CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
1520 West Adams St.
Phoenix, AZ 85007
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

PRINTED: 03/14/2003

ARIZONA DEPARTMENT OF MINES AND MINERAL RESOURCES AZMILS DATA

PRIMARY NAME: SHOSHONE & KICKAPOO GROUPS

ALTERNATE NAMES:
BUSHKIN GROUP

MARICOPA COUNTY MILS NUMBER: 769

LOCATION: TOWNSHIP 5 N RANGE 8 E SECTION 13 QUARTER --
LATITUDE: N 33DEG 46MIN 05SEC LONGITUDE: W 111DEG 29MIN 28SEC
TOPO MAP NAME: BOULDER MTN - 7.5 MIN

CURRENT STATUS: RAW PROSPECT

COMMODITY:
GOLD

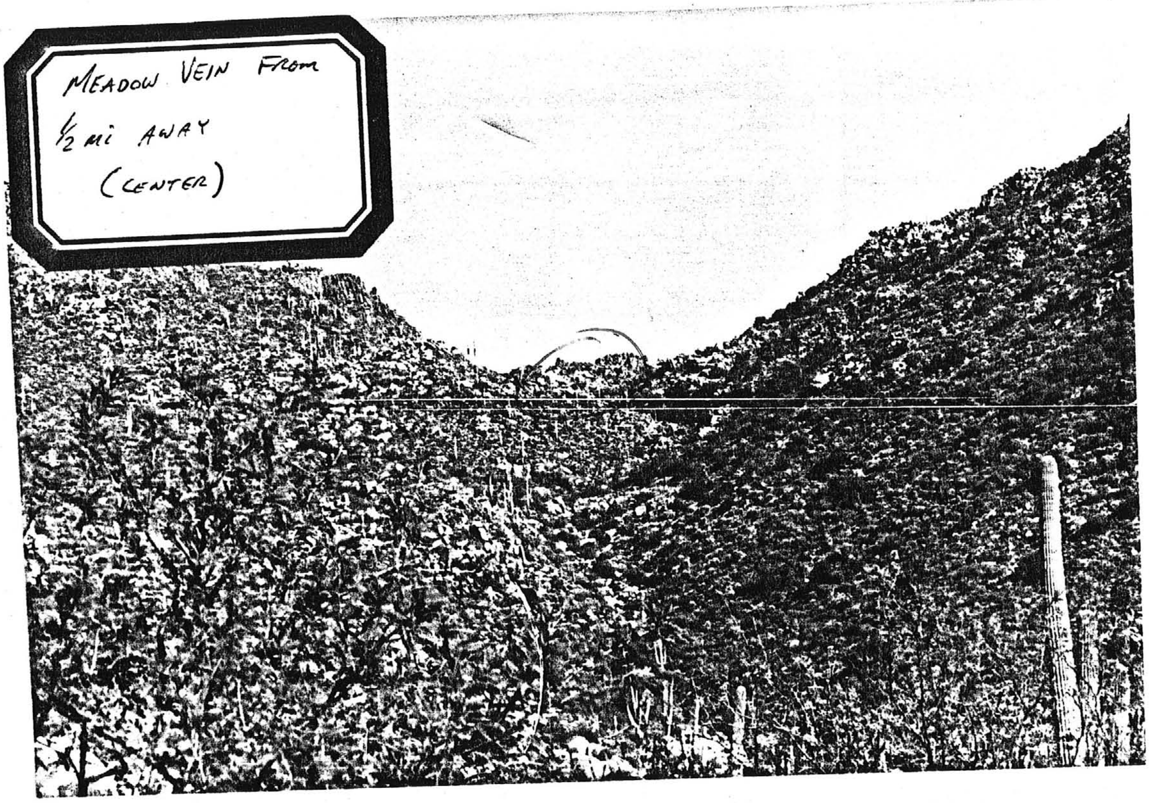
BIBLIOGRAPHY:
ADMMR SHOSHONE & KICKAPOO GROUPS FILE
ADDITIONAL CLAIMS IN SEC 24 AND T5N,R9E,18,19

SHOSHONE AND KICKAPOO GROUPS　　　　　　　　　　　　MARICOPA COUNTY

NJN WR 7/26/85: Rich Walker, 6380 E. Shiprock, Apache Junction, Az. 85220 reported that he has a large low grade gold prospect in the Mazatzal Mountains that he is currently interesting Lac Minerals (c) in. The occurrence is reported to be a couple thousand feet long and have widths up to a couple hundred feet. It is covered by a large group of claims which include the Shoshone and Kickapoo Groups located at T5N R8E, Sec 13. Additional claims are located in Sec 24 and in T5N R9E, Sec 18, 19.

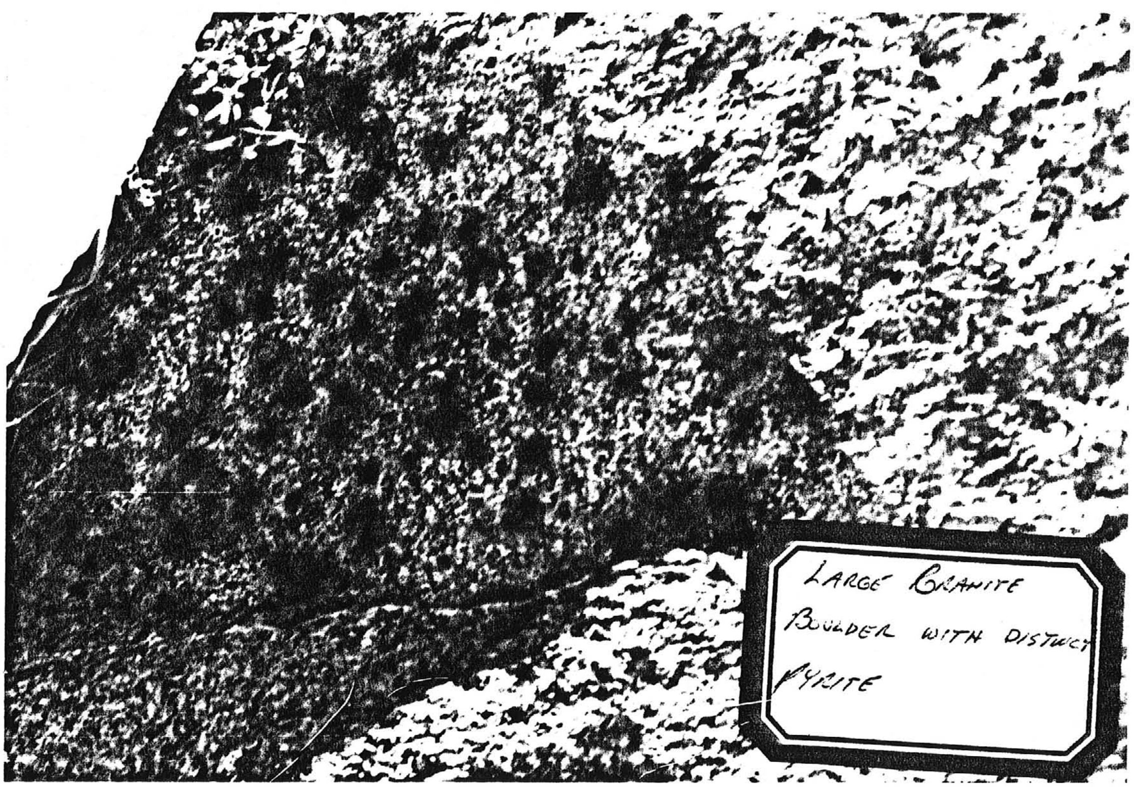
NJN WR 8/1/86: Rich Walker (c) visited and brought in a submittal package on his Shoshone and Kickapoo (file) Maricopa County.

SHOSHONE + KICKAPOO GROUPS(A)
MARICOPA
3/92



#1

AREA OF
#3+4 IS
CIRCLED



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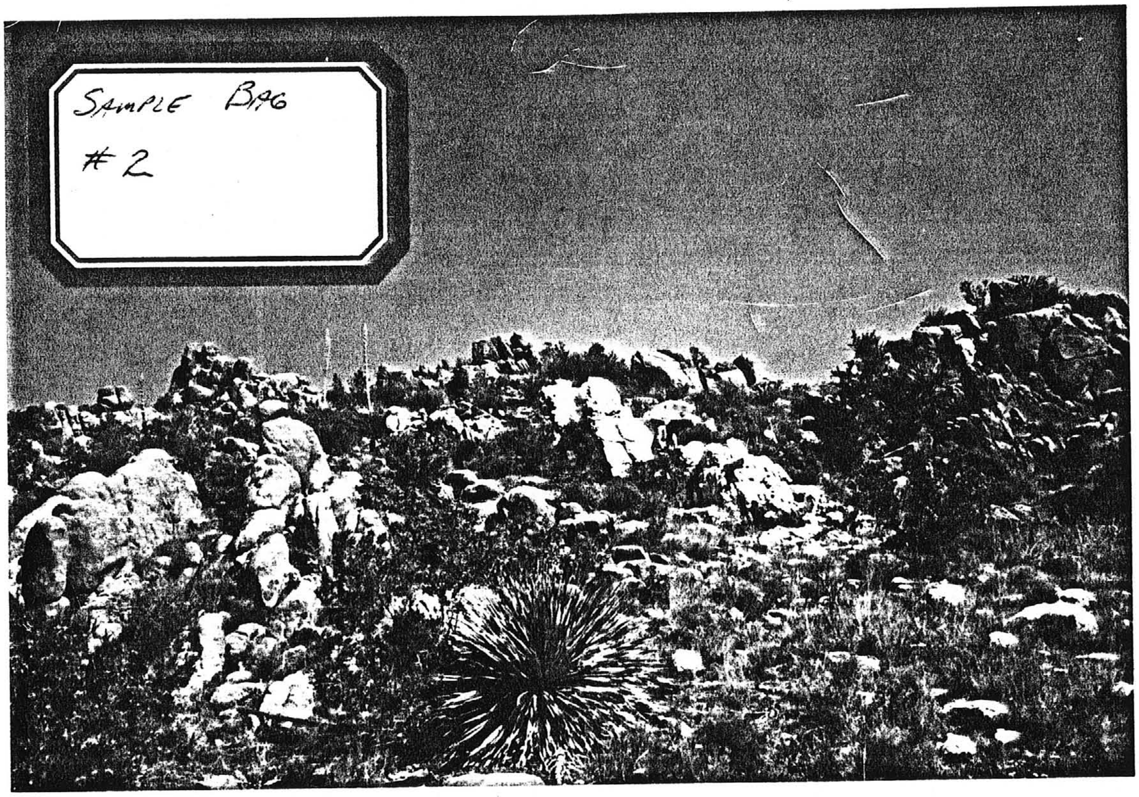
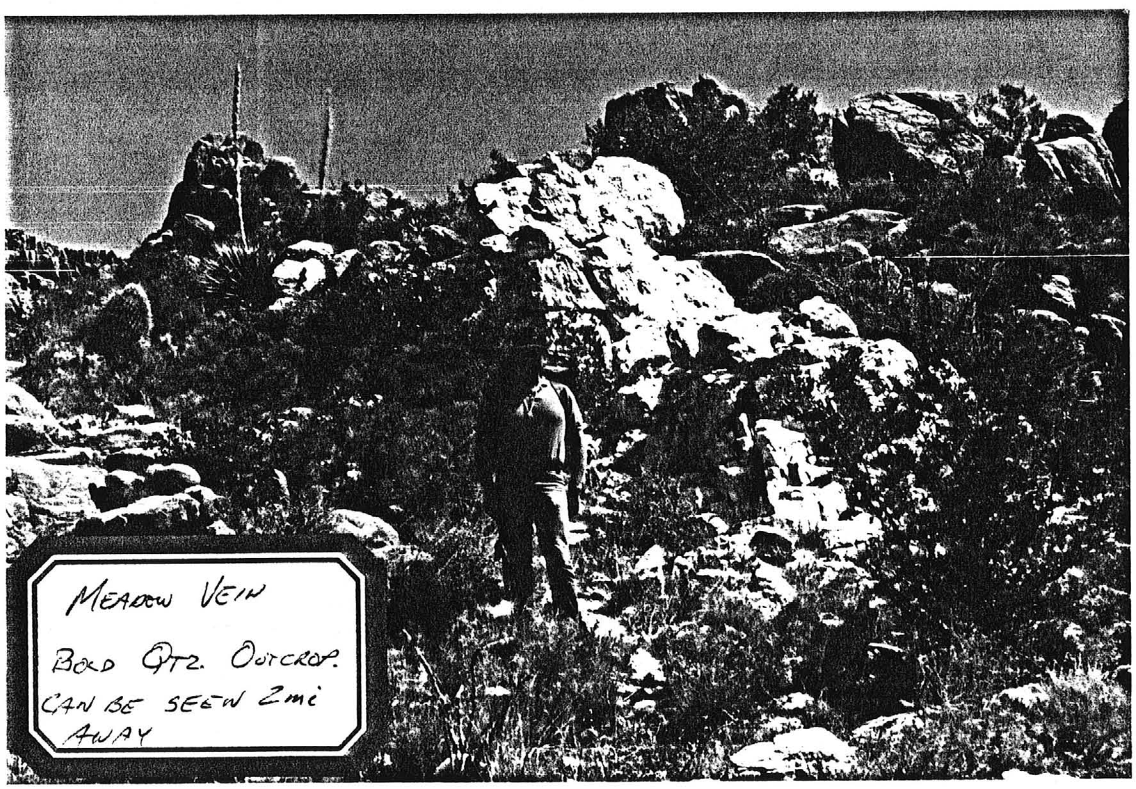
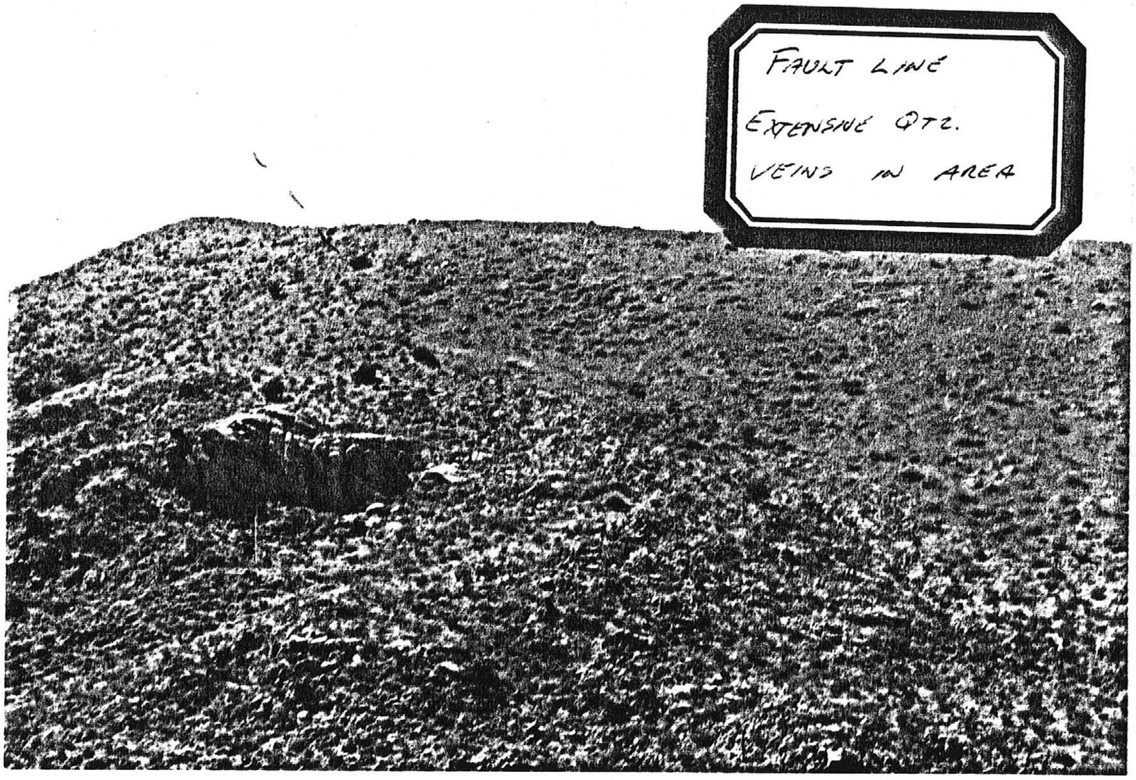
#3


SAMPLE BAG
#2

#4


MEADOW VEIN
BOLD QTZ. OUTCROP.
CAN BE SEEN 2mi
AWAY

#5



NORTH AMERICAN LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

Client Name: Richard Walker
Address: 6380 E. Shiprock
Apache Junction, AZ
Telephone: 982-7516

Job Number: MA-1822
Date: February 26, 1985
Copies to:

Submitted by: Richard Walker
Date Received: 1/23/85

Additional Info:

Client I.D.	Lab #		Fire Assay Au (Oz/ton)	Fire Assay Ag (Oz/ton)	Geochemical Analysis As (ppm)	Geochemical Analysis Pb (ppm)	Geochemical Analysis Hg (ppm)	Checks Au (ppm)	Checks Ag (ppm)
18 Nelson Springs	1	Epidote	<.001	<.01	<10	14			
19 Meadow Vein 2ft.	2		.003	<.01	<10	6	<.01	.003	<.01
20 Kickapoo #2	3		<.001	<.01		30			
21 Bushkin #2-N	4		<.001	<.01					
22 Skunk Ridge 'N'	5	Granite	.005	<.01		14	.03		
23 Skunk Pine	6		<.001	<.01					
24 Meadow Vein-Soil 3 ft.	7		<.001	<.01					

Registered Assayer Certificate No. 15184 James W. Anderson Date Signed 2/27/85 Arizona, U.S.A.

These analyses are based on materials supplied by the client to whom and for whose exclusive and confidential use this report is made. North American Laboratories, Inc., and its officers and employees assume no responsibility and make no representations as to the productivity or profitability of any mineral deposit in connection with which this report is made.

We will store the PULPS for ONE YEAR in case you desire further analysis. They will be returned to you if you so request or be discarded after one year.

Mineral and Water Analysis

1022 West 23rd Street ◦ Tempe, Az. 85282 ◦ (602) 894-0919

USBRC Geochemical Analysis --- MW84TS04 --- 4-DEC-84

Field Number	CU ppm	MO ppm	PB ppm	ZN ppm	AU/AA ppm
RAW-1R	21.	7.	78.	12.	< 0.02
RAW-2R	8.	5.	29.	15.	0.03
RAW-3R	8.	< 5.	34.	17.	< 0.02
RAW-4R	7.	9.	38.	54.	< 0.02
RAW-5R	10.	15.	19.	< 5.	< 0.02
RAW-6R	178.	11.	17.	19.	< 0.02
RAW-7R	17.	7.	62.	8.	< 0.02
RAW-8R	9.	15.	10.	< 5.	< 0.02
RAW-9R	16.	5.	41.	52.	< 0.02
RAW-10R	12.	6.	36.	50.	< 0.02
RAW-11R	69.	6.	36.	135.	< 0.02
RAW-12	21.	< 5.	50.	61.	< 0.02
RAW-13S	18.	6.	58.	63.	< 0.02
RAW-14S	28.	< 5.	38.	64.	< 0.02

U.S. BORAX - MOSTLY
GRANITE TYPES

NORTH AMERICAN LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

Client Name: Rich Walker
Address: 6380 E. Shiprock
Apache Junction, AZ
Telephone: 982-7516

Submitted by: Rich Walker
Date Received: 3/18/85

Job Number: MA-1895
Date: March 28, 1985

Copies to:

Additional Info:

Client I.D.	Lab #	Fire Assay Au (Oz/ton)	Fire Assay Ag (Oz/ton)	
25 Creston "B"	1	.010	<.01	– BASALT
26 Creston "Q"	2	.008	<.01	
27 Calcite	3	.003	<.01	– CALCITE CRYSTALS & BLACK MINERALS
28 North Pine	4	.005	<.01	– GRANITE

I AM AWARE THAT BASALT NORMALY DOES NOT CARRY THESE VALUES. SAMPLES CONFIRMED BASALT BY 2 GEOLOGISTS & JIM ANDERSON.

Registered Assayer CERTIFICATE No. 15184 JAMES W. ANDERSON Date Signed 3/28/85 ARIZONA, U.S.A.

These analyses are based on materials supplied by the client to whom and for whose exclusive and confidential use this report is made. North American Laboratories, Inc., and its officers and employees assume no responsibility and make no representations as to the productivity or profitability of any mineral deposit in connection with which this report is made.

We will store the PULPS for ONE YEAR in case you desire further analysis. They will be returned to you if you so request or be discarded after one year.

