ba (20)	Be (1)	Cd (20)	Co (5)	Cr (10)	Cu (5)	La (20)	Mo (5)	Ni (5)	Pb (10)	Zn (200)	Zr (10)	eU (20)
Anomaly minimum	Limestone	2	3,000	1.0	*	*	*	*	*	*	30	10	20	5	*	20	200	70	*
	Sandstone	4	10	1.0	200	*	*	*	*	5	*	30	*	5	5	15	*	*	20
	Shale	10	2,000	1.0	*	500	1,500	7	20	50	200	100	*	10	*	50	*	300	20

Sample No.	Fe	Mn	Ag	As	B	Ba	Be	Cd	Co	Cr	Cu	La	Mo	Ni	Pb	Zn	Zr	eU	Remarks
FCR9L	--	--	--	--	--	--	--	--	--	50	500	--	--	--	100	--	--	--	Limestone, fetid, carbonaceous.
FCR9L2	--	--	--	--	--	--	--	--	--	100	15	--	--	--	--	--	300	--	Limestone, carbonaceous.
FCR9C1	--	--	1.0	--	--	--	--	--	--	200	2,000	--	--	--	--	--	--	--	Shale, carbonaceous, visible copper minerals.
FC31M	--	5,000	--	--	--	--	--	100	--	--	200	70	10	--	--	1,000	--	--	Limestone, radioactivity equals 20 counts per minute (cpm).
FC32M	--	--	--	--	--	--	--	--	--	--	700	--	--	--	--	--	500	--	Shale, carbonaceous, radioactivity equals 29 cpm.
FC33M	10	100	100	200	--	--	--	--	50	--	>20,000	--	50	100	50	--	--	50	Concentrate of sandstone, handpicked for visible copper oxides, radioactivity equals 15 cpm.
FC34M	--	--	2	--	--	--	--	--	--	--	10,000	--	--	--	--	--	700	--	Shale, carbonaceous.
FC35M	--	--	10	--	500	2,000	10	--	--	--	>20,000	--	100	--	100	--	--	20	Concentrate of shale, carbonaceous, handpicked for visible copper oxides.
FC36M	--	--	1	--	500	--	--	--	50	--	10,000	--	20	--	--	--	500	--	Concentrate of shale, containing copper oxides.
FC37M	--	--	2	--	--	--	7	--	150	--	>20,000	--	15	300	--	--	--	--	Concentrate of sandstone and shale, handpicked for visible copper oxides.

*Where no anomaly minimum is given, no anomalous concentrations were found.

central part of the area, about a mile upstream from Fossil Springs. A suite of barium, beryllium, and copper anomalies occurs in the panned concentrates from the upper reaches of Calf Pen Canyon. The second suite suggests possible hydrothermal barite vein deposits.

The source of these anomalies is not known. One possibility is that the chromium, cobalt, and nickel anomalies are perhaps related to a thin mafic dike or flow having an ultramafic component that has not been observed or sampled in the field. However, although most of the samples of volcanic rocks have high concentrations of chromium, there are no correspondingly high concentrations of cobalt and nickel, and the intermediate tuffs contain anomalous concentrations of boron and lead as well as chromium. A possible alternative is that leakage along a fault zone has concentrated elements from a source in basement rocks, but this possibility is unlikely because ultramafic bodies are not known to occur in the region. No hydrothermal barite vein deposits were found within the roadless area, but they occur not far south of it along Tertiary fault zones (C. M. Conway, oral commun., 1982). The geochemical anomalies have interesting geologic implications, but are not considered indicative of probable mineral potential within the roadless area.

MINING DISTRICTS AND MINERALIZED AREAS

The Fossil Springs Roadless Area is not within a recognized mining district. A block of mineral claims was located in the central part of the roadless area in 1962 and again in 1969 in connection with prospecting for coal, copper, and uranium. Sandstone and basalt have been quarried near the border of the roadless area.

Copper-uranium occurrences

Copper-uranium occurrences have been prospected near the central part of the roadless area. The occurrences are within a light-gray, discontinuous zone, a few tens of feet thick, in the lower third of the Supai Formation, about 400 ft above the base of the formation. This gray zone is characterized by lenses of light-gray limestone-pebble conglomerate and sandstone and medium-gray carbonaceous shale, interstratified with lesser amounts of brownish-red siltstone, shale, and sandstone. The prevailing light gray of the zone contrasts strongly with the brownish red that is characteristic of most of the Supai Formation. Outcrops in the zone are rare because most of the slopes in this part of the roadless area are mantled with thick colluvium. The strata in the gray zone dip northeastward and are cut off on the northeast near the mouth of Calf Pen Canyon by a fault that drops the zone below the level of Fossil Creek. On the southwest the entire Supai Formation has been truncated by erosion.

Four prospects, consisting of more than 1,200 ft of bulldozed cuts and trenches, are in or near the roadless area, three on the south side of Fossil Creek below Nash Point, and one on the north side of Fossil Creek near the mouth of Mud Tanks Draw. The anomalous radioactivity is generally confined to coaly layers within carbonaceous shale, and most of the copper minerals occur in the carbonaceous shale or in gray sandstone and conglomerate interlayered with carbonaceous shale. Mineralization was sporadic and not concentrated; the sparsely mineralized rock occupies only a small part of the gray zone, is commonly only a few inches to a few feet thick, and extends a few feet to several tens of feet along the outcrop.

