DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1567-B

Base from U.S. Geological Survey
Sedona, 1969; Munds Mountain, 1965;
Lake Montezuma, 1969; and Casner
Butte, 1965

Geology from Karlstrom and others (1983)

EXPLANATION

SAMPLE LOCALITY--Showing sample number and type

△ 305 Stream sediment

▲ 214★ Heavy-mineral concentrate and stream sediment; star indicates heavy-mineral-concentrate sample containing ≥10,000 ppm barium; asterisk indicates heavy-mineral-concentrate sample containing ≥700 ppm lead

× 315 Rock

○ 254 Water

✱ 326 Rock and stream sediment

✱ 288 Stream sediment, heavy-mineral concentrate, and water

(Note: The following correlation, description of map units, and list of symbols are for the geologic base map shown here in gray.)

CONTACT--Dashed where approximately located; short-dashed where inferred; dotted where concealed

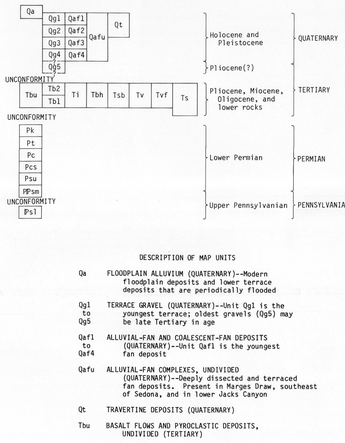
FAULT--Dashed where approximately located; short-dashed where inferred; dotted where concealed. Bar and ball on downthrown side. Figure indicates estimated amount of displacement in feet

OUTCROP--Fort Apache(?) Member of Supai Formation

STRIKE AND DIP OF BEDS

DIP FRACTURE

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qa FLOODPLAIN ALLUVIUM (QUATERNARY)--Modern floodplain deposits and lower terrace deposits that are periodically flooded

Qgl to Qg5 TERRACE GRAVEL (QUATERNARY)--Unit Qgl is the youngest terrace; oldest gravels (Qg5) may be late Tertiary in age

Qaf1 to Qaf4 ALLUVIAL-FAN AND COALESCENT-FAN DEPOSITS (QUATERNARY)--Unit Qaf1 is the youngest fan deposit

Qafu ALLUVIAL-FAN COMPLEXES, UNDIVIDED (QUATERNARY)--Deeply dissected and terraced fan deposits. Present in Marges Draw, southeast of Sedona, and in lower Jacks Canyon

Qt TRAVERTINE DEPOSITS (QUATERNARY)

Tbu BASALT FLOWS AND PYROCLASTIC DEPOSITS, UNDIVIDED (TERTIARY)

Tbl and Tbl2 BASALT FLOW(S) AND PYROCLASTIC DEPOSITS (TERTIARY)--Unit Tbl is the older flow

Tl BASALT INTRUSIVE (TERTIARY)--Dikes and plugs

Tbh BASALT FLOWS AND LACUSTRINE DEPOSITS (TERTIARY)--Basalt flows near House Mountain, west of lower Dry Beaver Creek; includes undivided complex of marginal lacustrine facies and intercalated basalt flows

Tsb SEDIMENTARY ROCKS AND BASALT (TERTIARY)--Undivided complex of interbedded conglomerate, mudstone, and dense limestone, and intercalated basalt flows; unit largely mantled by colluvium and locally slumped. Mapped east of lower Dry Beaver Creek; probably contains both Verde and pre-Verde deposits

Tv VERDE FORMATION (TERTIARY)--Lacustrine facies composed of mudstone, marlstone, and limestone

Tvf VERDE FORMATION FLOAT (TERTIARY)--Marlstone and limestone clasts, and local areas of stromatolitic limestone encrustation on surfaces of basalt flows