Mineral and Water Analysis

1022 West 23rd Street○Tempe, Az. 85282○(602)894-0919

NORTH AMERICAN LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

Client Name: Richard A. Walker
Address: 6380 E. Shiprock Street
Apache Junction, 85220
Telephone:

Job Number: MA 1966
Date: May 8, 1985

Copies to:

Submitted by: Mr. Walker
Date Received: April 24, 1985

Additional Info:

Client I. D.	Lab #	Fire Assay		Geochemical	
		--- oz/ton-----		-----ppms------	
		Au	Ag	As	Hg
29 Creston Dacite	1	.001	<.01	31	.05
30 G-R Quartz	2	.002	<.01	CRYSACOLLA, & CHALCOPYRITE IN SAMPLE	
31 Creston Quartz	3	.003	<.01		

Registered Assayer CERTIFICATE NO. 15184 JAMES W. ANDERSON Date Signed ARIZONA, U.S.A.

These analyses are based on materials supplied by the client to whom and for whose exclusive and confidential use this report is made. North American Laboratories, Inc., and its officers and employees assume no responsibility and make no representations as to the productivity or profitability of any mineral deposit in connection with which this report is made.

We will store the PULPS for ONE YEAR in case you desire further analysis. They will be returned to you if you so request or be discarded after one year.

Mineral and Water Analysis

NORTH AMERICAN LABORATORIES
1022 West 23rd Street
Tempe, Ar na 85282
(602) 894-0919

Job Number MA-2142
Page 1 / 1

SAMPLE RECORD

Client Identification	Lab #	Fire Assay Au Oz/ton	Fire Assay Ag Oz/ton	Atomic Absorption or Emission Ag	Pb	Hg								Spec	
Cactus May Outcrop	1	.008		.5	154	.11									
Lone Cactus	2	.003		<.2											
Cactus "C"	3	.013		<.2	36										

Client Name: Rich Walker
Address: 6380 E. Shiprock St.
Apache Junction, Ariz
Telephone: 982-7516

Samples Submitted By: Rich Walker
Received By: RE Rowe
Date: 7/26/85

North Amr. Labs MA - 2129

7/28/85

Sample ID	Lab #	Au (ppm)	Ag	Cu	Pb	Zn	As	Hg
A-5357	59	1.04	.4	89	34	47	<10	.04
A-5358	60	.12	.3	33	22	35	10	.04

Soil Sample - certainly anomalous (?)

(Hi grade random chip.) I was both surprised and suspicious of this number. Accompanying #'s are clearly background.

SAMPLES CHOSEN IN FIELD BY GARY EATON, PROJECT GEOLOGIST FOR LONG-LAC MINERALS.

Sorry I forgot to send this after our 7/16/85 visit. Good luck.

Gary Eaton

AMERICAN ANALYTICAL LABORATORIES

3441 EAST MILBER • TUCSON, ARIZONA 85714 • PHONE (602) 889-5787

LABORATORY ANALYSIS REPORT

NAME Rich Walker
ADDRESS 550 E. McKellips, Apt. 1012
Mesa, Arizona 85203

REPORT NUMBER 1833
DATE RECEIVED 02/03/86
DATE REPORTED 02/10/86

SAMPLE IDENTIFICATION	Lab No.	oz/T Au	oz/T Ag	ppm Cu	ppm Mo	% WO_3			
North Pine	1	.001	.02	-	-	-			
"Pyrite"	2	ND	.01	-	-	-			
Creston "Mn"	3	.001	.01	-	-	-			
Goetite (?)	4	ND	.04	-	-	-			
Kickapoo Quartz	5	.003	.07	63	30	-			
Kickapoo Copper	6	.002	3.10	279	450	-			
Kickapoo Moly	7	-	-	-	1560	-			
"T" sample (wolframite?)	8	-	-	0		0.09			

COMMENTS:

Registered Assayer CERTIFICATE NO. 15184 JAMES W. ANDERSON Date Signed 2/10/86 ARIZONA U.S.A.

ANALYST

EL OSO TUNGSTEN PROSPECT
(Harrison Tungsten Prospect - Arizona)

LOCATION: This group of fourteen tungsten claims is located near the top of Pine Mountain in the Mazatzal Range of Central Arizona at an elevation of around 5,500 feet. In an air line, the property is roughly 60 miles east of Phoenix and 20 miles north of the Roosevelt Dam. This is known generally as the Four Peaks Mining Dist.

To reach the property from Phoenix, two routes are optional. The first route crosses the Mazatzal Mountains on the Apache Trail to Roosevelt Lake, in the Tonto Basin, thence North 17 miles to Sycamore Creek, thence back west 14 miles by a good C.C.C. trail to the prospect. Total distance is 110 miles. The second route reaches the Tonto Basin by way of the Bush Highway and Slate Creek Road. This route is approximately 20 miles shorter and probably the better.

The line between Gila County and Maricopa County is the drainage divide of the Mazatzals. This places approximately half of the claims in each of these counties.

TIMBER: In the neighborhood of the claims, there is a good stand of Ponderosa Pine, much of it around ten inches in diameter. Oak, Manzanita and Juniper are also abundant.

WATER: There are several springs on the property which would provide amply for a camp. However, it is very improbable that any or all of these could ever supply a concentrating unit. Most likely ore would have to be hauled eleven miles down into the Tonto Basin where plenty of water would be available near the Tonto River and Roosevelt Lake. The Lake reaches to within a few miles of the foot of Pine Mountain.

GEOLOGY: The entire area is composed of a coarsely crystalline granite of pre-Cambian age. This mass comprises an enormous batholith extending in all directions for many miles which has been stripped of its main mass of invaded rocks and any other formations which may have been present.

The younger sediments and volcanics which are common to this section of Arizona do not occur within this portion of the Mazatzal Range, but lie about it as rim at lower elevations.

Small roof pendants of metamorphics do exist in the general mass of the batholith and while not present within the El Oso Claims, one is known within a mile of the property.

Besides the El Oso Claims, the only other known tungsten of the area occurs in this roof pendant in a prospect known as the Joleno Group of Claims owned by Joe Cline, a local rancher.

MINERALIZATION: The tungsten minerals are all found in, or associated with, quartz veins of a pegmatitic character. The highest grade of ore is within the veins themselves while occasionally values will occur within the granite as a disseminated replacement deposit adjacent to prominent ore shoots.

The dominant mineral of the veins is quartz. This usually has a sugar granular or aplitic texture. The associated minerals have a characteristic coarse crystallinity. Crystals of wolframite the size of a clenched fist are not uncommon. Large crystals of feldspar, quartz, mica, tourmaline and flourite are also conspicuous.

Wagner, who located them for tungsten in 1938. A few tons of sorted ore have been produced.

Here, Pinto Creek, a northward-flowing tributary of Salt River, has carved a canyon several hundred feet deep through pre-Cambrian Apache beds and into underlying coarse-grained granite.

This granite has undergone considerable fissuring and sheeting of northwestward trend. Some of these structures contain pegmatite and aplite dikes, and others are occupied by quartz veins. Along the vein walls it shows alteration to sericite.

This area contains numerous quartz veins of prevailing N. 25° to 45° W. strike and vertical to steep northeast dip. They commonly range from a thin seam to 12 inches, and exceptionally to 32 inches in width. Their filling consists essentially of coarse-grained, glassy, grayish-white quartz with locally abundant tourmaline, scattered particles of wolframite and scheelite, and grains of pyrite. Some of the outcrops show considerable iron oxide.

On the east side of the canyon and a few hundred feet above Pinto Creek, shallow pits or short adits have opened six veins, all generally less than a foot wide. About ½ mile farther southwest, on the west side of the canyon, a short tunnel has been driven on a vein 2 to 2½ feet wide. It shows rather abundant wolframite in places adjacent to the walls.

OTHER DEPOSITS

Tungsten mineralization is reported to occur in the drainage area of Pinto Creek at several other places, as on the S. Rose claims, 4 miles west of Horrel's ranch, and near the Superior highway.

MAZATZAL MOUNTAINS

PINE MOUNTAIN AREA

General features.—The Pine Mountain tungsten area is near the crest of the Mazatzal Mountains, 5½ miles northwest of Four Peaks. Most of the claims lie in Gila County, in the upper reaches of a drainage locally known as Sycamore Creek,[31] but some of them are on the Maricopa County side of the divide.

This area is characterized by deep canyons and steep slopes ranging from about 5,000 to 6,100 feet in altitude, with sufficient precipitation to support pine and oak timber and to supply a few springs.

Coarse-grained, pinkish-gray, pre-Cambrian granite is the predominant rock of this portion of the Mazatzal Range. In the vicinity of the tungsten deposits, it has been intruded by a northeastward-trending belt of granite porphyry about a mile wide. This porphyry is characterized by coarse phenocrysts of pink feldspar within an aplitic, sugary groundmass of feldspar, quartz, and biotite.

[31] Shown on the U.S. Geological Survey Roosevelt quadrangle map as Cline Creek. Unfortunately, there are at least two other Sycamore creeks, one other Pine Mountain, and a Pine Ridge, elsewhere in the Mazatzal Range.

Both the granite and granite porphyry are cut by numerous steeply dipping to vertical fissures which may be grouped according to strike as follows: N. to S., N. 20° to 25° E., N. 45° E., and N. 65° W. At many places these fissures have been intruded by aplite or pegmatite dikes, the walls of which are marked by sericitic alteration and iron stain. Some of them are occupied by tungsten-bearing quartz veins. There is considerable suggestion that the deposits of tungsten are associated with intersections of the fissures.

El Oso claims.—El Oso group of sixteen unpatented claims, held by the Harrison brothers, is accessible from the Roosevelt-Payson highway by 10 miles of trail. These claims were located in May, 1941. When visited early in July of that year, they had been developed by several shallow shafts and open cuts.

In the northern part of the group, a vein striking N. 65° W. is traceable for more than 2,000 feet. As shown by a 10-foot shaft on El Oso No. 4 claim, it dips 75° NE. and ranges from 1 to 1½ feet in width. It consists of coarsely crystalline, locally iron-stained, glassy quartz with scattered bunches of wolframite crystals which are coated with variable amounts of scheelite. Some masses of wolframite crystals several inches in diameter were found in the vein, and wolframite particles up to ½ inch wide are locally present in the footwall gouge.

A few hundred feet farther south, on El Oso and El Oso No. 1 claims, vein segments striking N. 65° W. crop out at several places. Where exposed in shallow cuts, they range from about 28 inches to 5 feet in width and dip 65° NE. The gangue consists of coarsely crystalline, glassy, grayish-white quartz together with some pink feldspar. Scattered particles of wolframite, scheelite, and pyrite are locally abundant.

A short distance northeast of the main divide, on El Oso No. 10 claim, a northeast vein, generally less than 1 foot wide, crops out at several places. This vein consists of coarsely granular to sugary, glassy quartz together with some large crystals of pink feldspar. Where opened by a shallow pit, it shows fairly abundant particles of wolframite and scheelite and also sparse pyrite.

On El Oso No. 7 claim, on the Maricopa County side of the divide, a vertical vein of northward strike crops out with a width of about 2½ feet. Early in July, 1941, this vein had been opened by a shallow shaft which showed it to consist of coarsely crystalline grayish-white quartz with fairly abundant, scattered, small masses of wolframite and scheelite.

Cline claims.—The Jolene group of five unpatented claims, held by Joe H. and John H. Cline, is about 1 mile east of the main divide and 7 miles by trail from the Roosevelt-Payson highway.

These claims were located in 1938. When visited early in July, 1941, they had been developed by a few shallow cuts and by a 20-foot shaft with a 15-foot drift.

mining claims are held as locations by men of limited means who are financially unable to do much more than the required assessment work each year. However, if the ground were all under one management and development work were vigorously and intelligently performed, it appears probable that enough ore could be found and mined to keep a 10-ton furnace in operation for several years.

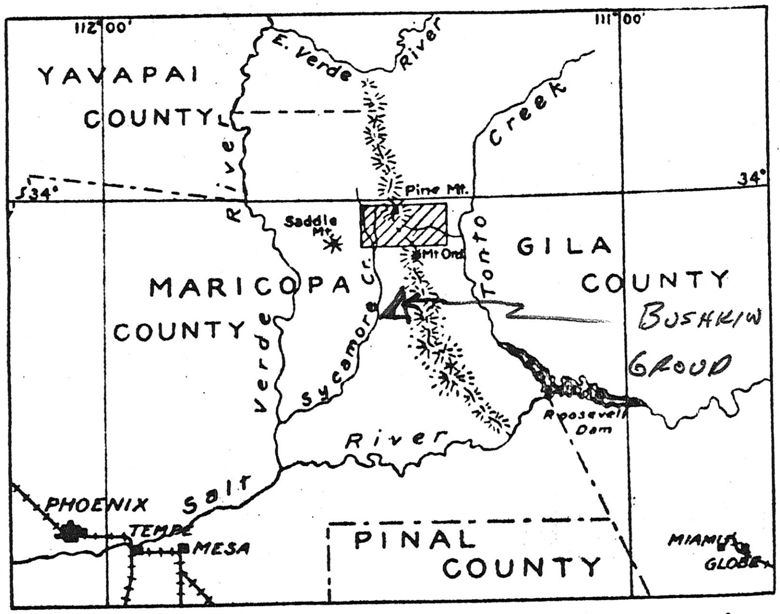


Fig. 10.—Index map of quicksilver deposits in the Mazatzal Mountains.

MAZATZAL MOUNTAINS DEPOSIT

LOCATION

The Mazatzal Mountains, of the Basin and Range type, lie in the central portion of the State. They trend slightly west of north, extend from the Salt River on the south to the East Verde River on thte north, and have a total length of about 50 miles. On the east side of the range is Tonto Creek which discharges into the Roosevelt Reservoir, and on the west side is the Verde River, a branch of the Salt River.

Cinnabar was discovered in 1911 on the west slope of this range on Alder Creek, about 6 miles north of the Sunflower Ranch. (See Fig. 10.) Within the last few years several promising deposits have been found on Slate Creek, on the east slope of the range. This mineralized belt trends nearly east and west and is approximately midway between the north and south ends of the range. As the summit of the range is the boundary between Maricopa and Gila counties, the deposits occur in both counties; those on the west side being located in Maricopa County.

The cinnabar deposits on Slate Creek are 4 miles from the Globe-Payson highway and about 70 miles from Globe. For a short time supplies were brought to the camp on Sycamore Creek from Globe. These supplies were hauled in motor trucks to Malone's camp on Slate Creek and then over the mountain on pack animals. During the past year supplies have been transported from Phoenix to Fort McDowell, thence across the Verde River and over a fair, but only locally improved, road to within less than 2 miles of the camp. The chief drawback to this route is that the Verde River can be crossed only at low-water stage. The distance from Phoenix to the camp is between 60 and 70 miles. In July, 1926, a wagon road had been completed 7½ miles up Slate Creek from the Globe-Payson highway and a survey was being made to extend the road all the way. Supplies were being taken into the Sunflower camp by pack animals from the end of the road.

CLIMATE AND VEGETATION

On both sides of the range the camps occur in deeply incised and steep-walled canyons and are surrounded by high peaks and ridges. The camp on Alder Creek is at an elevation slightly greater than 4,000 feet above sea level, while those on Slate Creek are somewhat under 3,000 feet. Even at the latter locality the summer heat is not excessive, and this is due largely to the greater elevation of the surrounding mountains which are an important factor in moderating the summer heat. During the winter months, however, snow falls frequently, but seldom remains on the ground more than a few days. The climatic conditions, therefore, are not likely to interfere with mine operations.

Rainfall, as in other parts of Arizona, is seasonal, and falls chiefly as torrential downpours during the summer months, and are usually accompanied by an intense electrical display. During the late autumn and winter the precipitation is chiefly as snow, and may be expected in the spring months even as late as the first of April. No records are available of the precipitation in this immediate vicinity, but it is probably greater than 15 inches per annum. In both Slate and Alder creeks water for domestic purposes is available throughout the year except following an exceptionally dry season, and even then some clear, cool water may be obtained from shallow wells sunk in the banks of the streams.

The vegetation in this vicinity is quite varied, and consists of a variety of trees, brush, and grasses. On Pine Mountain and on the upper slopes of Mount Ord is a good stand of yellow pine. At lower elevations and usually in sheltered ravines on the north sides of the higher points is an abundance of cypress. This occurs within easy reach of all the prospects and is the best wood available for mine timbers. A considerable stand of live oak and an occasional juniper are to be found at elevations around 4,000 feet. In the past oak wood has been used to fire the retorts. The slopes of the hills, especially at lower altitudes, are clothed with a dense growth of brush. Only a few of the species of brush occurring here are of value as feed for cattle, and as a whole they are a great hindrance to the prospector.

TOPOGRAPHY

The topography is rather rugged and consists of deeply incised, V-shaped canyons separated by high ridges. Both Alder and Sycamore creeks flow south across the schistose structure, while Slate Creek nearly parallels this structure. At the camp on Alder Creek the canyon is 1,000 feet deep and the slopes approach the critical angle for rock slides. The hardness of the rock has influenced the roughness of the topography; where slates outcrop, the hillsides are smooth and have rounded slopes, but, where rhyolite porphyry or jasper outcrop, cliffs predominate.

Nearly everywhere there is some evidence of recent uplift and rejuvenation of the streams. This uplift probably took place at the close of the Tertiary period.

GENERAL GEOLOGY

The quicksilver deposits in this region were examined by Dr. F. L. Ransome in the autumn of 1914 and his report was published by the United States Geological Survey.[1] Since Ransome's report was issued considerable development work has been done and many additional claims located. The deposits on Slate Creek have been located in the last few years.

The southern half of the Mazatzal Mountains consists almost entirely of granitic rocks that locally may be somewhat gneissic, and are probably entirely pre-Cambrian in age. Near the extreme southern end of this range where the Roosevelt Dam was constructed across the Salt River is an excellent section of Paleozoic rocks. This section

[1]Ransome, F. L., Quicksilver Deposits of the Mazatzal Range, Ariz.: U. S. Geol. Survey Bull. 620, pp. 111-128, 1916.

consists of quartzites and limestone of the Apache Group, and Devonian and Mississippian limestones.[1] These Paleozoic rocks, however, are limited to a small area in these mountains, but originally extended many miles farther north.

On the north slopes of Mount Ord the granitic rocks have invaded pre-Cambrian crystalline schist, and from Slate Creek northward the basement of the range consists of these metamorphic rocks. From Mazatzal Peak to North Peak a massive-bedded and highly indurated quartzite rests unconformably on the upturned edges of the crystalline schists. This formation has been described by E. D. Wilson;[2] and it was by him assigned to the pre-Cambrian and correlated with the Grand Canyon series.

At lower altitudes, on the west side of the range, the older rocks are locally covered by volcanic flows and associated tuffs. Volcanic rocks are rare on the east slopes of these mountains and only a single occurrence of lava was observed. This consisted of a flow of basalt intercalated in conglomerate on Slate Creek. On both sides of Tonto Creek, and extending nearly to the base of the Mazatzal Mountains, are numerous exposures of buff sandstone and red and green shales which in places are gypsiferous. These sediments and volcanic rocks are probably of late Tertiary age. The youngest formation in this vicinity consists of Quaternary gravels and sands, and caps the Tertiary sediments mentioned above.

METAMORPHIC ROCKS

In the immediate vicinity of the quicksilver prospects the prevailing rock is a crystalline schist that varies considerably both in mineral composition and texture. Quartz-sericite schist and brown slate predominate, but in addition chlorite schist, quartzite, and a dolomitic marble have been found. A massive vermilion-red jasper and a schistise rhyolite-porphyry form a part of this pre-Cambrian crystalline complex.

When Ransome[3] examined the quicksilver prospects in this region he found that the schists could be subdivided into eight zones arranged symmetrically on each side of the jasper as a central axis. The relations of these zones to each other are shown diagrammatically in Fig. 11. He says: "It will thus be seen that in the southwestern part of the quicksilver belt the distribution of the rocks is such as to suggest that

[1]Ransome, F. L., Some Paleozoic Sections in Arizona and their Correlation: U. S. Geol. Survey Prof. Paper 98-K, pp. 149-152, 1916.
[2]Wilson, E. D., Proterozoic Mazatzal Quartzite of Central Arizona: Pan-American Geologist, Vol. 38, pp. 299-312, 1922.
[3]Ransome, F. L., Quicksilver Deposits of the Mazatzal Range, Arizona: U. S. Geol. Survey Bull. 620, p. 117, 1916.

the jasper zone occupies the axis of a compressed syncline or anticline. Towards the northeast, on the east slope of the Mazatzal Range, the symmetrical arrangement of the rock zones is less evident."

The strike of the schistosity varies somewhat from place to place, and in Alder Creek is from 43° to 70° east of north, while on Slate Creek it is more nearly east and west. The dip of the schistosity is usually at steep angles to the northwest, but exceptions to this prevailing northwest dip were noted at several places. Surface creep is very pronounced on these steep slopes and often extends for a distance of 15 or 20 feet below the surface. This has sometimes misled prospectors, who do not know the cause of this phenomenon, and has led them to believe that their vein dips into the hillside at a low angle.