No uranium minerals have been recognized. Peirce and others (1977, p. A8) report a maximum of 90 ppm uranium from their sampling of mineralized rock in the roadless area. Four samples collected from the prospects by the U.S. Bureau of Mines ranged from 2 to 5 ppm U_3O_8. Examination by the U.S. Bureau of Mines of the prospects on the south side of Fossil Creek with a gamma-ray spectrometer showed that about half the radiation was from potassium, the rest from uranium.

Malachite, azurite, bornite, chalcocite, chalcopyrite, and covellite have been detected in these occurrences (Peirce and others 1977, p. 33; Rogers, 1977, p. 21). The copper minerals occur as coatings of sand grains, as blebs in matrix and pebbles, and as fillings of fractures and cavities. Copper was detected in only two of the U.S. Bureau of Mines samples: 200 ppm in a specimen sample and 100 ppm in a sample from a 2-foot channel cut through gray-green siltstone. Samples selectively collected for visible mineralization by the U.S. Geological Survey showed copper concentrations greater than 20,000 ppm (table 5). Because mineralization was spotty and discontinuous, and the rugged terrain and small areal extent of the roadless area are not conducive to exploitation, the mineral potential is deemed low.

Construction materials

Flagstone has been quarried from two small workings in the Coconino Sandstone (Permian) about 0.6 mi and 1.2 mi north of Strawberry, near the east edge of the roadless area (Keith, 1969, p. 444). Basalt of Tertiary age has been quarried from two small workings about 1.6 mi and 1.8 mi north of Strawberry and near the east edge of the roadless area, and from a pit about 0.8 mi south of Fossil Springs near the south edge of the study area. Probably all the quarried basalt was used locally as road material. In 1980 and early 1981 all quarries in or near the roadless area were inactive.

MINERAL RESOURCE POTENTIAL

The mineral resource potential of the Fossil Springs Roadless Area is low. The resources assessed include construction materials, copper and uranium, and oil and gas.

Construction materials in the roadless area include sandstone from the Supai Formation and Coconino Sandstone; limestone and dolomite from the Redwall Limestone, Naco and Supai Formations, the Kaibab Limestone, and Quaternary travertine deposits; basalt and tuff from Tertiary volcanics; and gravel from Quaternary alluvial deposits. Only sandstone and basalt have been quarried in or near the roadless area. Adequate supplies of the construction materials listed are readily accessible in nearby locations.

None of the prospects in copper-uranium occurrences in the area are presently active. The potential for an undiscovered copper-uranium resource in the roadless area is low.

The oil and gas potential of the Fossil Springs Roadless Area appears low. Formations not breached by Fossil Creek are mostly clastic and carbonate rocks of Devonian and Mississippian age. These subsurface formations are potentially petroliferous but have not yielded oil in central Arizona (Peirce and others, 1970, p. 53-56). The only productive wells in Arizona are in the northeast corner of the state and tap units not present near Fossil Springs. Only four test wells have been drilled within 20 mi of the roadless area; all were dry and have been plugged and abandoned.

REFERENCES CITED

Beard, L. S., and Weir, G. W., in press, Geochemical data for the Fossil Springs Roadless Area, Yavapai, Gila, and Coconino Counties, Arizona: U.S. Geological Survey Open-File Report.

Davis, W. E., and Weir, G. W., in press, Map showing aeromagnetic survey of the Fossil Springs Roadless Area, Yavapai, Gila, and Coconino Counties, Arizona: U.S. Geological Survey Miscellaneous Field Studies Map, scale 1:24,000.

Keith, S. B., 1969, Sandstone, in Mineral and water resources of Arizona: Arizona Bureau of Mines Bulletin 180, p. 441-448.

Krauskopf, K. B., 1979, Introduction to geochemistry (2d ed.): New York, McGraw-Hill Book Co., 617 p.

Levinson, A. A., 1974, Introduction to exploration geochemistry: Calgary, Applied Publishing, Ltd., 612 p.

Peirce, H. W., Damon, P. E., and Shafiqullah, Muhammad, 1979, An Oligocene(?) Colorado Plateau edge in Arizona: Tectonophysics, v. 61, p. 1-24.

Peirce, H. W., Jones, Nile, and Rogers, Ralph, 1977, A survey of uranium favorability of Paleozoic rocks in the Mogollon Rim and slope region, east-central Arizona: Arizona Bureau of Geology and Mineral Technology Circular 19, 60 p., app. 11 p.

Peirce, H. W., Keith, S. B., and Wilt, J. C., 1970, Coal, oil, natural gas, and uranium in Arizona: Arizona Bureau of Mines Bulletin 182, 289 p.

Rogers, R. D., 1977, Copper mineralization in Pennsylvanian-Permian rocks of the Tonto Rim segment of the Mogollon Rim in central Arizona: Tucson, University of Arizona M.Sc. thesis, 65 p.

Rose, A. W., Hawkes, H. E., and Webb, J. S., 1979, Geochemistry in mineral exploration (2d ed.): London, Academic Press, 657 p.

Siegel, F. R., 1974, Applied geochemistry: New York, John Wiley & Sons, Inc., 353 p.

Twenter, F. R., 1962, The significance of the volcanic rocks in the Fossil Creek area, Arizona, in Guidebook of the Mogollon Rim region, east-central Arizona, New Mexico Geological Society, 13th Field Conference, 1962: Socorro, N. Mex., p. 107-108.

Weir, G. W., and Beard, L. S., in press, Geologic map of the Fossil Springs Roadless Area, Yavapai, Gila, and Coconino Counties, Arizona: U.S. Geological Survey Miscellaneous Field Studies Map, scale 1:24,000.