Ts MAINLY PREVOLCANIC SEDIMENTS (TERTIARY)--Conglomeratic facies containing interfingering mudstone, marlstone, and limestone beds. Conglomerate composition varies from monolithologic gravels from local Paleozoic rocks to gravels of mixed lithologies reflecting both local and more distant rock sources

Pk KAIBAB FORMATION (LOWER PERMIAN)--Gray to reddish-buff dolomite, limestone, and sandstone

Pt TOROWEAP FORMATION (LOWER PERMIAN)--Grayish, medium-bedded sandstone facies. Bottom of formation mapped at conspicuous change in lithology, weathering characteristics, and topographic expression

Pc COCONINO SANDSTONE (LOWER PERMIAN)--Grayish, medium- to thick-bedded sandstone; largely eolian

Pcs TRANSITION ZONE BETWEEN COCONINO SANDSTONE AND SUPAI FORMATION (LOWER PERMIAN)--Interbedded white and red sandstone and siltstone. Top of unit mapped at top of uppermost red siltstone

Psu SUPAI FORMATION, UPPER PART (LOWER PERMIAN)--Reddish, thin- to medium-bedded siltstone and sandstone. Top of formation mapped at top of Fort Apache(?) Member that forms a limestone marker bed 5-25 ft thick; bottom at top of Rancho Rojo Member of Schnebly Hill Formation of Blakely (1979). Equivalent to most of "A" member of McKee (1945)

PPsm SUPAI FORMATION, MIDDLE PART (LOWER PERMIAN AND UPPER PENNSYLVANIAN)--Purplish-red, thin- to medium-bedded sandstone containing intraformational conglomerates. Equivalent to "B" member of McKee (1945)

Ps1 SUPAI FORMATION, LOWER PART (UPPER PENNSYLVANIAN)--Gray to brown, limey conglomerate, siltstone, and sandstone. Equivalent to "C" member of McKee (1945)

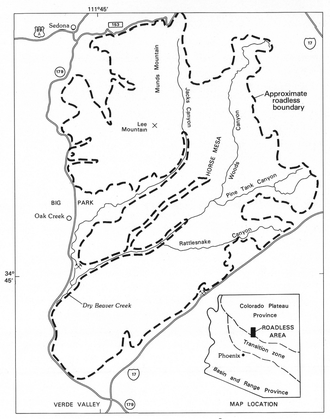


Figure 1.--Index map showing location of the Rattlesnake Roadless Area (03054).

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas of Federal lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geochemical survey of the Rattlesnake Roadless Area (03054) in the Coconino National Forest, Coconino and Yavapai Counties, Ariz. The Rattlesnake 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.

INTRODUCTION

The geochemical survey of the Rattlesnake Roadless Area was conducted in May 1982 by the U.S. Geological Survey to aid in a mineral resource appraisal of the area. A total of 114 stream-sediment samples, 68 heavy-mineral concentrates from stream sediment, 20 rock samples, and 4 water samples was collected by S. C. Rose, D. E. Hendrei, and W. J. Gerstel, with helicopter support from Jack Ruby, pilot for Helicopters Unlimited. All sample localities are plotted on the map; sample localities showing anomalous barium and lead are also indicated on the map.

Geographic setting

The Rattlesnake Roadless Area is near Sedona, Ariz., about 30 mi south of Flagstaff, Ariz. (fig. 1). The roadless area covers about 32,870 acres (51.4 sq mi) of the Coconino National Forest, between lat 34°40'00" and lat 34°52'30" N. and between long 111°37'30" and long 111°47'30" W.

The roadless area consists of mesas, having elevations of as much as 6,800 ft, dissected by two major canyon systems, which trend primarily northeast-southwest, known as Woods and Jacks Canyons. Both canyons were formed by Dry Beaver Creek. Dry Beaver Creek drops a total of 2,000 ft over the distance of 11.8 mi from where it enters the roadless area from the northeast to its confluence with Jacks Canyon, just west of the roadless area boundary. Dry Beaver Creek joins Wet Beaver Creek a few miles to the south to form Beaver Creek, which flows into the Verde River near the town of Camp Verde. The lowest point in the roadless area is about 3,900 ft at the mouth of Woods Canyon, along the southwest boundary of the roadless area.