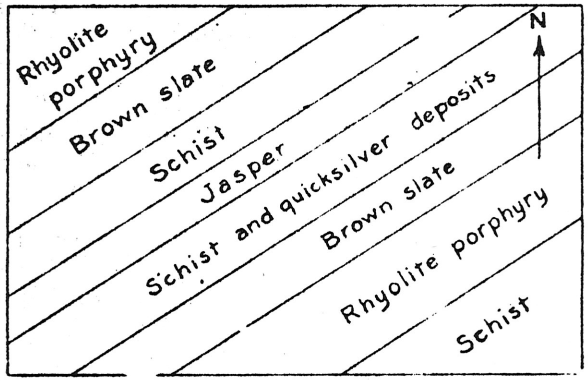


Fig. 11.—Sketch showing relative positions of the schist zones, Mazatzal Mountains.

Quartz-sericite schist is the most abundant type of metamorphic rock in the district. It varies in composition from a quartzite containing a little mica to a light-colored phyllite in which mica predominates. Other mineral constituents are present, but only in minute quantities, and are unimportant in the classification of these rocks. A notable exception is at Baker's camp on Slate Creek where this variety of schist contains considerable calcite and a small amount of chlorite.

The brown slate is a fine-grained rock with a well-developed parting along which the rock cleaves readily. Although the mineral constituents are of small size, quartz and sericite were determined microscopically, and the brown color is due to a ferruginous pigment, probably the mineral hematite. Banding due to slight differences in composition may represent bedding planes, and near the Cornucopia claim this feature indicates that the schistosity makes an angle of approximately 45° with the original stratification.

Plate IX-A. View up Alder Creek, Mazatzal Mountains.

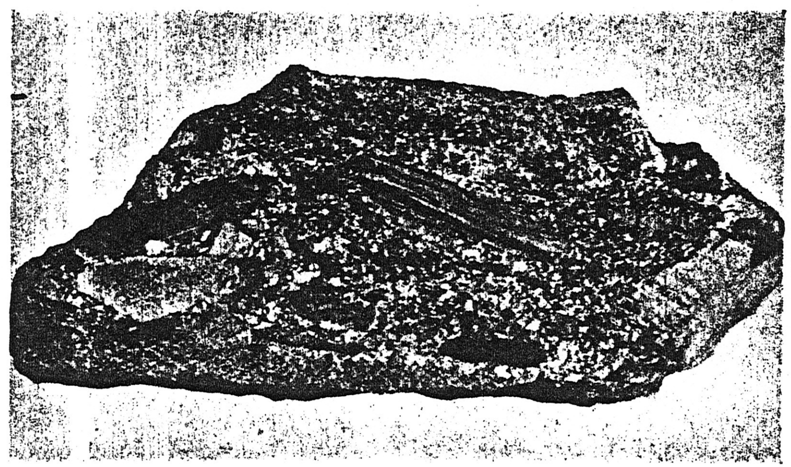


Plate IX-B. Specimen of schist-conglomerate from Alder Creek.

Plate X-A. Oxidized ore showing columnar structure.

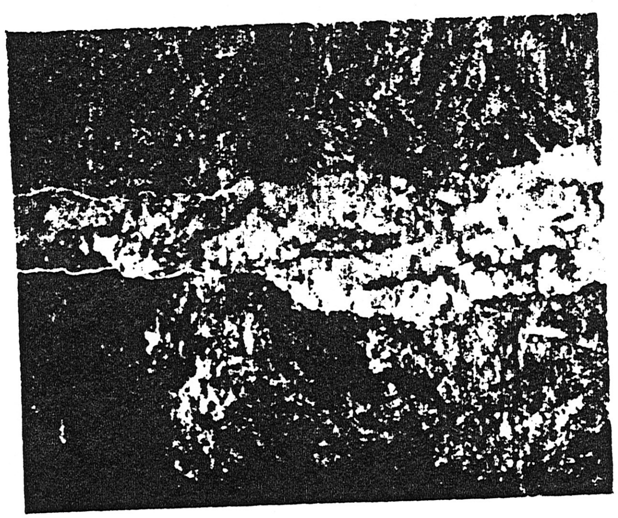


Plate X-B. Veinlet of carbonate and quartz carrying cinnabar.

An area of chlorite schist is well exposed on the Packover and Go-By claims of the Sunflower Group. The rock is of a dark greenish color, and does not cleave as readily as the other mica schists or brown slates. The rock consists largely af chlorite and quartz, but small amounts of magnetite, sericite, and limonite are present. Some thin sections consist entirely of angular fragments of andesite and suggest that the rock was originally a volcanic tuff or breccia. A little red jasper was found associated with this variety of schist.

Bold outcrops of bright red jasper were seen north of the quicksilver deposits. The rock occurs as thin bands or layers in a pale yellow, dolomitic limestone. These bands are highly contorted and are often broken into angular fragments by the dynamic metamorphism that produced the schistosity. Occasionally the rock has a mottled appearance due to small white specks in a vermilion-red matrix, and is very striking in appearance, especially on a wetted surface. Small crystals of pyrite were found on a fresh fracture in some specimens.

A schistose conglomerate was observed on Alder and Sycamore creeks, and is a part of the quartz-sericite schist zone. The pebbles are all more or less angular, and comprise such rock types as rhyolite, andesite, banded quartzite, brown slate, and red jasper. The angularity of the fragments, which show no distortion due to deformation, suggests a local derivation and transportation for only a short distance. Microscopic examination showed the feldspars in the fragments of andesite to be remarkably fresh, although the ferro-magnesian constituents were entirely altered to chlorite.

Rhyolite-porphyry occurs as two broad bands traversing this district in a northeast direction, and more or less paralleling the schistosity. The rock is of a creamy-yellow color and porphyritic texture with numerous phenocrysts of quartz and feldspar visible on a weathered surface. The central portion of this intrusion is rather massive and shows but slight schistosity, while the borders have been compressed and recrystallized to a quartz-sericite schist.

Microscopically, the less sheared rock consists of phenocrysts of quartz, orthoclase, and acid plagioclase. Much of the feldspar is altered to secondary quartz and sericite. No original ferro-magnesian minerals remain, but the form of the alteration products suggests that biotite was an original constituent. The groundmass is microcrystalline and consists of quartz and orthoclase, with sericite and kaolin as secondary minerals. The more sheared portions of the rhyolite-porphyry consist of quartz and sericite, and the positive identification of this highly compressed portion rests on the gradational intensity of the shearing from the center to the borders of the intrusive.

A specimen of rock collected near the trail along Alder Creek was found to be an amygdaloidal basalt. The rock breaks readily in one direction showing that a rude schistosity has been developed, but the general appearance in a hand specimen closely resembles an igneous rock. The amygdules, which consist of calcite, apparently have not been distorted by the metamorphism to which the rock has been subjected. Examined in thin sections the rock was found to consist largely of alteration products. No feldspar or original ferro-magnesian minerals remain. The alteration products are quartz as irregular grains and tiny veinlets, chlorite, serpentine, sericite, limonite, and kaolin. Nests of serpentine may have been formed from original olivine. Much of the magnetite present may be original.

Most of the schist exposed in this region was derived from sedimentary rocks. This conclusion is based on the finding of a conglomerate, original bedding planes in the slates and quartzite, and the presence of limestone. Very likely all the quartz-sericite schist was formed from sediments. The rhyolite-porphyry, chlorite schist, and amygdaloidal basalt are of igneous origin.

This belt of schist continues northeastward to the northern end of the Sierra Ancha where the metamorphic rocks are overlain by a member of the Apache group of supposedly Cambrian age. The schists are therefore pre-Cambrian.

VOLCANIC ROCKS

The effusive rocks are abundant on the west slope of the range and usually occur as lava mesas. Saddle Mountain, about 4 miles west of the camp on Alder Creek, is such a mesa. Here Ransome[1] examined the various flows that make up this mountain and described them as follows:

> "The volcanic rocks under which the schist passes at its southwest end have a thickness of about one thousand feet on Saddle Mountain. At the base is a soft-brown tuff, andesitic or basaltic, with many schist fragments. This appears to be fifty to sixty feet thick. It is overlain by light-gray fine-grained andesitic tuff of approximately the same thickness. Above this lies about 200 feet of coarse andesitic tuff-breccia, the fragments being mostly a light-gray hornblende-biotite andesite. This is succeeded by about 300 feet of andesitic flow breccia, which appears to pass upward without recognizable plane of demarcation into a somewhat porous pink lava which, although resembling the dacite of the Globe-Ray region, proved on microscopic examination to be a fresh hornblende andesite with glassy groundmass. This flow or part of the flow is at least four hundred feet thick and forms the top of the mountain."

[1]Op. cit., p. 117.

South of Red Rock Pass, between Sycamore and Slate creeks, the volcanic rocks have a total thickness of not over 700 feet. Here a well-stratified, brownish tuff, probably andesitic in composition, is the lowest member of the volcanic series observed in the vicinity of this pass; but, as the basement upon which it rests is not exposed, other flows may occur beneath it. This tuff is apparently present only on the west side of the pass, dips to the southwest at a low angle, and appears to fill a depression in an older topography. Above this tuff are flows of a light-colored biotite andesite with a thickness of at least 300 feet. On the east side of the pass a gravel rests on the eroded surface of these flows.

In the lower portion of Slate Creek is an exposure of olivine basalt intercalated in tilted conglomerate. The flow and conglomerate dip to the east at about 15°. Cliff sections along the stream show the basalt to have a thickness of between 80 and 100 feet. The rock is rather dark in color and very fine-grained, with olivine as the only megascopic mineral. This basalt has been thoroughly shattered and the fractures filled with innumerable veinlets of calcite.

The volcanic rocks in this region are a part of the extensive lava field occurring to the northwest of the Mazatzal Mountains. In this region, as in many other parts of the State, the volcanic rocks are probably of Tertiary age; and the andesites are undoubtedly older than the basalts exposed in the banks of Slate Creek.

ORE DEPOSITS

At the time of Ransome's visit, in the autumn of 1914, very little development work had been done; and, although considerably more underground development work has been completed since then, the deposits are still to be considered as prospects rather than developed mines. Several new groups of claims have been located in the last few years, but only location and assessment work has been done on them.

The distribution of the groups of claims located for cinnabar is shown in Fig. 12. An inspection of this map shows that there are three distinct belts or zones of mineralization: The Alder Creek belt; Sycamore Creek-Pine Mountain belt; and the Slate Creek belt. In general, these groups of claims closely parallel the schistosity.

been developed. Further development work may demonstrate that ore bodies large and rich enough to work occur on the ground.

ECONOMIC POSSIBILITIES OF MAZATZAL DISTRICT

In discussing the economic possibilities of the district Ransome[1] states:

"Not enough mining work has been done at the time of visit to determine whether the quicksilver deposits of the Sunflower district are susceptible of profitable exploitation. The geologic facts of occurrence and the sampling by Mr. Hutchinson indicate that the parts of the lodes of minable dimensions now exposed to view carry no more than 3 to 4 per cent of quicksilver at the most, although exceptional stringers here or there which might be sorted out from the broken ore are of much higher grade. To obtain a 3 or 4 per cent product—that is, $60 to $80 ore at present prices—considerable sorting would have to be done, with rejection of three-fourths or more of the rock broken. The chances for obtaining considerable quantities of 2 per cent or $40 ore with only moderate sorting appear to be good.

"Although costs are probably lower in California than in Arizona the situation of the New Idria mine is comparable with that of the Arizona deposits in that the mine has a 60-mile wagon haul to the nearest railway. Mr. Hutchinson's sampling, while thoroughly reliable, was only preliminary to possible work and was rendered difficult by the lack of development. Before the deposits can be appraised at their probable value additional sampling will be necessary. This sampling should be directed particularly to the estimation of the probable available quantity of ore of the minimum grade that can be profitably worked without sorting. To what width, for example, can a lode be mined as a whole to get a 1 to 2 per cent ore and how much of such ore can reasonably be considered available?

"Facts that promise well for future exploitation are the undoubted persistence of the lodes for long distances over the surface and the lack of any evidence of decrease of tenor with increase in depth. Too little has been done to prove that the lodes continue downward without diminution in quicksilver content, and it is generally recognized that quicksilver ores, as a rule, are not deposited at as great depth as some other ores. Lindgren (Lindgren, Waldemar, Mineral Deposits, p. 472, 1913) states that no quicksilver deposit has been worked to a depth of 2,000 feet below its outcrop. On the other hand, the work already done on these deposits gives no foundation for a belief that the cinnabar is less abundant at moderate depth than near the surface."

[1]Ransome, F. L., Quicksilver Deposits of the Mazatzal Range, Arizona: U. S. Geol. Survey Bull. 620, p. 127.

Since Mr. Ransome's visit the ore has been opened up on the Robbins Group. The best exposures of ore that were exposed on the Sunflower Group at that time have either been mined out or further development work has proved the ore bodies to be of small size with no appreciable vertical dimensions. The mineral showings disclosed by recent work on the Sunflower Group by the Arizona Quicksilver Corporation appear more promising than previous discoveries, and there now appears to be a possibility of opening up ore bodies of larger size. The open-cuts and the tunnels being run on the Go-By claim in October, 1925, indicate the probability of finding a fair-sized ore body of medium grade. However, the work done to date has not actually blocked out any ore.

The discoveries of cinnabar made during 1925 in the Slate Creek part of the Mazatzal district look more encouraging than surface disclosures of ore elsewhere in the district. Cinnabar has been found over a distance of 4 miles along Slate Creek and it is quite likely that other discoveries will be made. Remarkable results have been obtained, considering the short time the ground has been prospected.

The discoveries of disseminated quicksilver ore on the Pine Mountain and Mercuria groups also add to the possibilities of the district. The pink color which indicates the values on the Pine Mountains and Mercuria groups had previously been mistaken for iron stain. It is possible that similar quicksilver outcrops elsewhere in the district have been overlooked and further developments are to be expected.

OTHER OCCURRENCES OF QUICKSILVER IN ARIZONA

ROADSIDE MINE

A specimen of quartz containing many small specks of cinnabar was shown the writers at the Roadside mine by Mr. Courtenay DeKalb. This is essentially a copper prospect, and is situated 35 miles west of

ABOUT THE AUTHOR

Stanley W. Ivosevic has mineral property experience and local contacts in a number of places across North and Central America. This experience is with a variety of metals and nonmetals in a spectrum of geologic settings. A 1976 Mackay School of Mines graduate, his employment by Behre-Dolbear and Company Inc., Freeport Exploration Company, Houston Oil & Minerals Corporation, Nevada Bureau of Mines and Geology, and the U.S. Geological Survey culminated with discovery of a precious metals deposit subsequently developed by a major resources corporation.

Since 1979, he has furnished a wide range of consulting and management services to the domestic and international exploration and development programs of the explorationist, producer, marketer, supplier, economist, and researcher.

Arizona Bureau of Geology and Mineral Technology
FIELDNOTES
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ARIZONA'S BACKBONE: THE TRANSITION ZONE

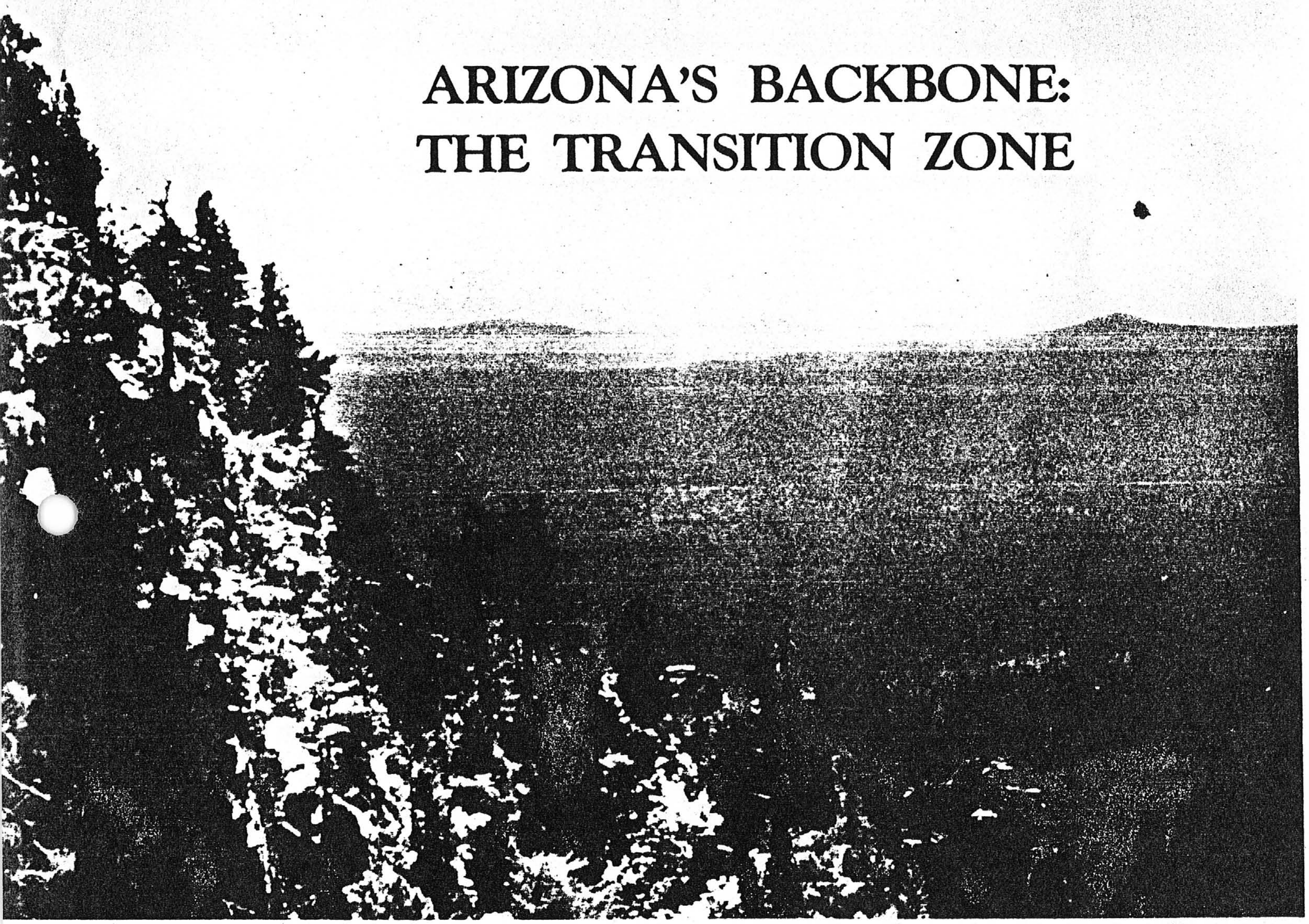


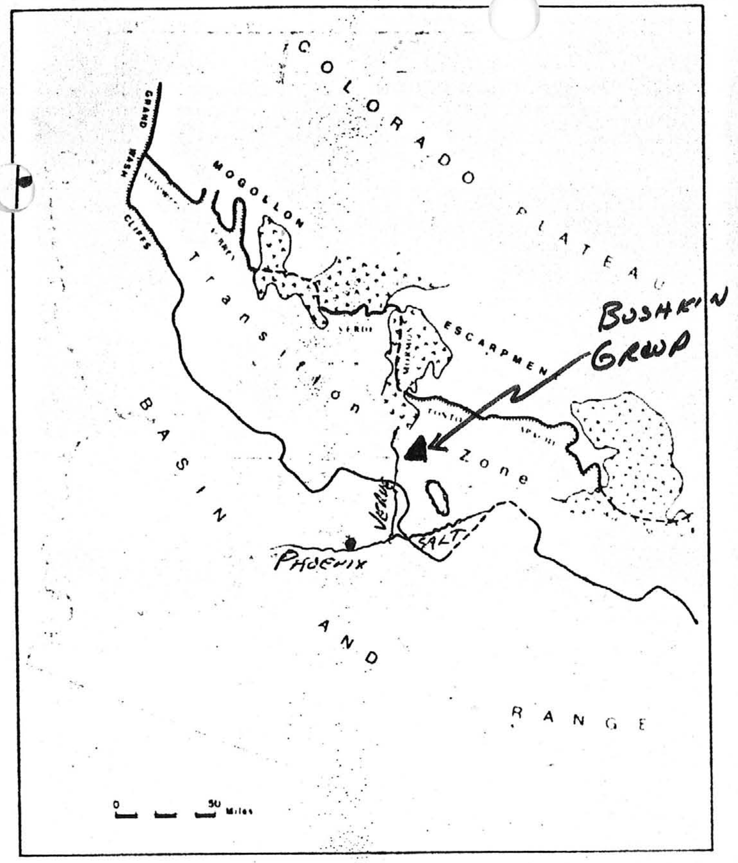
Figure 1. A southerly view into the mountainous terrain of the Transition Zone from the edge of the Colorado Plateau province (Mogollon Rim).

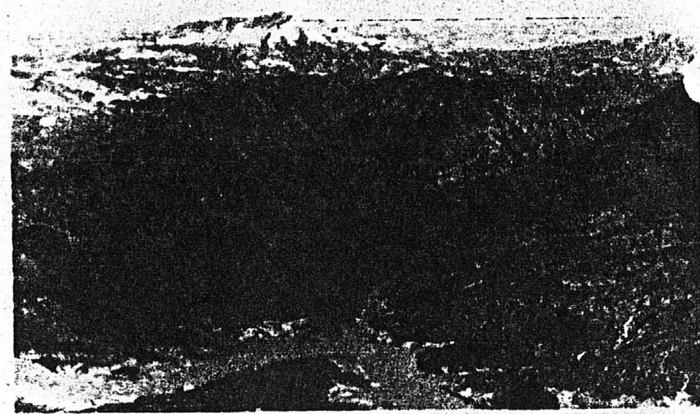
by H. Wesley Peirce

Principal Geologist
Arizona Bureau of Geology
and Mineral Technology

Because Arizona is a land of geologic diversity, it is blessed with a kaleidoscope of fascinating landscapes. The resulting variety of ecologic habitats is reflected in the State's unusual array of flora, fauna, and land uses.

Physiography, or lay of the land, because of its wide impact, is a fundamental aspect of the earth and its political subdivisions. For more than 80 years, geologists and geographers have been defining and redefining Arizona's basic physiographic attributes. Peirce (1984) reviewed these schemes and, based upon an updated geologic understanding, suggested further modifications. Whereas all schemes recognize that Arizona contains two of the major physiographic provinces of the western United States, they differ on how to define a boundary between them. One of these large provinces, the Colorado Plateau (CP), occupies parts of four states, including the northeastern half of Arizona. The other, the Basin and Range (BR) province, involves eight states and occupies much of the southwestern part of Arizona. Most geologists have not continued to support this simple bipartite subdivision in central Arizona because they do not believe that it conveys the true nature of the central part of the State. The answer seems to be the recognition of a transition.





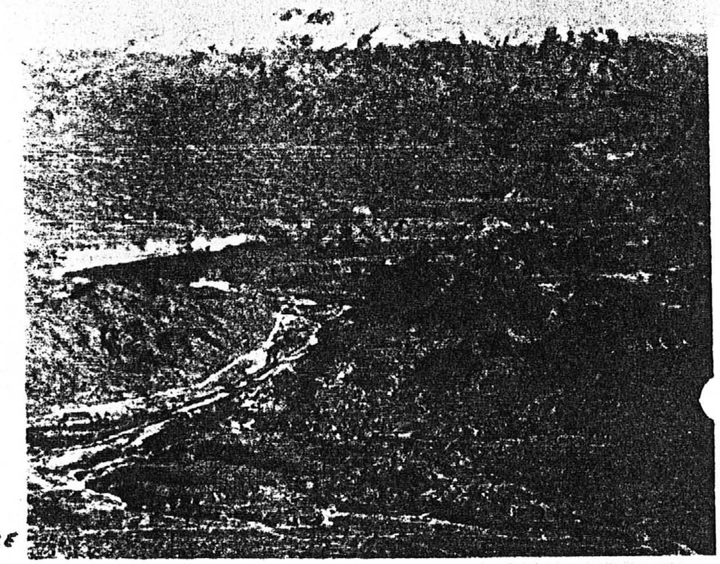


Figure 2 (above). Boundaries of physiographic provinces in Arizona, as suggested by Peirce, 1984

Figure 3 (top right). Looking northeast across Bartlett Reservoir on the Verde River toward Mazatzal Peak, the highest point in the Transition Zone at 7,888 feet. The Sierra Ancha, on the skyline at right, is within the Transition Zone

Figure 4 (bottom right). A northerly view into the Transition Zone showing Saguaro Lake on the Salt River, the Superstition volcanic field in right center, and Four Peaks (elevation, 7,657 feet) in the snowcapped Mazatzal Mountains. The rocks of the Mazatzal Mountains are among the oldest known in Arizona.

Peirce (1984) suggested that an expanded, formally defined Transition Zone (TZ) be considered in subdividing Arizona physiographically (Figures 1 and 2). This article assesses the importance of the TZ and suggests that it be recognized as one of the State's three basic physiographic subdivisions.

Definition and General Characteristics

Any definition of the TZ must consider the two major provinces that flank it. The classic CP and BR provinces differ markedly in their geologic and topographic attributes. Simply put, the BR region has been severely broken by geologic processes, whereas the CP region has not. This contrast can be easily observed on any State map that depicts geology or topography.

The TZ trends northwest and its northern boundary with the CP is the Mogollon Escarpment, commonly known as "the Rim." Its southern boundary with the BR country is marked by the interface of extensive bedrock exposures with extensive, low-elevation, alluvial desert basins or valleys. The TZ embraces an estimated 18,000 square miles, or about 16 percent of Arizona. It is 350 miles in length and averages 50 miles in width. It extends from the Grand Wash Cliffs near Lake Mead to the New Mexico border and incorporates portions of Mohave, Yavapai, Gila, Maricopa, Navajo, Graham, and Greenlee Counties. It includes what has been informally called the central mountain region. Its highest point is Mazatzal Peak at 7,888 feet above sea level (Figure 3) and its lowest is about 1,500 feet near the confluence of the Verde and Salt Rivers.

Although much of the TZ is more than a mile high, its average elevation is intermediate between the higher plateau rim and the lower southern desert basins. The topography is magnificently diverse and features deep canyons (Salt River), high peaks (Four Peaks; Figure 4), and a myriad of interspersed mesas, valleys, and small mountains. Because it contains topographic aspects of *both* the CP and BR provinces, the TZ actually bears little resemblance to either.

The TZ is the surface-water province of Arizona (Figures 3 and 4). The Mogollon Rim is a drainage divide and topographic impediment that, together with the TZ, stimulates precipitation by forcing the prevailing northerly flows of warm, moist air to higher, cooler elevations. Much of the precipitation (rain and snow) from storms falls within the TZ drainage area, where surface runoff is augmented by immediate rainfall and snowmelt or by delayed runoff (spring flow). The TZ, being largely a region of bedrock and steep stream gradients, tends to promote surface flow and inhibit wholesale infiltration into the subsurface. Consequently, rapid rises in streamflow are the dominant natural hazard. Phoenix stands in a low desert basin that is bisected by the Salt River, the major drainage in the adjacent TZ. Plans are being made to create additional flood-control reservoir capacity upstream in the TZ on both the Verde and Salt Rivers. These surface waters also provide recreational outlets. Thousands of boaters, swimmers, and fishermen take advantage of TZ waters every year. The zone contains six large reservoirs, including Roosevelt Lake, Arizona's largest self-contained water body.

The contrast of the TZ with flanking region is also expressed in the vegetation (University of Arizona, 1963). Chaparral and juniper-pinyon-oak woodland, typical of intermediate elevations, are dominant. Ponderosa pines occupy islands of higher elevation and desert scrub occurs in small areas of low elevation. Because of limited soil distribution and water availability patterns, agriculture is negligible in the TZ. Cattle ranching, however, is significant.

Wildlife populations, taking advantage of TZ life-supporting attributes, also tend to be distinctive. Some of the best bear habitat in the western United States is found in the TZ, and Arizona's largest antelope herds thrive in its northwestern section. Most of the bald-eagle nesting pairs in the State take advantage of riparian strips along its perennial waterways. An otter reintroduction program by the Arizona Game and Fish Department is underway in the lower Verde River section of the zone.

Rock and mineral attributes of the TZ are unique in several respects. The TZ, as will be explained later, has the most extensive display of Arizona's oldest rocks, rocks that give the region much of its bold character. In Arizona a type of ore deposit known as a "massive-sulfide deposit" is associated only with these oldest Precambrian rocks, which are about 1.8 billion years (b.y.) in age. Unlike the more famous porphyry coppers, which are disseminated, low-grade deposits, massive-sulfide deposits, such as those found near Jerome, are compact and high grade. The Verde mineral district, which includes Jerome, yielded ores (largely copper, zinc, and silver) valued at $3.5 billion at today's metal prices. Typical porphyry copper deposits occur at Bagdad and near Prescott, and gold placers in the Prescott region attracted early interest. Ninety-five percent of the mercury produced in Arizona came from a cluster of mines in the Mazatzal Mountains district. Numerous small uranium deposits, some of which were exploited, are known in the Sierra Ancha and adjacent regions. The expanse of Precambrian rocks in the TZ, their relationship to early growth of the continent, and their mineralization make them a target for ongoing research and exploration.

Significant deposits of nonmetallic materials have also been found in the TZ. A narrow, northwest-trending belt of good-grade, lower Paleozoic (which overlies the Precambrian) limestone crops out in the northwest part. Limestone from this belt supports a large lime plant just east of Peach Springs, as well as a cement plant in the Verde Valley that today supplies much of Phoenix's cement, but was first built to supply cement for Glen Canyon Dam. A salt deposit in the Verde Valley was mined by Indians. Some of the highest quality chrysotile asbestos in North America was mined from the Sierra Ancha-Salt River region. Schist used as decorative facing stone is quarried near Mayer.

Fourteen of the State's 49 wilderness areas are within the TZ. In other words, the TZ, which contains 16 percent of Arizona's total acreage, contains nearly 30 percent of its wilderness areas, a proportion that clearly indicates this area's relative remoteness and unusual qualities.

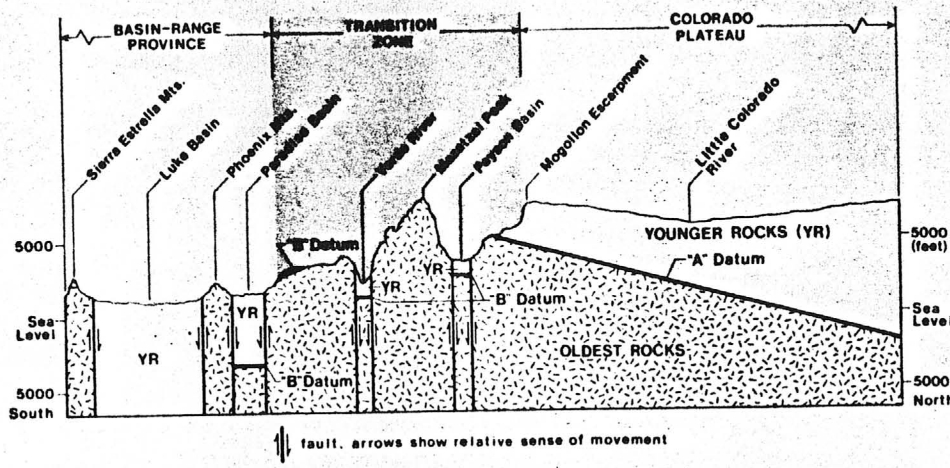


Figure 5. Schematic diagram showing present structural highness of Precambrian rocks in the Transition Zone (TZ) with respect to the adjacent Basin and Range (BR) and Colorado Plateau (CP) physiographic provinces. The "A" Datum is the contact between Precambrian (oldest) and Paleozoic (younger) rocks in the CP province; the "B" Datum is the contact between Precambrian and Tertiary (younger) rocks in the BR province.

Structural Processes

Terrain differences are direct indicators of geologic differences. The State's three physiographic regions reflect three contrasting sets of geologic conditions. The most fundamental physical parameter that controls these differences is "structure."

"Structure" is a term that describes the regional arrangement and geometric shapes (architecture) of rock masses. Rock masses can be unaffected, pulled, pushed, bent, broken, tilted, raised, and lowered to varying degrees and on different scales. The older the rock mass, the more likely it is to have undergone one or more episodes of structural disruption. An area's structural history can be determined by making systematic observations and interpretations of rock positions. Many geologists have contributed to unraveling Arizona's geologic history, and much contemporary geologic research is devoted to a better comprehension of its structural character.

The earth's surface features are the result of interaction between internal and external forces. These forces operate unequally, creating irregularities on the earth's surface. Structural disruption causes surface highs and lows. Once differential elevations exist, other physical and chemical processes (e.g., weathering, transport, and deposition) begin to attack the highs and fill the lows in an effort to regain a planar surface of equilibrium. Structural highness (uplift) brings older rocks closer to the surface. This is why Arizona's oldest rocks are so well exposed in the TZ.

Relative structural highness can be easily identified by noting the elevations of traceable reference surfaces. One such surface in the CP province is the contact between the Precambrian and Paleozoic rocks near the bottom of the Grand Canyon. This contact or interface ("A" Datum; Figure 5) has been penetrated in deep drill holes elsewhere beneath the plateau surface and resurfaces near the TZ-CP boundary (Mogollon Escarpment). Elevations of this reference contact are 1,600 feet *below* sea level beneath Black Mesa in northeastern Arizona; 3,000 feet above sea level at the Grand Canyon; 5,000 feet above sea level at the TZ-CP boundary; and some unknown amount above 7,900 feet at Mazatzal Peak in the TZ. The elevation of the reference surface at Mazatzal Peak is unknown because erosion has removed the overlying Paleozoic rocks and an unknown thickness of Precambrian rocks. The elevational extremes (-1,600 and +7,900) differ by almost 10,000 feet. Unlike the Grand Canyon, where the datum is beneath 4,000 feet of nearly flat-lying sedimentary rock, the datum on Mazatzal Peak is above the surface and is at least 5,000 feet structurally higher than at the Grand Canyon. This reference surface is also 2,000 feet higher at the plateau margin than at the Grand Canyon, and at least 3,000 feet higher at Mazatzal Peak than at the plateau margin. All data lead to the conclusion that presently there is a southerly rise in regional structure that culminates within the TZ. This rise exists because certain rock strata in the CP are warped and gently tilted downward toward the northeast (Figure 5). Geologic evidence indicates that some of this tilt was imposed prior to 90 million years (m.y.) ago when these CP rocks were much lower in elevation than they are now.

Mazatzal Peak represents the maximum elevation of Precambrian rocks in the TZ. Even the *lower* surfaces on these old rocks, for the most part, are at higher elevations than the same rocks beneath the CP. Overall, this elevational difference renders the Precambrian rocks of the TZ structurally higher than those in the CP and helps to explain why these oldest rocks appear at the surface in the TZ. It also explains why the classic Grand Canyon sedimentary rock sequence of Paleozoic age is absent in the Phoenix region: it has been eroded from areas that remain, or once were, structurally higher than the CP now is or once was. This condition applies to much of central Arizona; structural highness, lo[illegible] relief caused by erosion in the Grand Canyon exceeds 4,000 feet. This local relief, however, could not exist if there were no *regional* structural differential to induce erosion (i.e., if there were no regional relief to cause the river to downcut). Where surface relief is involved, therefore, caution is needed in assigning immediate causal factors. This is especially true of the TZ, where spectacular surface irregularity is characteristic. The complex, rugged terrain results from an incompletely understood history that includes multiple structural and erosional events. Whatever the details, the TZ is now, from a structural point of view, the backbone of Arizona (Figure 5).

The TZ is geologically unique because it preserves a geologic record that has not been found in the larger provinces that bound it. An important aspect of this record is the preservation of evidences of ancient erosion that indicate a complex history of terrain development. Because structural and erosional events are closely related, erosional events can be a key to recognition of causal structural events. Another clue to a structural happening, as already mentioned, is an out-of-place datum. A good example is the occurrence of fossil marine oysters and clams at 7,000 feet above sea level along the edge of the CP near Show Low. The enclosing sandstones, believed to be about 95 m.y. old, were deposited in a shallow sea that covered much of northern Arizona and adjacent states. Based on the belief that sea level at that time was not greatly different than at present, most geologists would say that the fossils have been uplifted and the CP province structurally raised several thousands of feet sometime during the last 95 m.y. A question remains, however: what was uplifted when? This is really two questions and neither lends itself to easy answers. In Arizona, such answers can not be found in the CP province; rather, they must be sought in adjacent regions, especially the TZ. The TZ, as discussed earlier, was uplifted more than the CP; the "what" question must therefore include the TZ as well.

The TZ, as already stated, contains a complex and fascinating erosional history that necessarily reflects a complex history of structural movement. An erosional history, such as one that is reflected in the Salt River drainage system, might be related to the major regional uplift that drove the seas from Arizona and left the oysters high and dry.

Much of the Salt River flows within the TZ. This drainage system can be divided into segments that differ markedly in terrain characteristics. The 18-mile-long segment between Canyon Creek to the northeast and Lake Roosevelt to the southwest, in which the river flows southwest, is especially intriguing. Relief between the river and the regional high point in the adjacent Sierra Ancha (Aztec Peak - 7,694 feet) is about 4,700 feet. This is more than the relief in the Grand Canyon [illegible] El Tovar on the south rim.

Upstream from Canyon Creek is the more familiar Salt River Canyon segment that is

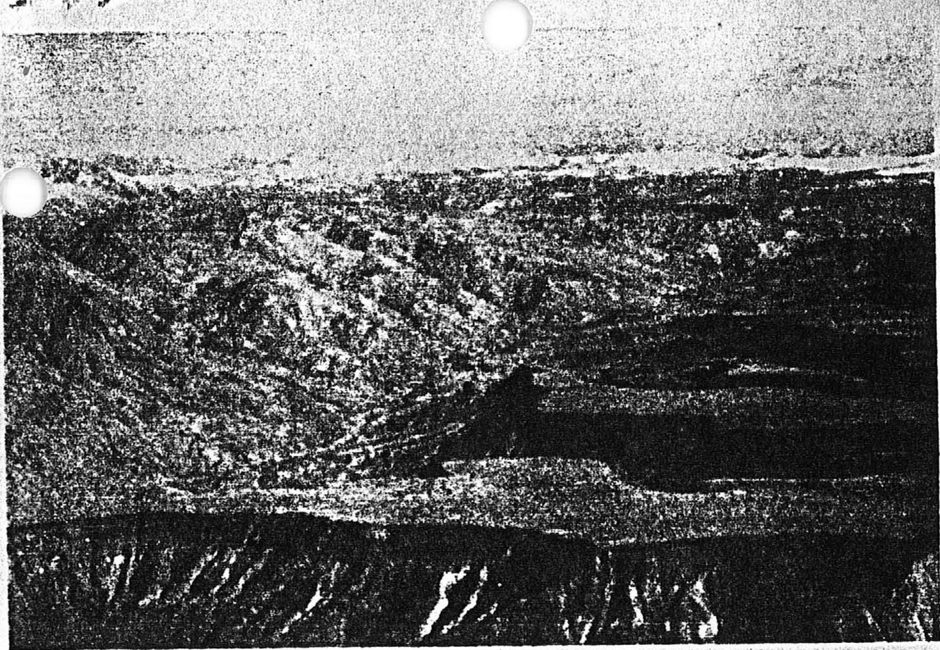


Figure 6. *Looking north into the Transition Zone. Flat topped, eroded mesas are capped by the lava (volcanic rocks) of "B" Datum (see Figure 5). Although locally the lavas overlie slightly older sedimentary materials (white foreground), they generally overlie Arizona's oldest rocks. The sediments and volcanics, which are about 15 to 17 m.y. old, are believed to have accumulated in a previously existent erosional valley. They are now being destroyed by a continuing episode of erosion. Drainage is to the south into the topographically lower country of the Basin and Range province.*

past and present, promotes erosion.

A reference surface is also needed for structural comparison of the TZ with the BR province to the southwest. The sedimentary rocks used as a reference surface in the CP [illegible]ince have been eroded away in the BR [illegible]vince. Although Precambrian rocks are present in the BR region, they tend to be covered by much younger rocks than in the CP region to the north. The contact between the Precambrian rocks and these younger rocks serves only as a reference surface for interpretation of events that have happened since the development of these younger rocks ("B" Datum, Figures 5 and 6).

One of the characteristics of the BR province is the expanse of low-elevation desert valleys or basins. Drill samples and other information indicate that deep structural basins commonly underlie the low desert surfaces. Relative to the TZ, these basins are downdropped along faults. Available data indicate that downdrops of 6,000 to 8,000 feet are not unusual; displacement may be as much as 10,000 feet in some areas. Paradise Valley north of Phoenix, for example, represents a BR basin adjacent to the TZ. A drill hole at the north end of the basin was stopped above the younger reference datum at an elevation of 3,676 feet *below* sea level. To the north near Carefree, the outcropping datum at the edge of the TZ is at an elevation of 2,500 feet *above* sea level (Figure 6). The minimum structural differential of these two points, therefore, is about 6,000 feet, with the [illegible]n floor as the low point and the TZ [illegible]crop as the high point. The causal mechanism for this structural disruption is faulting. A minimum differential of more than 11,000 feet, however, exists between Precambrian rock in the Paradise Valley basin of the BR province (-3,676 feet) and Precambrian rock at Mazatzal Peak in the TZ (+7,900 feet). Faulting accounts for 6,000 feet; the remaining 5,000 feet that is confined to the TZ itself was inherited *prior* to the BR faulting event and is subject to investigation of the actual cause(s) of this internal differential.

The time span between "A" Datum and "B" Datum represents a missing record of about 500 m.y. in the Phoenix and TZ regions where all Paleozoic and Mesozoic strata are absent. Where this missing record prevails, there is no simple way of reconstructing all of the structural movements that have affected the very old crystalline rocks. The only conclusions to be drawn here might be these: (1) in the CP, the older "A" Datum was tilted so that structural highness prevailed to the south; and (2) "B" Datum shows that there is considerable differential elevation, much of which is caused by faulting that leaves the TZ structurally high relative to the flanking basins in the BR province. The net result of geologic history has been the creation of a TZ, which, because of its structural highness relative to the CP and BR province basins, features extensive exposures of Arizona's oldest rocks (Figure 5).