The roadless area is accessible by several four-wheel-drive trails from Arizona Highway 179, near the town of Oak Creek. From there, trails lead several miles into Woods and Jacks Canyons and a short distance into other areas to the north and east. The upper reaches of the canyons are accessible only along pack trails or the canyon floor.

Geologic setting

The Rattlesnake Roadless Area includes a portion of the deeply embayed Mogollon Rim margin of the Colorado Plateau Province and part of the Verde Valley. The Verde Valley is a deeply dissected lacustrine basin, one of several tectonic basins in the Arizona transition zone that separate the Basin and Range Province from the Colorado Plateau Province (fig. 1). Deep dissection of the rim by headward erosion of canyons draining the Colorado Plateau has created stepwise interfluve ridges, mesas, and buttes, wherein are exposed about 1,500 ft of nearly flat-lying sedimentary rocks. These rocks range in age from Pennsylvanian to Early Permian and include, in ascending order, the Pennsylvanian and Permian Supai Formation, red sandstone; the Lower Permian Coconino Sandstone, yellowish-tan crossbedded sandstone; and the Lower Permian Kaibab Formation, gray to tan limestone.

The sedimentary rocks are overlain by a series of Tertiary basaltic flows of variable thickness, and by tuffs, ashflows, and other associated sediments of Tertiary age that mantle the rim surface. The flows locally preserve remnants of old erosion surfaces that occur at progressively lower elevations and which define successive stages in the erosional history of the rim. Intercalation of southwest-dipping basalt flows in marginal fluviolacustrine sediments below 5,000 ft elevation indicates that late phases of Colorado Plateau volcanism were contemporaneous with late phases of deposition of Lake Verde evaporites and other lake-bed sediments (Nations and others, 1981). Following regression of Lake Verde from the area, cyclical deposition and dissection along drainage lines took place in Quaternary time.

The structural setting is one of flat-lying to gently westward-dipping sedimentary rocks cut by a conjugate normal-fault system of nearly vertical faults that trend primarily north-south, east-west, and northwest-southeast. Significant faulting occurred either prior to or concurrent with early volcanism and continued through late Miocene time (Karlstrom and others, 1983).

No mines, prospects, or mineral occurrences are known to exist within the roadless area.

SAMPLE COLLECTION

The stream-sediment sampling density for the geochemical survey of the Rattlesnake Roadless Area averaged 1.5 samples per sq mi. Each stream-sediment sample, collected wherever possible from first-order channels, was a composite of the streambed material sieved through a 2-mm stainless-steel screen. Approximately 1 lb of such material was collected at each sample locality. For the heavy-mineral concentrates, collected at about 60 percent of the sample localities, approximately 10 lb of the screened streambed composite was panned down to 3 oz of material.

Water samples were taken from springs and ephemeral first-order streams. Two samples were collected at each site: one 60 ml, the other 250 ml. The 60-ml samples, used for the determination of selected cations, were filtered through a 0.45-micrometer membrane filter and stabilized by the addition of a few drops of concentrated nitric acid. The 250-ml samples, used for the determination of pH, alkalinity, conductivity, and selected anions, were neither filtered nor acidified.

Rock samples were collected from various stratigraphic units in the roadless area and vicinity to obtain geochemical background information. However, the Coconino Sandstone was sampled somewhat more extensively because it is known to contain slightly anomalous amounts of silver (2-7 parts per million) in an area about 20 mi south of the Rattlesnake Roadless Area (Ulrich, 1983).