Erosional Events

Two basic processes create differences in land elevation: (1) structural processes, or the differential movement of rock masses, as discussed earlier; and (2) erosion, which causes local land-surface differentials. The crossed by State Highway 77 between Globe and Show Low. Because of the low width-to-depth ratio, this portion is impressive compared to the Sierra Ancha segment, which has twice the relief, but is also much broader (Figure 7). Why are there such form differences in adjacent segments of the same river?: they have contrasting pre-Salt River geologic histories. Evidence now indicates that the shallower and narrower west-trending Salt River Canyon segment was carved by the Salt River since 12 m.y. ago. In contrast, the deeper and broader southwest-trending Sierra Ancha segment has a notably earlier history of canyon-cutting (prior to 30 m.y. ago) by a river that drained towards the northeast — 180° opposite to the present flow direction (a view first expressed by Peirce, 1982).

The ground work for establishing this idea of paleotopography in the Sierra Ancha segment was actually laid by N. H. Darton (1925, p. 229, 230), a most perceptive field geologist. Although he clearly diagrammed the critical factors, he did not discuss or otherwise acknowledge their implications. Likewise, although Wilson and others (1959) clearly mapped paleocanyon relationships, they never acknowledged or discussed them. The only explanation for these uninterpreted observations seems to be that they were subordinate considerations at the time. Had these geologists had the benefit of present-day age-dating techniques, they would probably have grasped the antiquity behind these relationships and thus been more impressed with their own findings. The important structural implications behind these and subsequent observations are reviewed below.

The contrast between the Sierra Ancha and Salt River Canyon segments is sharply defined by the slightly west of north-trending Canyon Creek Fault (Figure 7). Finnell (1962) has shown that there were at least two episodes of movement along the Canyon Creek Fault, each with an opposite sense of movement relative to the other. The early movement, before 30 m.y. ago, *raised* the west side (relative to the east) several thousands of feet. This early movement promoted about 4,000 feet of canyon-cutting erosion on the high western block and defined the ancestral southeastern edge of the Sierra Ancha segment (Figure 8A). This drainage flowed northeastward from the high block towards the CP province. Whether or not it drained onto the CP remains an elusive point of research. After the canyon was incised, later movement *dropped* the western block (relative to the east) several thousand feet to its present position, where vestiges of the early canyon could be preserved and the new southwesterly flowing Salt River could establish itself. This later dropping of the west side left the east side high and thus promoted the younger cycle of canyon cutting that characterizes the modern Salt River Canyon segment (Figure 8B).

Such ups and downs of the land surface, though sometimes difficult to document, are not unusual. In any given locality, earth stresses and their manifestations vary through time. The early indication of pre-30-m.y. uplift cited here is based upon local evidence. Although a much larger region undoubtedly underwent structural adjustment, it is not yet possible to delimit with certainty the larger zone that was affected. The rock units that accumulated in the bottom of the paleocanyon are the same as those that overlie the large copper deposits in the Miami, Globe, and Ray areas: It seems likely, therefore, that the uplift-erosion episode that produced the paleocanyon may have also caused the unroofing of these ore deposits. Young (1982) postulates that 180 miles to the northwest other TZ paleocanyons, also with 4,000 feet of relief, were eroded by north-flowing drainage. Dating methods indicate that these paleocanyons and the Sierra Ancha segment are similar in age. Such evidence suggests that the TZ was once even structurally higher than it is today and that it has foundered since its heyday.

This structural information from the TZ enables further interpretation of the oyster fossils at 7,000 feet along the southern edge of the adjacent CP province. It seems probable that their structural position was influenced by an uplifting event that induced canyon-cutting in the TZ during and after formation of the youngest of the nearby copper deposits (59 m.y. ago) and before rock units began to accumulate on the irregular erosional surface 30 m.y. ago.

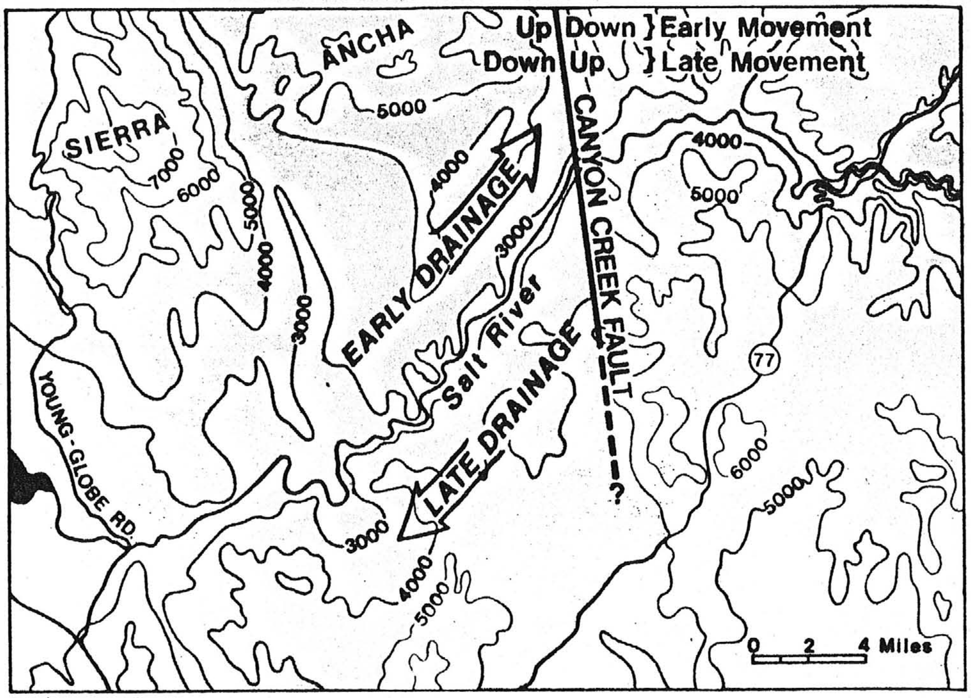


Figure 7. Map depicting contrasting forms of two canyon segments occupied by the Salt River in the Transition Zone; the Canyon Creek fault is the boundary between the two segments. Shading of elevations below 5,000 feet illustrates the comparative widths and contours the overall relief. See Figure 8 for faulting history.

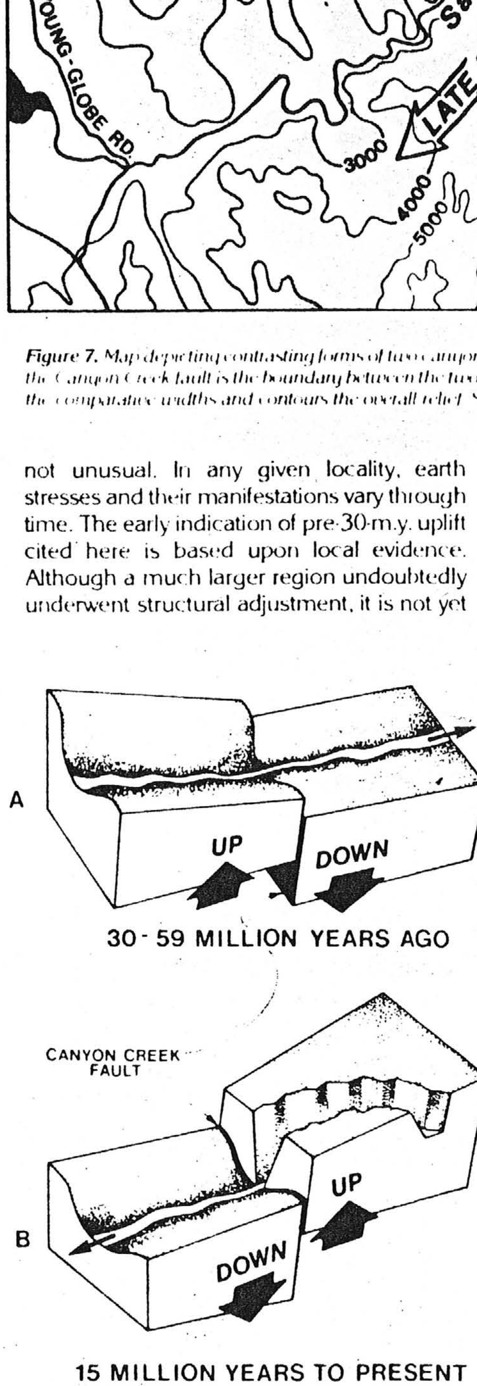


Figure 8. Block diagrams illustrating how two episodes of movement on the Canyon Creek fault influenced drainage development and canyon styles along the course of the Salt River. (See also Figure 7.)

Conclusion

A Transition Zone, in one form or another, deserves to be recognized as one of Arizona's three basic physiographic subdivisions. Proportionally, its contributions to the State (water, wildlife, scenery, wilderness, recreation, minerals, etc.) far exceed its size. Its

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

TO ACCOMPANY MAP MF-1573-A

MINERAL RESOURCE POTENTIAL OF THE MAZATZAL WILDERNESS AND CONTIGUOUS ROADLESS AREA GILA, MARICOPA, AND YAVAPAI COUNTIES, ARIZONA

SUMMARY REPORT

By

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STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, 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 Mazatzal Wilderness (NF3048) and Mazatzal Wilderness Contiguous Roadless Area (3-016) in the Tonto and Coconino National Forests, Gila, Maricopa, and Yavapai Counties, Arizona. Mazatzal Wilderness was established by Public Law 88-577, September 3, 1964. The contiguous 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.

SUMMARY

Small quantities of gold, silver, and copper have been produced from the Mazatzal Wilderness. The wilderness has a high potential for gold, silver, and lead resources in veins in the vicinity of the Story mine, a high potential for silver and copper resources in vein deposits near Copper Mountain, a moderate potential for silver, gold, and copper in vein deposits in one area along the eastern border, and a high potential for copper in vein deposits at Mineral Creek. The Copper Mountain area, the area of silver, gold, and copper vein deposits along the eastern border, and the Mineral Creek area also have a low potential for copper in massive sulfide deposits. Two additional areas in the eastern and northern parts of the wilderness have a low potential for copper in vein and massive sulfide deposits. The wilderness has a high potential for copper in massive sulfide deposits and a moderate potential for copper in carbonate veins at Copper Camp Creek. An area east of the Mazatzal Wilderness has a high potential for gold resources in rocks that also occur in the wilderness, though no gold was found in these rocks in the wilderness. Three areas in the southern part of the wilderness have high, moderate, and low potential for mercury resources. A low potential for molybdenum exists west of the wilderness in three areas, two of which extend into the roadless area and the wilderness. The central part of the wilderness has occurrences of tin, but little evidence of a resource potential for tin. Two areas southwest of the wilderness have low and moderate potential for uranium, and one of these areas extends into the roadless area and the wilderness. No evidence of a potential for fossil fuels was identified in this study.

INTRODUCTION

The Mazatzal Wilderness and the contiguous roadless area are located in the Tonto and Coconino National Forests, west and southwest of Payson, and are almost exactly in the geographic center of Arizona (fig. 1). This is a region of relatively small mining districts and few mines, but occurrences of many different metals are widespread. This report documents the geology, mining activity, and mineral potential of the Mazatzal Wilderness and adjacent areas and discusses long-known, as well as newly discovered, mineral occurrences and the possibility of undiscovered mineral resources.

Investigations summarized in this report were conducted in the field by the U.S. Bureau of Mines and the U.S. Geological Survey, principally in 1979-1980. A few areas were studied briefly in 1981 and 1982. The Bureau of Mines examined mines, prospects, mineral claims, and mineralized areas and searched mining records. The Geological Survey conducted geologic mapping, geochemical sampling, remote-sensing studies, and geophysical examinations.

Physiography

The Mazatzal Mountains constitute the dominant physiographic feature of the wilderness. The eastern slopes of these mountains rise steeply from about 3,500 ft in altitude along the valley of Rye Creek east of the range to 7,903 ft at Mazatzal Peak. To the west, the range slopes steeply from the crest, then more gently along the lower flanks to the Verde River, one of the main drainage channels of Arizona. In the northern part of the wilderness, the East Verde River, a tributary of the Verde, occupies a deep canyon that separates the Mazatzal Mountains from mesas to the north. The lowest parts of the wilderness have altitudes of about 2,200 ft and are located near Bartlett Reservoir in the southwestern part of the area studied.

Geologic setting

The Mazatzal Mountains lie at the margin of the Basin and Range physiographic province in a region of Arizona where the mountain ranges are about as wide as or wider than

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[1]U.S. Geological Survey
[2]U.S. Bureau of Mines

the intervening basins. The Mogollon Rim, which defines the southern physiographic border of the Colorado Plateau, is about 5 mi north of the Mazatzal Wilderness. Paleozoic rocks, extensively exposed along the Mogollon Rim, have been largely eroded from the wilderness and roadless areas. The few remaining masses of Paleozoic rocks in the wilderness rest on thick sequences of mostly steeply tilted stratified Proterozoic rocks and on Proterozoic granitic rocks. These rocks are similar to Proterozoic layered and intrusive rocks exposed widely in central Arizona east and northwest of the wilderness. Tertiary volcanic rocks exposed within the wilderness are at the southern end of a large volcanic field that extends north and northwest for more than 100 mi in the western parts of the Colorado Plateau and adjacent areas of the Basin and Range province.

Mining activity

Prospecting has been conducted intermittently in the Payson area, including the Mazatzal Wilderness, since the discovery of gold near Payson in the 1870's. Within the wilderness and contiguous roadless area, gold and silver were the object of prospecting activity before World War II (Lausen and Wilson, 1925) and may have been mined in small quantities from several deposits. Few records are available for this period. Sporadic exploration for precious and base metals since World War II has resulted in the production of small amounts of copper, gold, and silver in the wilderness. Within a few miles of the southeast corner of the wilderness, mercury was produced at several mines from 1913 to the 1960's (Beckman and Kerns, 1965), and exploration continued at a low level of activity to 1979. Ore containing copper, gold, and silver was mined in areas immediately east of the wilderness in the period 1938-1956. Uranium occurrences near Bartlett Reservoir were revealed in drill cores in the 1970's. Exploration for gold was being conducted a few miles southwest of Payson in 1980.

GEOLOGY, GEOCHEMISTRY, AND GEOPHYSICS PERTAINING TO MINERAL RESOURCE ASSESSMENT

General Geology

The geology of the Mazatzal Wilderness and contiguous roadless area was mapped during this study and is shown on the accompanying 1:48,000-scale map and on figure 2. The only previous description of the geology in the wilderness (Wilson, 1939) is of the Proterozoic rocks in higher parts of the Mazatzal Mountains between Cactus Ridge and North Peak. Ludwig (1973) mapped the geology of the mercury district, which is mainly outside the wilderness south of Cactus Ridge. Part of this mapping is included in the geologic map that accompanies this report.

The oldest rocks of the Mazatzal Wilderness and the surrounding area consist of sequences of Early Proterozic sedimentary and volcanic stratified rocks intruded by gabbro, diorite, and alkali granite. These rocks in turn are overlain depositionally by Early Proterozoic sedimentary strata. The aggregate thickness of the Proterozoic stratified rocks is 61,000 ft. The Proterozoic rocks locally are capped by Paleozoic strata or they are partly buried by Tertiary volcanic flows and interstratified sedimentary rocks.

The oldest of the Early Proterozoic rocks in the wilderness may be the structurally fragmented stratified sequence of mafic volcanic flows, pillow basalts, volcaniclastic rocks, graywacke, minor rhyolite, jasper, and siltstone exposed on the east flank of the Mazatzal Mountains, along the East Verde River, and on the south rim of Buckhead Mesa. This stratigraphic section is about 26,000 ft thick and is informally referred to here as the East Verde River sequence. It is thought to be older than the Early Proterozoic Alder Formation[3] and has lithologic similarities to the older (1,740-1,760 m.y.) Yavapai Series in the Jerome-Prescott region (Anderson and others, 1971; L. T. Silver, oral commun., 1982). A correlation with the Yavapai Series is not clearly established.

Proterozoic rocks of two stratigraphic sequences, each about 3,300 ft thick, crop out near the confluence of the Verde River and East Verde River in the northwestern part of the wilderness. One sequence, consisting of siltstone overlain by rhyolite conglomerate, rhyolite, and andesite is exposed in the Limestone Hills and rests in apparent conformity on the East Verde River sequence described above. The second sequence occurs to the west in the vicinity of Squaw Butte and is composed of graywacke, quartzite, and rhyolite. A contact between the two sequences has not been found. Both of these sequences have rocks similar to the upper part of the Alder Formation and the overlying rhyolite, and to the rhyolite that is widespread in the eastern part of the wilderness beneath quartzite. Both sequences are weakly metamorphosed to the greenschist facies and are largely unfoliated.

Diorite, gabbro, and minor syenite of Early Proterozoic age occur as small intrusive masses in the Proterozoic stratified rocks in the Limestone Hills in the northwestern part of the wilderness, and as a large complex east of the wilderness between Buckhead Mesa and Rye Creek. These rocks contain a few large inclusions of metasedimentary rocks in the eastern part of the area outside the wilderness.

Sedimentary and volcanic rocks of the Alder Formation, including felsic porphyry sills, are exposed in a tightly appressed syncline along the southern margin of the area. The formation comprises weakly to strongly foliated sandstone, graywacke, shale, conglomerate, rhyodacite and rhyolite tuffs and flows, and subordinate mafic volcanic rocks. These rocks are metamorphosed to the greenschist facies of regional metamorphism. According to Ludwig (1973), the formation is entirely volcanic or volcanogenic in origin. He estimated the thickness of the formation to be about 18,000 ft. During the present study an additional 5,000 ft of strata were found in the wilderness beneath the rocks mapped by Ludwig. Ludwig (1973) described the Alder Formation as conformably overlain by the Red Rock Rhyolite of Wilson (1937, 1939), a thick (more than 3,000 ft) sequence of alkali rhyolite, predominantly ash-flow tuff. The Alder Formation is in contact with other Proterozoic rocks of the area only along the northeast-trending Sheep Mountain fault. Lithologically the Alder Formation is dissimilar to the East Verde River sequence, and regional relations suggest that the Alder Formation is younger.

The central part of the Mazatzal Wilderness is underlain by a large complex of alkali granite and granophyre that intruded the East Verde River sequence and the gabbro-diorite complex. Regional relations indicate that the granite also is younger than the Alder Formation. Granophyre is widespread in the wilderness and was emplaced as huge sheet-like bodies high in the alkali granite complex. The granite contact dips shallowly northward beneath stratified rocks of the East Verde River sequence, which are intruded by dikes of tourmaline-bearing rhyolite porphyry that probably are related to the alkali granite. The alkali granite is thought to correlate with granite for which an apparent age of 1,730±15 m.y. was obtained by L. T. Silver (Conway, 1976) from a sample collected 3.5 mi east-northeast of Payson.

A quartz monzonite porphyry crops out in a 2.5 mi^2 area at Tangle Creek on the west border of the area, just outside the wilderness and adjacent roadless area. This rock type appears to be more calcic than the associated alkali granite and differs in geochemical signature from the alkali

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[3]Anderson and others (1971) geographically restricted the Alder Group to its type locality in the Mazatzal Mountains. The unit is here reduced in rank to Alder Formation since it contains no formations. Furthermore, the age of the unit is here revised from Precambrian to Early Proterozoic based on Pb-U dates of 1,730±20 m.y. from metavolcanic rocks as reported by Ludwig (1973).

granite in having anomalous a[illegible]unts of molybdenum, boron, tungsten, thorium, niobium, and yttrium, and in having distinctive gravity and aeromagnetic signatures. The quartz monzonite porphyry is thought to have intruded the alkali granite, but the relative ages of these intrusive rocks have not been established, and it is not known if the quartz monzonite is Proterozoic.

A sequence of Early Proterozoic rocks underlying the higher parts of the Mazatzal Mountains consists of alkali rhyolite ash-flow tuff overlain in turn by the Deadman Quartzite of Wilson (1939), the Maverick Shale of Wilson (1939), and the Mazatzal Quartzite (Wilson, 1939). The close spatial association of the rhyolite with the upper parts of the alkali granite complex and the apparent chemical affinities of the rhyolite and granite suggest that the rhyolite may be the extrusive roof-rock equivalent of the granite that intruded it. Similar thicknesses and lithologic and chemical similarities suggest that this rhyolite and the Red Rock Rhyolite, which crops out south of the Sheep Mountain fault, may be equivalent. This is compatible with the sequence in Tonto Basin (Conway, 1976), where a thick alkali rhyolite rests on the Alder Formation and is overlain by a great thickness of quartzite that is similar to the Deadman and Mazatzal Quartzites. An obstacle to this idea, however, is the fact that the Alder Formation, thousands of feet thick south of Sheep Mountain fault, is apparently missing beneath the rhyolite north of the fault. Conway (1976) and Wilson (1939) suggested that the Deadman Quartzite of Wilson (1939) and the Mazatzal Quartzite correlate with quartzite at Natural Bridge. Silver (1967; oral commun., 1976) dated a rhyolite flow within the quartzite at Natural Bridge as 1,715 ±15 m.y.

Porphyritic quartz monzonite and pegmatite crop out in the southwest corner of the area outside the wilderness and resemble granitic rocks of Middle Proterozoic (Ruin Granite) age that have been recognized in a wide area farther south in the Mazatzal Mountains.

Cambrian and Devonian sandstone and carbonate rocks once were more abundant throughout the wilderness, but they crop out today only in the Limestone Hills, along lower Pine Creek, and, together with Mississippian and Pennsylvanian strata, in upper Pine Creek. These rocks have a total thickness of about 800 ft and are regarded as having been deposited in shallow seas at the western edge of the North American craton.

Rocks of Tertiary age cover about one-half of the area and record an intricate history of volcanism and sedimentation from the middle of the Miocene to about the middle of the Pliocene. Rocks emplaced during this time interval include basalt flows and intertonguing sandstone, limestone, and gravel, forming a composite section as thick as 2,000 ft. Dacite flows and tuffs occur locally in the Tertiary strata, and dacite porphyry exists as intrusive rocks at Lion Mountain, Squaw Butte, and near the northwest corner of the area.

The youngest rocks in the area are poorly consolidated Quaternary sand and gravel in pediment alluvium, terrace gravels, and stream deposits. Quaternary travertine accumulated at a locality in lower Pine Creek, and landslide masses are found in many parts of the area.

The rocks of the Mazatzal Wilderness record a long and complex structural history (Wilson, 1939; Conway and others, 1982). The oldest deformation that affected rocks in the area was the northwestward to northward tilting of the Proterozoic stratified rocks of the East Verde River sequence. The Alder Formation may have been deformed at this time, although the relative ages of the deformation experienced by these rocks and the stratified sequences along the East Verde River are unknown. The next recorded event was the emplacement of the alkali granite and associated granophyre into the roof rhyolite. After deposition of the Deadman Quartzite, Maverick Shale, and Mazatzal Quartzite, this sedimentary sequence and, locally, the underlying rocks were folded into a northeast-trending syncline and broken by thrust faults along which movement was to the northwest. Prominent northeast- to north-trending faults, including the arcuate Deadman and Sheep Mountain faults, formed subsequently, as did some northwest-trending faults. These faults are the youngest Proterozoic structural features in the area studied. Many north- and northwest-trending faults are of Tertiary age, and some of them merged with Proterozoic faults and reactivated them. The Tertiary faults appear to have been active as early as middle Miocene and to have contributed to the development of Basin and Range topography and structures.

Geology related to mineralization

Many of the mineral occurrences in the Mazatzal Wilderness appear to be related directly or indirectly to the alkali granite. The granite and associated granophyre are tin bearing. Cassiterite has been found in modern stream sediments in areas of greisen zones in the granitic terrane, although it has not been identified in bedrock samples. The greisen zones are composed of highly sericitized quartz-rich granitic rocks containing abundant quartz veins and locally tourmaline and hematite. The presence of cassiterite and tourmaline and high values of tungsten, beryllium, boron, fluorine, and rare-earth elements in stream sediments in areas of greisen in the granitic terrane are indicative of mineralization late in the crystallization history of the granite. This mineralization was followed by deposition of tin, silver, copper, gold, arsenic, antimony, mercury, bismuth, lead, and zinc in northeast-trending veins. The genetic relationship of this mineralization to the alkali granite is based on the presence of tin and mercurian, auriferous, and argentiferous sulfosalts in veins in both the granite and its host metamorphic rocks and on the existence of the same suite of trace elements (tin, boron, and niobium) in these veins as in the greisen zones in the alkali granite. Tourmaline and fluorite locally are abundant in the vein systems. The sulfide minerals contain silver, bismuth, arsenic, and other elements found in well-known tin mineralization systems in the world (Taylor, 1979). The northeast-trending faults that contain the veins displace rocks as young as the Mazatzal Quartzite and could have been active earlier. These relationships indicate that a significant time interval may have occurred between emplacement of the granite and the development of related vein mineralization, as has been described for tin granites elsewhere (Sainsbury and Reed, 1973; Jones and others, 1977).

Gold occurrences in diorite east of the Mazatzal Wilderness may be related to the alkali granite, but this association has not been firmly established. The gold deposits occur on northwest-trending faults that have had movement—presumably of Tertiary age—since the gold mineralization. It is not known if these faults existed in Proterozoic time, but Proterozoic faults of northwest trend occur in the area.

Secondary copper minerals occur in mafic volcanic rocks of the East Verde River sequence in the Eisenhauer Canyon area immediately east of the wilderness boundary. This copper may have been derived from syngenetic copper in the volcanic host.

The mafic volcanic rocks in the East Verde River sequence accumulated in a marine environment favorable for stratabound massive sulfide-type mineral deposits. Massive sulfide deposits occur in Proterozoic marine volcanic rocks at Jerome, Arizona (Anderson and Nash, 1972). Although no deposits of this type have been discovered in the area, the favorable rocks and the widespread copper vein deposits suggest that massive sulfide bodies may exist in the East Verde River sequence and could be the source of the secondary copper in Eisenhauer Canyon and elsewhere along the east and north sides of the Mazatzal Mountains as far northwest as Copper Mountain.

Copper occurrences in the same mafic volcanic unit from the Casterson mine to the House mine are spatially associated with apophyses of granitic rocks and include significant amounts of gold, silver, arsenic, mercury, and antimony, suggestive of a genetic relation to the hydrothermal system in the alkali granite. However, some of this copper may have come from the mafic volcanic host. These deposits were mined for their precious metal content with copper as a byproduct.

Primary and secondary copper minerals occur in mafic volcanic rocks in the Mineral Creek area near intrusive rhyolite related to the alkali granite. These minerals appear to be concentrated along faults that form a complicated pattern at the intersection of the Proterozoic Deadman and Tertiary East Verde fault zones. There is a weak expression in this area of the suite of elements related to the mineralization associated with the alkali granite. However, the location of copper minerals on or near Tertiary faults argues for remobilization.

Primary and secondary copper minerals with small amounts of gold, silver, and mercury occur at mines and prospects in the Copper Mountain area. These occurrences may represent extensions of vein systems in the granite. Widespread copper minerals in the mafic volcanic rocks and gossan interpreted as clasts in the graywacke are suggestive of earlier, syngenetic copper.

Abundant veinlets of secondary malachite are associated with stratiform lenses of gossan and chert at Copper Camp Creek in the wilderness south of Sheep Mountain fault. Primary sedimentary structures in the gossan and clasts of gossan in associated conglomerate attest to a syngenetic origin of the primary minerals and suggest that a massive sulfide body may occur in the Copper Camp Creek area. Extensive well-developed chlorite beneath the chert and gossan lenses is indicative of hydrothermal alteration and venting in the immediate vicinity. But here, as in copper deposits associated with mafic volcanic rocks immediately east of the wilderness, elements such as arsenic, antimony, bismuth, gold, silver, and mercury, typical of the hydrothermal system related to the alkali granite, are present and suggest an epigenetic overprint.

Mercury deposits of the Sunflower district east of the southern part of the Mazatzal Wilderness are in steeply dipping highly foliated strata of the Alder Formation and contain cinnabar near the surface and mercurian tennantite, tourmaline, and cinnabar at depth (Lausen and Gardner, 1927; Faick, 1958; Ransome, 1915). The mercurian sulfides and tourmaline suggest an affinity to the sulfide mineralization in the Proterozoic alkali granite. The cinnabar may have evolved from the breakdown of preexisting sulfides probably during Tertiary volcanism. Cenozoic basalt, apparently intrusive into the Alder Formation, occurs near Highway 87 immediately south of the Sunflower district, and Miocene volcanic rocks occur to the west in the wilderness. Aeromagnetic data suggest a possible buried intrusive body in the vicinity of the mercury district.

The quartz monzonite porphyry at Tangle Creek, immediately west of the Mazatzal Wilderness and contiguous roadless areas, was identified during this study as mineralized, although no prospects or mines were found. Unusual concentrations of molybdenum, bismuth, tungsten, uranium, thorium, and scandium were found in a narrow zone from the west side of Tangle Creek outside the wilderness and roadless area, north into the roadless area. Anomalous molybdenum and uranium concentrations in stream waters from the quartz monzonite porphyry at Tangle Creek were the highest found in the area. The geochemical suite and data from water analyses are suggestive of porphyry molybdenum mineralization.

Uranium in Tertiary tuffs and sedimentary rocks along the Verde River could have been derived from the siliceous tuffaceous debris they contain or from nearby Proterozoic granitic rocks. The granites of the area contain anomalous concentrations of uranium and were exposed when the sedimentary rocks accumulated.

A small occurrence of copper-stained quartz, locally considered a gem stone because it resembles turquoise, occurs in freshwater limestone and siltstone low on the east flank of Chalk Mountain.

Geochemistry

Three sample media were selected as best for geochemical sampling in the arid high desert environment of the Mazatzal Wilderness: stream sediment, heavy-mineral concentrates from stream sediment, and rock. Sediments and concentrates were collected from first- and second-order stream drainages at 472 localities in the wilderness and contiguous roadless areas, each drainage representing an area of approximately 1 to 2 mi^2. Selected rock samples also were taken from areas of altered outcrops and from existing mining areas to determine mineral suites and trace-element signatures of mineralized systems.

The samples were screened and the minus-80-mesh fraction of the sediment and the nonmagnetic heavy (+2.6 specific gravity) fraction of the concentrate were analyzed for 31 elements by a semiquantitative emission spectrographic method (Grimes and Marranzino, 1968). Rock samples were pulverized and also analyzed by semiquantitative emission spectrographic methods. The resulting analyses along with statistical data for the Mazatzal Wilderness and contiguous roadless area are listed in two reports by Marsh and others (1983).

Semiquantitative spectrographic analyses of the nonmagnetic fraction of the heavy-mineral concentrates from stream sediments proved to be the most useful in evaluating the Mazatzal Wilderness and contiguous roadless area and have provided the principal evidence for mineral systems related to the Proterozoic alkali granite and the quartz monzonite prophyry in the Mazatzal Wilderness and surrounding areas. This sample medium contains the common ore-forming sulfide and oxide minerals as well as barite and other nonmagnetic minerals (zircon, apatite, fluorite, cassiterite, rutile, and some sphene and tourmaline). The concentrate medium also provides data that give a greatly enhanced anomaly pattern, as all of the more common (low specific gravity, less than 2.6) rock-forming minerals (quartz and feldspar) that tend to dilute the anomalies have been removed.

Several suites of geochemically associated elements found in samples collected during this study were discussed earlier as having formed during two or more episodes of mineralization. In addition, chromium and nickel were identified in stream sediments and in panned stream-sediment concentrates from of Tertiary basalts that have not been mineralized. The highest concentrations of these elements form sharply defined geochemical map patterns at the east edge of the wilderness from the East Verde River north and in the west-central part of the Mazatzal Wilderness northeast of Horseshoe Reservoir. The source of the elements is thought to be a chromian pyroxene that formed the bulk of the concentrate samples taken from areas draining the basalts.

In an evaluation of uranium resource potential in conglomerate of several Proterozoic formations in central Arizona, Anderson and Wirth (1981) obtained data on the concentration of uranium in the Deadman Quartzite of Wilson (1939) and the Mazatzal Quartzite. Except for local minor enrichments of uranium (as much as 33 ppm) in hematite-rich conglomerate near the base of the Deadman, no significant sedimentary concentration of uranium was found in these quartzites in the Mazatzal Wilderness. Anderson and Wirth (1981) identified no resource potential.

Remote sensing

As part of this study, limonitic materials were identified in images of the Mazatzal Wilderness area using a color-ratio-composite method (Rowan and others, 1974). This technique combined with field data was used to map areas of hydrothermal alteration associated with limonitic materials and to help define mineralized systems. The term limonite, as defined by Blanchard (1968), is used as a general term for hydrous iron oxides but is modified to include any material with the unique spectral reflectance properties of the ferric oxide minerals such as hematite and goethite as defined by Hunt (1980). The minerals pyrite and (or) hematite are almost universally associated with hydrothermal alteration potentially related to mineralization and these minerals weather to produce limonite, which is detected by this technique. Areas of hydrothermal alteration that are totally lacking limonitic materials will not be detected by this technique; however, such areas missed by this approach are believed to be insignificant in the Mazatzal area. A more significant problem in the Mazatzal area was the presence of greater than 40 percent vegetation cover, which severely hindered the ability to map the distribution of limonitic rocks and soils by this technique. This vegetation problem was signficant for much of the wilderness where small scattered areas of limonite surrounded by areas of high vegetation cover were observed. These small limonitic areas are generally not related to mineralization but to exposed portions of known limonitic lithologies.

This vegetation problem, however, does not appear to be significant for the alkali granite, which includes the largest limonite anomaly. This large anomaly is characterized in a 1:250,000-scale color-ratio-composite image as an area of pervasive limonite staining, as opposed to the other part of the alkali granite, which, as seen in the image, has small scattered limonitic areas. These small limonitic areas are apparently due to limonite after mafic minerals in the granite. The large limonite anomaly is spatially associated with the tin mineral suite and is believed to define the extent of iron oxidation metasomatism associated with the tin mineralization. Inspection on the Landsat images of this same granite surrounding the Mazatzal Wilderness indicates that the iron metasomatism is not a universal characteristic of the granite and that the single largest area of iron metasomatism, which is spatially related to tin greisen, is within a part of this granite.

Geophysics

Aeromagnetic maps and a gravity map were made for this study. The aeromagnetic maps contain data from a low-level survey, flown at 1,000-ft terrain clearance, and a high-level survey flown at a constant altitude of 9,000 ft (Sauck and Summer, 1970). In addition, electromagnetic data were gathered in the Copper Camp Creek area in the southern part of the Mazatzal Wilderness during this study.

The low-level and the high-level aeromagnetic data are complementary in this study in that data from the low-level survey show the effects of rocks at and near the surface, and data from the high-level survey reflect control by deeper seated bodies.

The complex patterns of the small aeromagnetic highs and lows in the low-level survey are caused principally by Tertiary basalt. Aeromagnetic highs in the Sunflower mining district in the southeastern corner of the area, where the basalt is absent, follow the grain of the Alder Formation, and several highs along the East Verde River in the north-central part of the wilderness probably reflect Proterozoic gabbro, which lies in part beneath the basalt. Wherever alkali granite and the overlying thick sections of rhyolite and quartzites are preserved, relatively low magnetic values occur.

The high-level aeromagnetic survey also shows low magnetic relief in areas of alkali granite and the overlying rhyolite-quartzite section. A prominent high, centered west of Tangle Creek at the center of the western margin of the area, projects southeastward into the Mazatzal Wilderness. This anomaly is thought to result from an intrusive body that is concealed by Tertiary basalt and sedimentary rocks in the wilderness and may be related to the quartz monzonite porphyry exposed at Tangle Creek. A high-level aeromagnetic anomaly at the southeast corner of the area, outside the wilderness, extends northwestward into the Sunflower mercury district and is not explained by any exposed rocks. This anomaly may be caused by a buried intrusive mass. The spatial distribution of mercury deposits in the Sunflower district suggests a possible genetic relationship between mineralization and the inferred intrusion. Aeromagnetic anomalies of high relief at the eastern edge of the area outside of the wilderness, and two high anomalies in the north-center of the wilderness are interpreted as resulting from Proterozoic gabbro and diorite. The aeromagnetic gradient reflected by southward-rising magnetic values in the southern part of the high-level map may be related to a large Proterozoic granitic pluton.

An electromagnetic survey was conducted at Copper Camp Creek across a small part of the mineralized zone using an instrument especially designed to detect massive sulfide bodies. No evidence of a massive sulfide body was found above the maximum search depth of about 400 ft.

The gravity data for most of the Mazatzal Wilderness show relatively low values indictive of the widespread distribution of the Proterozoic alkali granite at the surface and of its inferred probable distribution in the subsurface. In particular, low gravity readings suggest that the granite underlies the rhyolite and overlying quartzites and shale in the vicinity of Mazatzal Peak in the east-central part of the wilderness, and that it may underlie the Tertiary basalt cover north of the East Verde River. Relatively high gravity values are associated with the Alder Formation south of the gravity gradient that follows the Sheep Mountain fault. This association suggests that alkali granite, if present, is very deep. This gradient extends to the Verde River along the projection of the fault and suggests a westerly extension of the Alder Formation beneath Tertiary rocks. A positive gravity anomaly in the Tangle Creek area lies over exposures of the quartz monzonite porphyry and is partially coincident with the nose of the high-level aeromagnetic high that trends southeastward into the wilderness at the assumed projection of an extensive intrusive mass, which includes the porphyry. The fact that the gravity anomaly in the Tangle Creek area is not coincident with the highest part of the magnetic anomaly west of the nose further suggests different geophysical responses to various phases of the larger intrusive body. The gravity and aeromagnetic patterns north of Tangle Creek along the west border of the roadless area also may reflect different phases of the quartz monzonite and related rocks. A positive gravity anomaly outside the east edge of the wilderness is caused by a large diorite body and the metamorphic mafic volcanic rocks to the west.

MINING DISTRICTS AND MINES

The Mazatzal Wilderness and contiguous roadless area are located between the main parts of the Green Valley (Payson), Mazatzal Mountains, Sunflower, and Magazine mining districts (Wilson and others, 1961; Mardirosian, 1973). Most mines and prospects in the wilderness lie in or adjacent to the Green Valley (Payson) district. Mineral deposits at the southeast corner of the wilderness are in the Sunflower and Mazatzal Mountain districts. Claims at Horseshoe Dam and east of Chalk Mountain have been recorded as belonging to the Magazine mining district. At the time of this investigation, no mining or claim activities were observed in the wilderness or contiguous roadless area with the exception of the area around McFarland Canyon (Marsh, 1983).

Green Valley (Payson) district

Claims, prospects, and mines in the part of the Mazatzal Mountains that lies in the wilderness are thought to be outside of formal mining districts, but most are informally associated with the Green Valley, or Payson, district. The Blue Lode, Los Conquistadores, and Stingy Lady prospects west of the crest of the Mazatzal Mountains may be part of the district. Assay and geochemical data indicate that these properties were explored chiefly for silver. These properties almost certainly were first worked before World War II, perhaps long before then, as trails leading to them are obscure; there are no roads today. Numerous mines and prospects in the area between Copper Mountain and Red Metal Tank also are informally considered to be in the Green Valley (Payson) district. Claims located for silver in this area postdate World War II. Exploration for silver and copper 1 mi southwest of Copper Mountain during the period 1964 to 1967 resulted in an open cut about 110 ft by 60 ft and 100 ft deep. This property was mined in 1967. Several miles of bulldozer roads were made during the exploration and mining.

The Casterson, Collom, Crackerjack, House, and Gowan mines are in the Green Valley (Payson) district. These mines may date from the early days of mining in the area, but there are few records. A photograph in an early report (Lausen and Wilson, 1925) shows a stope that was dug at the Gowan mine in the 1880's. The House and Collom mines are 1 mi east of the wilderness boundary. Portals of two adits of the Casterson mine are east of the boundary, but the workings extend into the Mazatzal Wilderness and the block of claims at the mine straddle the wilderness boundary (Ellis, 1982). At the time of the study, workings of the Collom and

Casterson mines were accessible, but mineralized parts of the House mine could not be reached.

Numerous roads and bulldozer cuts at Mineral Creek, north of the Collom mine, are the result of exploration work by at least six mining companies during the period 1957 to 1977. This work was conducted chiefly on the ridge north of Mineral Creek on both sides of the wilderness boundary. Bulldozer roads also were made in Eisenhauer Canyon in 1957 in an area that has a few prospects and several short adits (Ellis, 1982) and now is inside the wilderness.

Sunflower and Mazatzal Mountains districts

Early reports described the Sunflower district as including the mercury deposits that now lie east of the southern part of the wilderness (Ransome, 1915; Lausen and Gardner, 1927). Subsequently, mines of the area have been considered to be in the Mazatzal Mountains mining district (Beckman and Kerns, 1965; Bailey, 1969). Informal usage would include the Sunflower district as part of a larger Mazatzal Mountains district. The Story mine and the deposits at Copper Camp Creek are located in the wilderness 0.75 mi and 3 mi, respectively, west of the nearest mercury mine and informally are associated with these districts.

The Story mine was developed in a gold-silver-lead deposit located east of Saddle Mountain and less than 1,000 ft inside the Mazatzal Wilderness boundary. A shaft and two adits on the property are caved.

A few adits, prospect pits, and a shaft are located in McFarland Canyon north and northeast of the Story mine in rocks that show evidence of gold-pyrite-arsenopyrite mineralization. The workings appear to be old, as no roads lead to them.

At Copper Camp Creek, more than a dozen pits and trenches, a shaft 60 ft deep, and an adit 390 ft long occur in a block of 22 claims known as the Copper Cliff group. These workings were dug to explore the occurrence of copper carbonate minerals that locally are abundant in surface exposures. The age of the workings is unknown.