ANALYTICAL TECHNIQUES

Prior to analysis, stream-sediment samples were sieved to minus-250-micrometer (minus-60 mesh) size and the sieved material pulverized to minus-62-micrometer (minus-200 mesh) size. Heavy minerals were separated from the panned samples in bromoform (specific gravity 2.86). These heavy minerals were then passed under a hand magnet to remove the magnetite and further separated into a magnetic and non-magnetic fraction on a Frantz Isodynamic Separator set at 0.6 amperes. The non-magnetic fraction was ground by hand with an agate mortar and pestle. Rock samples were crushed and pulverized to minus-62 micrometers.

All stream-sediment, non-magnetic heavy-mineral-concentrate, and rock samples were analyzed for 31 elements by a six-step, semiquantitative emission-spectrographic method. The rock and stream-sediment samples were further analyzed for zinc, cadmium, bismuth, antimony, and arsenic by atomic-absorption-spectrophotometry techniques, and for uranium by fluorimetric procedures. Water samples were analyzed for sulfate, chlorine, fluoride, and nitrate by ion chromatography; for calcium, magnesium, sodium, potassium, lithium, silica, and zinc by flame atomic-absorption spectrophotometry; for copper, molybdenum, arsenic, iron, manganese, and aluminum by flameless atomic-absorption spectrometry; for uranium by laser-excited fluorescence; for specific conductance by conductivity bridge; and for alkalinity by Gran's plot potentiometric titration.

A complete listing of all analytical methods and results for the Rattlesnake Roadless Area, along with statistical analyses using USGS STATPAC programs (Vanfrump and Miesch, 1977), is available as an open-file report (Gerstel and others, 1983).

RESULTS

The results of the investigation of the Rattlesnake Roadless Area indicate the presence of geochemical anomalies of barium, chromium, lead, and strontium. Determination of anomalous values was based on subjective interpretation. The lower grouping of values in a bimodal distribution, roughly centered about a mean value, was interpreted as the normal background concentration. The grouping of higher values in this type of distribution was taken to be anomalous. Analytical data for the samples of unmineralized rock representing the various stratigraphic units of the area were used in the interpretation.

Percentile rankings, based on the results of geochemical analysis, for the 114 stream-sediment samples and the 68 heavy-mineral-concentrate samples appear in tables 1 and 2, respectively. All qualified values in the raw data, those falling either above or below the limits of detection for the methods of analysis, were replaced with unqualified values defined according to step intervals on the spectrographic scale.

Approximately 25 percent of the heavy-mineral-concentrate samples contained 10,000 ppm (parts per million) or greater barium, falling into the 75th or greater percentile ranking. These anomalous concentrations of barium were collected from the western and southern parts of the roadless area, from streams that drain the Pliocene marlstones, mudstones, and conglomeratic lake sediments of the Verde Formation. Occurrences of barite, the probable source of the barium, are common in saline lake deposits such as those laid down in the Verde Valley. No evidence of bedded barite was observed during any field investigations, but the possibility of this presence should not be ruled out. Gypsum, formed under the same conditions, has been identified in the roadless area and vicinity (Twenter and Metzger, 1963). The barium found in the samples may have been introduced into this environment by volcanism, known to have been contemporaneous with deposition of the Lake Verde sediments in late Pliocene time. Ancient hot springs, another possible source of the barium, are indicated by travertine deposits located at the junction of Woods and Pine Tank Canyons and also just south of the roadless area, near Winter Cabin Spring.

Many of the samples containing anomalous concentrations of barium are also high in strontium and calcium; some of these samples also have slightly anomalous values for boron and lead. This suite of elements is not uncommon in deposits of saline-lake environments where barite ($BaSO_4$), gypsum ($CaSO_4 \cdot 2H_2O$), celestite ($SrSO_4$), strontianite ($SrCO_3$), and, in some places, cerussite ($PbCO_3$) or a boron mineral, such as ulexite or colemanite, are found in association.

Five of the 68 heavy-mineral-concentrate samples contain lead in the range of 700-3,000 ppm. The statistical distribution of the lead values for all concentrate samples is bimodal. The population consisting of lower values, less than 700 ppm, is distributed about a mean of 100 ppm.