Magazine district

The Magazine mining district is centered southwest of the map area, about 7 mi west of Horseshoe Reservoir, in an area of silver and copper deposits (Wilson and others, 1961; Moore and Roseveare, 1969). In the 1970's, two blocks of 150 claims each were located on the east side of the Verde River and were recorded as belonging to the Magazine district. The claims extend from southeast of Horseshoe Dam, outside of the Mazatzal Wilderness, north to the vicinity of Chalk Mountain, where some of the claims are in the roadless area. At least three holes have been drilled in the claims. Tertiary sedimentary rocks in the claimed area contain abundant volcanic detritus and are uraniferous.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Geologic, geochemical, remote-sensing, and geophysical data acquired during this study and information obtained from the mining history, mineral exploration, and assays indicate that the Mazatzal Wilderness and contiguous roadless areas have mineral potential for a number of metals. Within the wilderness there is potential for gold, silver, copper, lead, uranium, mercury, molybdenum, and possibly tin. One roadless area has potential for uranium and molybdenum.

Areas of mineral resource potential are shown on the accompanying 1:48,000-scale map and on figure 3. The criteria used to define the 18 areas shown are listed on the accompanying 1:48,000-scale map and are discussed below.

The resource potential of mineralized areas in the Mazatzal Wilderness, the contiguous roadless areas, and adjacent areas is ranked <u>in this report</u> using the following criteria:

Low potential.—The available information defines a geologic environment that is permissive for mineral resources, but there is little evidence to indicate that geologic processes acted to produce a mineral resource.

Moderate potential.—The available information defines a geologic environment that is favorable for mineral resources, and there is evidence to support the interpretation that geologic processes could have resulted in a mineral resource.

High potential.—The available information defines a geologic environment that is favorable for mineral resources, and there is sufficient evidence to support the interpretation that geologic processes resulted in a mineral resource.

Available information used in evaluating mineral potential includes the results of geologic, geochemical, or geophysical studies and the results of investigations of mines, claims, and production records. Geologic environment refers to the rocks and the structural features of the rocks in a geographically restricted setting and includes any materials that may have been added during mineralizing events. Geologic processes are those naturally occurring systematic actions that result in the development of rocks and minerals or that cause changes in them. A mineral resource is a concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's surface in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible (U.S. Bureau of Mines and U.S. Geological Survey, 1980).

Areas 1, 2, 3, 4, 5, 6, 7, and 8—silver, gold, and copper

Areas favorable for silver, gold, and copper resources occur in metamorphic rocks in or near the northern, eastern, and southern parts of the wilderness. At some localities in the northern and eastern parts of the area, precious metals occur with substantial amounts of copper, but at other localities copper alone is the principal metal. In the southern part of the wilderness, precious metals and copper, other than in trace amounts, occur in separate deposits. The silver, gold, and copper deposits are small, and collectively they appear to constitute only a small resource of these metals. Occurrences of silver at the Stingy Lady prospect northeast of Midnight Mesa and copper at the Blue Lode and Los Conquistadores prospects in the west-central part of the wilderness are not indicative of resource potential for silver and copper.

The different ratios of precious metals to copper in the mineral deposits of these areas suggest a dual origin of the copper and possibly of the precious metals as discussed earlier. Some of the gold, silver, and copper are interpreted as having been derived from the alkali granite, whereas part of the copper may have been mobilized from syngenetic copper concentrations, possibly including massive sulfide deposits, in Proterozoic volcanic and volcaniclastic rocks. Gold and silver (with subordinate lead) in the southern part of the area may have yet a different origin.

Area 1

One of the principal areas of mineral resource potential in the Mazatzal Wilderness is located near the southern border of the wilderness in metamorphic rocks of the Alder Formation and includes the Story mine and nearby parts of McFarland Canyon. The Story mine was developed in tuffaceous volcaniclastic rocks containing silver-gold-lead vein deposits. As stated earlier, all of the workings are caved, and the only existing records of mining activity date from after World War II. Lead arsenate minerals related to the mineralization are evident in surface exposures in and around the old workings, and a gossan vein can be followed discontinuously for several hundred feet, possibly crossing the strike of the host rocks at a low angle.

Much of the area around the Story mine appears to be weakly sericitized, and the rocks exhibit a bleached and altered aspect (Marsh, 1983). The area has been strongly silicified and contains abundant quartz-chlorite veins. In many places, the fine-grained tuffaceous host rocks have been silicified, but they retain much of their original character. In many of the quartz veins, included tuffaceous material appears to have been altered to chlorite, which in some areas is further altered to iron oxides. In some quartz veins, sites once occupied by altered bedrock inclusions are now only voids. The altered area extends for at least 0.5 mi radius around the Story mine, and the zone of silicification extends much farther.

Assay values and the old mining records from the Story mine show that the mine has about 78,000 tons of indicated resources containing 0.06 oz/ton gold, 1.9 oz/ton silver, and 3.9 percent lead. These estimates are for resources remaining after subtraction of recorded production but include any unrecorded production that may have occurred.

In McFarland Canyon, gold occurs with pyrite and arsenopyrite in intrusive rhyolite sheets and in phyllitic, partly tuffaceous shale and metasiltstone of the Alder Formation, from about 0.5 mi inside the Mazatzal Wilderness to about 0.5 mi east of the wilderness boundary (Marsh, 1983). The mineralized area is about 1,500 ft wide and is parallel to the trend of the host rocks. The greatest concentrations of mineralized rock found in this area are 3,000 ft north of the Story mine and in an area about 1,500 ft in diameter centered 4,000 ft northeast of the Story mine. Several short adits, a shaft, and a few prospect pits are located in the area, but there is no record of production.

Mineralization in the McFarland Canyon area resulted in disseminated pyrite and generally sparse, but locally abundant, disseminated arsenopyrite in the rhyolite, and as arsenopyrite veins in the rhyolite and more commonly in the host sedimentary rocks. Arsenopyrite occurs as 0.75-1.5 in.-wide veinlets either as selvages to quartz veins or alone. Veins are not abundant in the area. They can be followed 10 to 20 ft subparallel to bedding and appear to form parts of a vein system that can be traced with interruptions for several thousand feet along McFarland Canyon (D. M. Brown and J. L. White, Texasgulf Western, Inc., oral commun., 1982). As at the Story mine, weakly sericitized rock is widespread and is found in the rhyolite as well as the metasedimentary rocks. The rhyolite and metasedimentary rocks are locally silicified, and the metasedimentary rocks contain quartz veins.

The rhyolite sheets follow the strike of the adjacent sedimentary rocks but are clearly intrusive, as the sheets locally cross the lithologic layering and foliation of these rocks. The rhyolite is unfoliated and thus postdates the Proterozoic deformation.

Geochemical data show that arsenic, gold, silver, lead, and small amounts of copper occur in the mineralized area and that the highest values for gold are in places having high concentrations of arsenopyrite. This is the same suite of elements that was found at the Story mine.

The origin of the mineral deposits at the Story mine and in McFarland Canyon is uncertain. The spatial association of rhyolite to the mineralized rocks in McFarland Canyon indicates a genetic relationship and might also account for the mineralization at the Story mine, although no rhyolite is exposed in the immediate vicinity of the Story mine. An argument against a genetic tie between the rhyolite and the mineralization is that the rhyolite sheets and adjacent host rocks are barren outside of McFarland Canyon.

Genesis of the mineral deposits by volcanogenic processes in the Story mine-McFarland Canyon area is suggested by the apparent stratabound distribution of the mineralized rock, its association with tuffaceous volcaniclastic rocks, and the widespread effects of silicification and sericitization. The existence of a small tongue of basalt on strike with the Story mine shows that volcanism was closely contemporaneous with sedimentation in that area, and high concentrations of lead, abundant in many distal massive sulfide deposits (Anderson and Guilbert, 1979), occur in the mineralized zone at the Story mine and in McFarland Canyon. Evidence of volcanogenic sulfides has been found in the lower part of the Alder Formation in the Copper Camp Creek area, discussed later, and interbedded jasper and sulfide-barren, but iron-rich carbonate rocks are suggestive of an exhalative process in the stratigraphically higher part of the Alder Formation. However, the mineralization in McFarland Canyon postdates emplacement of the rhyolite sheets, which were intruded after development of foliation in the host rocks. The quartz veins are later still and are subparallel to layering of the strata. Had the quartz veins formed in fractures that channeled rising hot solutions during volcanism, some of the veins likely would extend through the altered zones at large angles to the host strata (Boyle, 1979, p. 301).

The mineral deposits in the Story mine-McFarland Canyon area may have developed from an igneous source at depth, possibly an intrusive body related to the aeromagnetic high discussed earlier as occurring in the mercury mining area east of the Story mine. Although mercury was detected in sulfides, no evidence of cinnabar was found at the Story mine or in McFarland Canyon, and there is no evidence at present indicating a connection between this mineralization and mineralization in the mercury district.

Area 1 has a high potential for the occurrence of gold-silver-lead resources. Considerable exploration would be required to determine the extent and grade of mineralized rocks in the area.

Area 2

Silver and copper veins occur in the vicinity of Copper Mountain in the north-central part of the wilderness. This area includes upper parts of the steep north-facing slope of the canyon of the East Verde River south from Copper Mountain and contains Bullfrog Ridge and the ridge that trends northeasterly from Red Metal Tank. The area has a large block of claims (Ellis, 1982) and many mines and prospects, reflecting widespread mineralization. The veins trend north-northeast and occur in a zone of intensely fractured rocks on both sides of a major fault of the same trend. This fault separates Early Proterozoic mafic volcanic rocks to the east from Early Proterozoic graywacke to the west and cuts the alkali granite to the south.

Mineral occurrences in the part of area 2 east of the fault are mainly along Bullfrog Ridge and consist of silver-bearing copper sulfide and oxide minerals in volcanic rocks. Geochemical samples collected from prospects in mineralized rocks on the ridge and assay values from old workings show that the veins and the adjacent altered country rock are rich in copper, silver, lead, and zinc, and that they contain trace amounts of bismuth, cadmium, antimony, arsenic, and mercury. This geochemical suite is typical of the hydrothermal mineralization related to the alkali granite, which crops out a short distance to the south and may underlie the area at relatively shallow depth. The hydrothermal mineralization greatly overwhelmed any copper that may reasonably have been contributed by the mafic volcanic host. It is possible that massive sulfide deposits exist in the volcanic rocks and could be the source of the copper in the vein deposits.

The graywacke west of the north-trending fault locally is intensely altered and has abundant quartz veins. Iron oxide is abundant, and yellow and green complex secondary minerals coat fracture surfaces. No sulfide minerals were found in these rocks. Geochemical data from the veins show high concentrations of copper, silver, lead, and zinc, and trace quantitites of antimony, arsenic, and tin. This suite of elements also is indicative of the hydrothermal mineralization that emanated from the alkali granite.

Silver and copper in quartz veins in the area occur at the open-cut mine located west of Bullfrog Canyon and 1 mi southwest of Copper Mountain. This is the only place in the Mazatzal Wilderness where copper and silver production has been recorded. According to records of the U.S. Forest Service, this mine produced 33.5 tons of ore containing 938 lb of copper and 485 oz of silver in 1967. Based on this production and the presence of spotty but locally high-grade rock in the mine area, the deposit has a high potential for additional resources of silver and copper. Geochemical analyses and assays showing high concentrations of these metals in altered rock outside the mine are indicative of a high potential for the occurrence of silver and copper resources elsewhere in area 2. The silver and copper resources could be expected to occur in a few deposits containing hundreds to a few tens of thousands of tons of mineralized rock. The possibility for the recovery of copper in the area may depend on the tenor of associated silver. The potential for the presence of massive sulfide resources in area 2 is low.

Area 3

Veins containing silver, gold, and copper occur at the House, Collom, and Casterson mines, which are located east of the east border of the Mazatzal Wilderness in area 3.

Evidence from underground workings, surface exposures, and dump materials show that mineral deposits in area 3 consist of well-defined veins in mafic volcanic rocks of the Proterozoic East Verde River sequence. Veins mapped at the Collom and Casterson mines follow northerly and northwesterly trends (Ellis, 1982) and contain quartz and locally sulfide and oxide minerals. The deposits in area 3 resemble those mineralized parts of area 2 near Copper Mountain that are underlain by mafic volcanic rocks. Like the deposits of Copper Mountain, the alkali granite crops out near mineralized parts of area 3. These exposures are 1 mi northwest of the House mine and in the eastern part of the Casterson mine area.

Geochemical and assay data from samples collected at mines in area 3 reveal low to high concentrations of silver, gold, and copper. A geochemical sample containing secondary copper minerals collected from the dump at the House mine was found to contain >30 ppm silver, 13 ppm gold, 20,000 ppm copper, and high concentrations of arsenic, antimony, bismuth, cadmium, lead, and zinc. A sample of country rock from this dump was found to have the same elements in lower but still anomalous concentrations. Samples from the dump of the Collom mine contain the same suite of elements. The trace-element suite in these rocks therefore has the same geochemical signature as mineralized rocks formed during the hydrothermal phase of the alkali-granite. However, it is reasonable to assume that some of the copper in the mineral deposits of area 3, like the deposits at Copper Mountain, may have been supplied by the mafic volcanic host rocks, possibly massive sulfide deposits.

The Casterson and Collom mines produced a few ounces of gold, about 300 oz of silver, and a few pounds of copper in the early 1940's. Both mines probably had some production before these dates. There is no recorded production from the House mine. The probable total production from all three mines was small. Combined inferred reserves of the Casterson and Collom mines are estimated to be 52,000 tons of mineralized rock containing 7 oz/ton silver and 0.07 oz/ton gold (Ellis, 1982). There is a moderate potential for the presence of additional vein-type mineral resources in favorable geologic settings in other parts of area 3, especially near granitic rocks, either exposed or at shallow depths. If present they probably would occur in deposits of high grade and small size and would measure from hundreds of tons to a few tens of thousands of tons of mineralized rock. The area has a low potential for resources of copper in massive sulfide deposits.

Area 4

Copper minerals are widespread in area 4, which trends approximately east-west for a distance of about 1.25 mi in the vicinity of Mineral Creek, north of North Peak, at the eastern border of the Mazatzal Wilderness. Half of the area is inside the wilderness. A large block of claims centered east of the wilderness covers most of area 4 and extends into the wilderness (Ellis, 1982).

At least six mining companies conducted mineral exploration work in the area during the period 1957-1977. This work resulted in the construction of many roads and bulldozer cuts, chiefly on the ridge north of Mineral Creek, on both sides of the Mazatzal Wilderness boundary.

Mafic volcanic rocks in the Mineral Creek area have copper oxides on fracture surfaces and local concentrations of secondary potassium feldspar. The greatest concentration of copper minerals is near the junction of the Deadman and East Verde River faults. Rocks associated with the alkali granite intruded graywacke south of Mineral Creek, and it is likely that these intrusive rocks also underlie the mafic volcanic rocks in the Mineral Creek area. Geochemical data show a weak trace-element signature of hydrothermal mineralization related to the alkali granite. However, much of the copper here could have been derived from the mafic volcanic bedrock. Copper carbonate minerals in faults indicate some remobilization of copper as young as Tertiary.

The resource potential for copper in mineralized veins and fractures in area 4 is high in an area 800 ft by 3,000 ft astride the Mazatzal wilderness boundary on the north side of Mineral Creek. This locality has the highest concentration of copper in area 4. The concentration is spotty, and copper averages 0.09 percent (Ellis, 1982). There is a moderate potential for the occurrence of copper resources in veins in the mafic volcanic rocks outside the area of greatest exposed mineral concentrations. Area 4 also has a low potential for copper resources in massive sulfide deposits.

Area 5

Copper carbonate veins locally are abundant in area 5, which is located at Copper Camp Creek in the southern part of the Mazatzal Wilderness. A shallow shaft, a short adit, and numerous prospect pits and trenches have been developed in the area in a block of 22 mining claims (Ellis, 1982). There is no record of production, and the amount of copper ore that might have been shipped would have been small (Ellis, 1982). Rocks in one of the more intensely mineralized parts of the adit in this area averages 0.71 percent copper and 0.2 oz/ton silver (Ellis, 1982). As discussed earlier, an attempt during this study to determine the presence of massive sulfides by geophysical means showed that such deposits are not present above the maximum search depth of 400 ft.

Beds and lenses of impure gossan, locally about 6 ft thick and interlayered with chert in the Alder Formation in area 5 suggest an early mineralization of the stratabound massive sulfide type in which volcanogenic sulfides were deposited by sedimentary processes. Fragments of gossan in volcanic breccia interlayered with the chert resulted from breakup and transport of the gossan and provide additional evidence of an early mineralization. The abundant malachite veinlets occur in the volcanic breccia and record a late mineralizing event. Significant concentrations of arsenic, antimony, bismuth, gold, silver, and tungsten in geochemical samples of the malachite-bearing rocks suggest that the late mineralization may be an overprint by the hydrothermal system related to the alkali granite, but it also is possible that the veins formed from copper derived from massive sulfide mineralization.

There is moderate potential for the occurrence of copper resources in carbonate veins and high potential for the occurrence of copper in massive sulfide deposits in the Copper Camp Creek area.

Areas 6 and 7

Scattered and generally low concentrations of copper minerals occur in areas 6 and 7, located respectively in the eastern and northern parts of the area studied. Area 6 is situated partly inside and partly outside the Mazatzal Wilderness Wilderness at the eastern border, near North Peak. It includes all of the area underlain by mafic volcanic rocks outside of area 3. Area 7 is situated entirely in the wilderness northwest of area 6 and contains mafic volcanic rocks outside of area 2.

Eisenhauer Canyon is the only part of area 6 showing possibly significant mineral occurrences. Mineral exploration was conducted in the area in 1957. There is no record of production.

Mineral occurrences at Eisenhauer Canyon consist of secondary copper minerals, principally malachite, and quartz concentrated in faults and fractures. The host mafic volcanic rocks are propylitized and contain abundant epidote. Spectrographic and wet-chemical analyses of rocks and stream sediments collected in the area show small amounts of copper, and assay data (Ellis, 1982) i. .ate that silver is present locally in low concentrations. Chemical elements indicative of mineralization related to the alkali granite are not present. The copper is interpreted as having been mobilized from the mafic volcanic bedrock, possibly from stratabound sulfide deposits.

A few occurrences of secondary copper minerals exist in mafic volcanic rocks of area 6 outside of Eisenhauer Canyon and in area 7. They are small and widely separated, and only a few prospects have been found in them. The weak mineral occurrences in these areas are thought to be of copper that originally was syngenetic in the host volcanic rocks, which could contain massive sulfide deposits. No clear evidence of massive sulfide deposits was found in areas 6 or 7.

The scattered occurrences of secondary copper minerals in areas 6 and 7 suggest the mineral resources of these areas are small, but if massive sulfide bodies exist the copper resources could be large. Available data indicate that areas 6 and 7 have a low potential for copper resources in veins and a low potential for copper resources in massive sulfide deposits.

Area 8

Gold is the principal commodity of area 8, which is located in the east-central part of the area studied, east of the Mazatzal Wilderness and contiguous roadless areas. Copper locally is important. The area has numerous prospects and a few mines and forms part of the Green Valley (Payson) mining district. Geologically, area 8 is similar to parts of the Green Valley district to the east, where many gold deposits are known (Lausen and Wilson, 1925). Although entirely outside of the wilderness, the area was examined briefly because it is mineralized and has some of the same rocks as nearby parts of the wilderness.

Gold deposits in area 8 occur as quartz-bearing veins in Proterozoic diorite and included metasedimentary rocks. According to Lausen and Wilson (1925) the veins contain free gold and gold in pyrite. The veins are in fault zones of westerly and northwesterly trend. Some of the veins show evidence of movement that postdates the mineralization (Lausen and Wilson, 1925). In addition to gold, the veins contain silver and copper.

The two largest mines in area 8 were examined during this study (Ellis, 1982). The Gowan mine was first worked during the period 1880-1882, but no production data are available for those years (Lausen and Wilson, 1925). The Gowan mine also produced gold in 1938-1940. The Crackerjack mine produced gold, silver, and copper during the period 1942-1956. Most of the 17,596 lb of copper produced from the Casterson, Collom, Crackerjack, and Gowan mine came from the Crackerjack mine. Assay data from the Gowan and Crackerjack mines show significant values of gold and silver, and the data from the Crackerjack mine show high copper values (Ellis, 1982).

Our studies suggest that, considering the existence of mines that have had production, the large size of area 8, and the extensive soil and forest cover, it is reasonable to assume that the area has a high potential for gold, silver, and copper resources in deposits the size of those at the Gowan and Crackerjack mines. Geochemical sampling in the area (not conducted during this study) would be helpful in estimating the number and location of any additional deposits. Although no gold deposits have been found in the dioritic rocks in the wilderness, faults of westerly and northwesterly trend in these rocks may nevertheless have potential for gold resources.

Areas 9, 10, and 11—mercury

About 95 percent of the mercury that has been recovered in Arizona has come from the Sunflower mining district (Bailey, 1969), which is centered a few miles east of the southern part of the Mazatzal wilderness. Although production from the district has been significant for Arizona, it amounts to far less than one percent of the total production of mercury in the United States (Bailey, 1969), and there has been little production from the district since the 1960's. About half of the district, including two of the four most productive mines—the Pine Mountain and Sunflower mines—are in the area studied. A small part of the district extends into the wilderness (fig. 3).