The five samples with values ranging from 700 to 3,000 ppm lead might indicate localized pods of mineralization related to a sedimentary unit, possibly the Lake Verde sediments, or some lead-bearing detrital mineral. Generally though, the local rock types do not suggest an environment conducive to lead mineralization. Other elements commonly associated with strata-bound lead deposits, such as copper and zinc, are not present in anomalous concentrations. Most of the samples having anomalous lead values were collected from streams draining areas near roads. It is therefore more likely that the high lead values result from some sort of contamination rather than from mineralization.

Anomalous chromium concentrations were detected in some of the stream-sediment and concentrate samples just west of the roadless area boundary. Dry Beaver Creek joins Wet Beaver Creek a few miles to the south to form Beaver Creek, which flows into the Verde River near the town of Camp Verde. The lowest point in the roadless area is about 3,900 ft at the mouth of Woods Canyon, along the southwest boundary of the roadless area.

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Table 1.--Statistical percentile ranking of elements in stream-sediment samples from the Rattlesnake Roadless Area

[Values in parts per million unless otherwise noted. Symbols used: <, less than the value shown; >, greater than the value shown. Elements not detected have been eliminated from this table. Appropriate unqualified values at step intervals of the spectrographic determination scale were substituted for qualified values]

Element	Percentiles			
	75th	90th	95th	99th
Fe (pct.)	10	20	20	20
Mg (pct.)	3	7	10	>10
Ca (pct.)	5	5	10	17.5
Ti (pct.)	.7	>1	>1	>1
Mn	2,000	5,000	>5,000	>5,000
Ag	<.5	<.5	<.5	<.5
B	100	200	200	200
Ba	1,000	1,000	1,500	1,500
Be	2	2	3	3
Co	50	70	100	125
Cr	500	1,000	1,500	2,000
Cu	100	200	200	300
La	50	70	100	175
Mo	<5	<5	<5	5
Nb	20	30	30	60
Ni	150	300	400	500
Pb	70	70	85	100
Sc	30	30	40	60
Sr	300	500	600	1,000
V	200	300	500	500
Y	50	70	70	85
Zr	700	1,000	1,000	>1,000
As	5	5	5	10
Zn	55	80	90	155
Cd	.2	.4	.5	.6
Sb	<1	<1	1	1.5
U	.5	.695	.96	1.15

Table 2.--Statistical percentile ranking of elements in heavy-mineral-concentrate samples from the Rattlesnake Roadless Area

[Values in parts per million unless otherwise noted. Symbols used: <, less than the value shown; >, greater than the value shown. Elements not detected have been eliminated from this table. Appropriate unqualified values at step intervals of the spectrographic determination scale were substituted for qualified values]

Element	Percentiles			
	75th	90th	95th	99th
Fe (pct.)	2	3	5	5
Mg (pct.)	1	2	5	15
Ca (pct.)	1.25	7.5	10	10
Ti (pct.)	2	2	>2	>2
Mn	500	1,000	1,750	2,000
B	300	500	700	700
Ba	10,000	10,000	10,000	15,000
Co	12.5	20	40	70
Cr	700	1,250	1,500	2,500
Cu	60	150	150	175
La	<70	175	400	2,000
Nb	<50	<50	<50	50
Ni	70	150	300	700
Pb	100	200	700	2,000
Sc	85	150	150	150
Sn	<20	<20	<20	125
Sr	500	2,000	3,500	7,500
V	200	200	250	400
Y	700	1,000	1,250	3,250
Th	<200	<200	<350	350

[1]Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

SCALE 1:24 000

1 ½ 0 1 MILE

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

GEOCHEMICAL MAP OF THE RATTLESNAKE ROADLESS AREA, COCONINO AND YAVAPAI COUNTIES, ARIZONA

By

Wendy J. Gerstel

1985

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1985

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