Area 9

The major mercury mines in the northern part of the Sunflower mining district, and the strongest indications of mercury in the area studied, are in area 9. This area begins at the eastern border of the Mazatzal Wilderness and extends to the northeast in a belt about 5,000 ft wide. It includes many prospects as well as numerous mines (Ellis, 1982).

Mercury in area 9 occurs as cinnabar in shaly tuff and sandstone of the Alder Formation. The mercury occurs intermittently along strike for 5 mi within a stratigraphic interval of about 5,000 ft on the north limb of a major syncline. Mercury mines in this limb are coextensive with an irregular Proterozoic felsic sill of the Pine Mountain Porphyry of Wilson (1939). Most mines occur near the margin of the sill; only a few prospects occur within it. Cinnabar is disseminated in the host rocks and is concentrated along prominent foliation planes. The northwest-trending nose of an aeromagnetic high underlies the central part of area 9 and may represent an unexposed intrusive body related to the mercury mineralization.

Occurrences of mercury in area 9 extend beyond the Sunflower mine workings and have been explored intermittently in recent years. No quantitative estimates have been made of the mercury resources of this area, with the exception of the Sunflower mine at the southwest end of area 9, which is estimated in this study to have inferred resources of 26,000 tons of rock containing 0.14 percent mercury outside the wilderness and 3,600 tons of rock containing 0.21 percent mercury inside the wilderness. The potential for the presence of mercury resources in area 9 is high.

Area 10

Two areas containing mercury are designated as area 10 (fig. 3). One surrounds area 9 and extends 0.3 mi into the Mazatzal Wilderness. The other part of area 10 is at the southeast margin of the area studied and contains highly foliated rocks of approximately the same stratigraphic interval in the Alder Formation as in the northern area. The aeromagnetic anomaly mentioned as occurring in area 9 is centered close to the southern of the two areas labeled as 10 and extends into the northern area. Both parts of area 10 contain few prospects and have few mines (Ellis, 1982), all of which have had little or no production.

Mercury is sparsely distributed in area 10. Only rock samples from the Story mine showed highly anomalous concentrations of mercury. Area 10 has a moderate potential for the occurrence of mercury resources. However, the chances of a deposit the size of the old producing mines in area 9 are considered small.

Area 11

Area 11 contains all exposures of the Alder Formation outside of areas 9 and 10. Most of the area is in the southern part of the Mazatzal Wilderness, but the area extends to the west and east of the wilderness boundaries (fig. 3). The only indications of mercury in the area are widely scattered anomalous geochemical concentrations. The potential for mercury resources in the area is low.

Areas 12, 13, and 14—molybdenum

Indications of molybdenum mineralization found in stream sediment, heavy-mineral concentrates from stream sediment, rock, and water in the Tangle Creek area west of the Mazatzal Wilderness during this study suggest that the quartz monzonite porphyry exposed west of Tangle Creek may contain a porphyry molybdenum resource. Area 12 is the exposed part of the quartz monzonite porphyry. Gravity and aeromagnetic data indicate that the qu...z monzonite porphyry pluton may be moderate in size and may extend eastward and northeastward into the roadless area and the wilderness beneath younger rocks. The outline of area 13 is based on the gravity and aeromagnetic highs that project southeastward from the vicinity of the outcropping quartz monzonite porphyry. The outline of area 14 is based on weak gravity and aeromagnetic highs suggestive of the quartz monzonite porphyry at depth and on high molybdenum concentrations in a few surface samples. Additional sampling will be required in area 12, and drilling will be necessary in areas 13 and 14 to determine the existence, distribution, and grade of any mineralized rocks. On the basis of the meager data from the geologic reconnaissance and the geochemical and geophysical surveys, the potential for the occurrence of molybdenum resources in areas 12, 13, and 14 is low.

Areas 15 and 16—tin

Evidence of tin mineralization was found during this study in the alkali granite in the central part of the Mazatzal Wilderness. Cassiterite identified in heavy-mineral concentrates of stream-sediment samples collected in this part of the area had to have been derived from the granitic rocks, although none was found in the granite. Moreover, greisen zones in the alkali granite appear to be the favored host for the tin mineralization. High concentrations of tin, tungsten, beryllium, boron, fluorine, and rare-earth elements in the cassiterite-bearing panned concentrates provide additional indications of hydrothermal tin mineralization. The greisen zones occur in area 15, which is located near the center of the wilderness. This is the most favorable area for tin identified during this study, but it is not certain if the abundance of tin is great enough to be indicative of a potential for tin resources. Geochemical evidence suggests that other parts of the alkali granite pluton, labeled as area 16, also may contain greisen zones. However, area 16, like area 15, may not have concentrations of tin great enough to be indicative of a potential for tin resources. Additional sampling will be required to identify areas of tin concentration and to evaluate more fully the tin resource potential of the alkali granite. The chances of any part of the alkali granite pluton containing recoverable cassiterite are extremely poor. No significant concentrations of placer cassiterite were found. Evidence of tin mineralization has not previously been reported as occurring in this rock type in Arizona.

Areas 17 and 18—uranium

Uranium exists in Tertiary tuffs and sedimentary rocks near Horseshoe Reservoir, west of the Mazatzal Wilderness. A large block of claims has been staked in this area outside the wilderness and partly inside one roadless area (Ellis, 1982). Concentrations of uranium occur in siliceous tuff and tuffaceous, carbonate-rich Tertiary sandstone northwest and southeast of Horseshoe Dam, and in tuffaceous siltstone on the east, west, and north sides of Horseshoe Reservoir to about 2 mi north of Chalk Mountain. The highest assay value obtained was 165 ppm uranium oxide from a sample taken across a 4-in-thick bed southeast of Horseshoe dam (Ellis, 1982). All other values obtained in the same area were 18 ppm uranium oxide or less. Area 17, which trends northwesterly on the south side of the reservoir, has a moderate potential for the occurence of uranium resources, based on the assay concentrations and a favorable host rock. Area 18 has a low potential for the presence of uranium resources. The proximity of Proterozoic granitic rocks, which are slightly uraniferous, could be a source for some of the uranium in areas 17 and 18.

REFERENCES CITED

Anderson, C. A., Blacet, P. M., Silver, L. T., and Stern, T. W., 1971, Revision of Precambrian stratigraphy in the Prescott-Jerome area, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1324-C, p. C1-C16.

Anderson, C. A., and Nash, J. T., 1972, Geology of the massive sulfide depo... at Jerome, Arizona—a reinterpretation: Economic Geology, v. 67, p. 845-863.

Anderson, Phillip, and Guilbert, J. M., 1979, The Precambrian massive sulfide deposits of Arizona—a distinct metallogenic epoch and province, in Ridge, J. D., ed., Papers on mineral deposits of western North America, International Association on the Genesis of Ore Deposits, Fifth Quadrennial Symposium Proceedings, v. 2: Nevada Bureau of Mines and Geology Report 33, p. 39-48.

Anderson, Phillip, and Wirth, K. R., 1981, Uranium potential in Precambrian conglomerates of the central Arizona arch: Final report: Grand Junction, Colo., U.S. Department of Energy Report GJBX-33 (81), 122 p.

Bailey, E. H., 1969, Mercury, in Mineral and water resources of Arizona: Arizona Bureau of Mines Bulletin 180, p. 226-230.

Beckman, R. T., and Kerns, W. H., 1965, Mercury in Arizona, in Mercury potential of the United States: U.S. Bureau of Mines Information Circular 8252, p. 60-74.

Blanchard, Roland, 1968, Interpretation of leached outcrops: Nevada Bureau of Mines Bulletin 66, p. 7.

Boyle, R. W., 1979, The geochemistry of gold and its deposits: Canada Geological Survey Bulletin 280, 579 p.

Conway, C. M., 1976, Petrology, structure, and evolution of a Precambrian volcanic and plutonic complex, Tonto Basin, Gila County, Arizona: Pasadena, California Institute of Technology Ph. D. thesis, 460 p.

Conway, C. M., Wrucke, C. T., Ludwig, K. W., and Silver, L. T., 1982, Structures of the Proterozoic Mazatzal orogeny, Arizona abs.: Geological Society of America Abstracts with Programs, v. 14, no. 4, p. 156.

Ellis, C. E., 1982, Mineral resource potential of the Mazatzal Wilderness and contiguous RARE II Further Planning Areas, Gila, Maricopa, and Yavapai Counties, Arizona: U.S. Bureau of Mines Open-File Report MLA 56-82, 12 p.

Faick, J. N., 1958, Geology of the Ord mine, Mazatzal Mountains quicksilver district, Arizona: U.S. Geological Survey Bulletin 1042-R, p. R685-R698.

Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.

Hunt, G. R., 1980, Electromagnetic radiation: The communication link in remote sensing, in Siegal, B. S., and Gillespie, A. R., Remote sensing in geology: New York, John Wiley and Sons, p. 5-45.

Jones, M. T., Reed, B. L., Doe, B. R., and Lanphere, M. A., 1977, Age of tin mineralization and plumbotectonics, Belitung, Indonesia: Economic Geology, v. 72, p. 745-752.

Lausen, Carl, and Gardner, E. D., 1927, Quicksilver resources of Arizona: Arizona Bureau of Mines Bulletin 122, 112 p.

Lausen, Carl, and Wilson, E. D., 1925, Gold and copper deposits near Payson, Arizona: Arizona Bureau of Mines Bulletin 120, 44 p.

Ludwig, K. R., 1973, Precambrian geology of the central Mazatzal Mountains, Arizona: Pasadena, California Institute of Technology Ph. D. thesis, 395 p.

Madirosian, C. A., 1973, Mining districts and mineral deposits of Arizona: Charles A. Madirosian, scale 1:1,000,000.

Marsh, S. P., 1983, Arsenic and gold mineralization in the McFarland Canyon—Story mine area, Maricopa County, Arizona: U.S. Geological Survey Open-File Report 83-442, 22 p.

Marsh, S. P., Erickson, M. S., Forn, C. L., and McDougal, C. M., 1983, Spectrographic analyses of panned concentrate from stream-sediment samples from the Mazatzal Wilderness and Mazatzal Wilderness Contiguous Roadless Area, Gila, Maricopa, and Yavapai Counties, Arizona: U.S. Geological Survey Open-File Report 83-524, 38 p.

Marsh, S. P., Forn, C., and McDougal, C. M., 1983, Spectrographic analyses and statistical data for stream

SUMMMARY REPORT DESCRIBING THE BUSKIN CLAIM GROUP
SUNFLOWER MINING DISTRICT, MARICOPA COUNTY ARIZONA

by Richard J. Lundin, Mineral Exploration Consultant

1. Mine or Property Name: Buskin Group
2. Mining District, County & State: Sunflower Mining District, Maricopa County, Arizona
3. Quadrangles or Map Names: Boulder Mountain Quadrangle (1:24,000)
4. Location: T. 5N, R. 8E, Sections 12,13,14 & 24; T. 5N, R.8E, Sections 19 G&SRB&M
5. Any Former Names: None
6. Owners: Rich Venture Mining Co.
7. Address of Owners: 550 E. McKellips #1012, Mesa AZ 85203
8. Operator: (same as above)
9. Address of Operator: (same as above)
10. Principal Metals: Mo, Cu, Au, Ag, Pb, Mn
11. Number of Claims, Title etc.: Approximately 40 unpatented lode and placer claims.
12. Previous Published or Unpublished Reports: Long Lac Mineral Exploration Letter Report (1985); U.S. Borax Letter Report (1984)
13. Names of Mining Companies or Governmental Agencies that have worked or are now working on this property: Long Lac Minerals, U.S. Borax
14. Ore & Gangue Minerals: Disseminated py, ccpy, molybdenite, copper oxides assoc. with silicified zones in granite. with iron and manganese oxides.
15. Geology: Older Precambrian granite-granite gneiss, felsic volcanics, volcaniclastics and carbonate-rich sediments? Jasper-chert bodies with associated copper-iron oxide staining.
16. Type of Mineralization-Metallurgical Considerations: Disseminated py assoc. with quartz veins in granite, copper-iron oxides associated with outcrops of jasper-chert.
17. Ore Reserves: none currently developed
18. Mine, Mill Equipment & Flow Sheet: none
19. Road Conditions: The property is accessable by a series of trails from State Highway 87. (see figure 1)

22. Brief History: The property was located by the present ownership in March of 1984 and has been held since then with performance of annual labor. The 1984-1985 Assessment Work has been filed with Maricopa County and the Bureau of Land Management.
23. Previous Sampling, Drilling & Other Studies on Dumps or Tailings: Sampling of outcropping mineralization by Long Lac and U.S. Borax personnel (see Attachment A)
24. Environmental-Social-Political Conditions & Considerations: The area is one of past mining and prospecting activity and is not within any area considered for Wilderness or Restricted Use Status.
25. Sampling: see figure 1 and Attachment A
26. Financial Terms, Conditions & Considerations: The property is currently open for lease or purchase. (For specific terms, contact owner)
Remarks: Property is an undeveloped prospect with interesting precious and base metal values associated vein systems in Precambrian granite-granite gneiss.

United States Department of Agriculture
Forest Service
Mesa Ranger District
P.O. Drawer A
Mesa, AZ 85201

Reply to 2810

Date June 20, 1984

Mr. Richard A. Walker
6380 E. Shiprock St.
Apache Junction, AZ 85220

Dear Mr. Walker:

This letter will serve as approval of your Notice of Intent to Operate dated 6/18/84. This approval is for the taking of samples by hand to be backpacked out from your claims. Please remember that this is all that is approved at this time. Any further work must be approved before work begins.

Thank you for your cooperation.

Sincerely,

Donald A. Van Driel

DONALD A. VAN DRIEL
District Ranger

Custom Smelting
Chemical Analysis
Flow Sheet Design

GOLD DOME
MINING CORPORATION
Refining Division

4329 East Magnolia
Phoenix, Arizona 85034
(602) ~~243-2226~~
437-3058

5-21-84

ASSAY RESULTS

TO: Rich Walker
6380 E. Shiprock Street
Apache Junction, AZ 85220

	SAMPLE ID NO.	PROCESS USED		AU(GOLD) OZ/TON	AG(SILVER) OZ/TON
1	Hillside red #1	Fire Assay	RED STAINED GRANITE	trace	.31
2	Hillside red #2	Fire Assay		.03	.44
3	Hillside #3	Fire Assay		.14	25.86

NORTH AMERICAN ASSAY COMPANY

1022 West 23rd Street
Tempe, Arizona 85282
(602) 894-0919

Job Number MA-1452

Page 1 Of 1

Date June 13, 1984

ANALYTICAL REPORT

Client I.D.	Lab #	Fire Assay	
		Au (Oz/ton)	Ag (Oz/ton)
Bushkin #1362	1	.459	1.5
Duplicate	2	.462	1.5

Client Name: Richard A. Walker

Address: 6380 E. Shiprock St.
Apache Junction, AZ

Telephone: 982-7516

Samples Submitted By: Rich Walker

Date Received: June 8, 1984

6/13/84

Custom Smelting
Chemical Analysis
Flow Sheet Design

MINING CORPORATION
Refining Division

Phoenix, Arizona 85034
(602) ~~XXXXXXX~~
437-3058

ASSAY RESULTS

6-18-84

TO: Rich Walker

SAMPLE ID NO.	PROCESS USED	AU(GOLD) OZ/TON	AG(SILVER) OZ/TON
5 #1 5	Fire Assay	.03	.52

NORTH AMERICAN LABORATORIES, INC.
1022 West 23rd Street
Tempe, Arizona 85282
(602)894-0919

CERTIFICATE OF ANALYSIS

Date: June 30, 1984
Job Number: MA-1475

Client Name: Richard Walker
Address: 6380 E. Shiprock Street
Apache Junction, AZ 85220
Telephone: 982-7516

Samples Submitted by: Richard Walker
Date Received: June 21, 1984

Sample Preparation: The entire sample was crushed to -1/4 inch, blended, split and the split pulverized to -200 Mesh.
Fire Assay: The Fire Assay sample was one assay ton.
Geochemical: Analyses performed by Atomic Absorption - Au

F I N A L   R E S U L T S

Job Number - MA-1475
Date - June 30, 1984

	Client I.D.	Lab #	Fire Assay Au (Oz/ton)	Fire Assay Ag (Oz/ton)	Geochemical Analysis Au (Oz/ton)	
6	Bushkin Conc.	1	.388	.4		Rosty Granitic Rocks
7	Hillside Red Conc.	2	4.648	15.6		
	Hillside Red Ore	3	* 100 LB samples crushed & concentrated		<.01	Separate sample
	Bushkin Head Ore	4	.041	<.1		

REGISTERED ASSAYER
CERTIFICATE NO. 15184
JAMES W. ANDERSON
Date Signed 7/2/84
ARIZONA, U.S.A.

NORTH AMERICAN LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

Date: September 18, 1984
Job Number: MA-1596

Client Name: Richard A. Walker
Address: 6380 E. Shiprock Street
Apache Junction, AZ
Telephone: 982-7516

Samples Submitted by: Rich Walker
Date Received: September 12, 1984

Telephone Results: to Rich Walker by SJS on 9/14/84

Sample Preparation: The entire sample was crushed to -10 mesh, blended, split and the split pulverized to -200 mesh.
Fire Assay: The Fire Assay sample was one assay ton.

Additional Information: 4 Sample Preparation @2.75 ea.
4 Fire Assay Au, Ag @12.00 ea.

Mineral and Water Analysis

1022 West 23rd Street Tempe, Az. 85282 (602)894-0919

F I N A L   R E S U L T S

Page

Job Number: MA-1596
Date: September 18, 1984

Client I.D.	Lab #	Fire Assay Au (Oz/ton)	Fire Assay Ag (Oz/ton)
Stream Conc	1	<.001	<.01
Shale Ore	2	.007	<.01
Meadow Vein	3	.009	.40
Metal 'D'	4	.009	.05

Registered Assayer
CERTIFICATE NO.
15184
JAMES W.
ANDERSON
Date Signed 9/20/84
ARIZONA U.S.A.

These analyses are based on materials supplied by the client to whom and for whose exclusive and confidential use this report is made. North American Laboratories, Inc., and its officers and employees assume no responsibility and make no representations as to the productivity or profitability of any mineral deposit in connection with which this report is used.

NORTH AMERICAN LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

Client Name: Richard A. Walker
Address: 6380 E. Shiprock Street
Apache Junction, AZ
Telephone: 982-7516

Job Number: MA-1759
Date: December 17, 1984

Copies to:

Submitted by: Rich Walker
Date Received: December 17, 1984

Additional Info:

	Client I.D.	Lab #	Fire Assay Au (Oz/ton)	Fire Assay Ag (Oz/ton)	Geochemical Analysis Hg (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)
12	Cactus May 'C'	1	.064	5.14	— Country Rock with Pyrite Pseudo-morphs			
13	Trail Vein	2	.012	.21				
14	Cactus May #1	3	.006	.10		64	325	48
15	Hillside Red Soil	4	.016	.11				
16	Hillside Red	5	.009	<.01	<.01	1	27	42
17	Cactus May #2	6	.017	<.01				

Registered Assayer Certificate No. 15184 James W. Anderson, Arizona, U.S.A. Date Signed 12/19/84

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We will store the PULPS for ONE YEAR in case you desire further analysis. They will be returned to you if you so request or be discarded after one year.

Mineral and Water Analysis

1022 West 23rd Street∘Tempe, Az. 85282∘(602)894-0919

UNITED STATES DEPARTMENT OF THE INTERIOR
(BUREAU OF MINES)

MINERAL-RESOURCE POTENTIAL OF THE MAZATZAL WILDERNESS AND CONTIGUOUS RARE II FURTHER PLANNING AREA, GILA, MARICOPA, AND YAVAPAI COUNTIES, ARIZONA

By
Clarence E. Ellis

MLA 56-82
1982

This open file report summarizes the results of a Bureau of Mines wilderness study and will be incorporated in a joint report with the U.S. Geological Survey. The report is preliminary and has not been edited or reviewed for conformity with the U.S. Bureau of Mines editorial standards. Work on this study was conducted by personnel from Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, CO 80225.

Mining activity

Mining activity in the area peaked in the 1880's, and has since remained at a low level. In 1979, an adit was being driven at the Sunflower Mine (Plate 1), and the road to the Casterson Mine was being repaired; both activities, however, were curtailed by 1980. In recent years there has been trenching at the Sunflower Mine; drilling and trenching at Mineral Canyon on the eastern boundary; trenching, geochemical, and geophysical prospecting, and minor copper-silver production at Copper Mountain inside the Wilderness; drilling for uranium near Horseshoe Dam near the RARE II area; and applications were filed with the U.S. Forest Service for permission to drill at Copper Camp Creek inside the Wilderness.

MINING DISTRICTS AND MINERALIZED AREAS

Mining Districts

Payson

The Payson, or Green Valley, mining district (Plate 1) surrounds Payson, except on the north. The part of the district adjacent to the Wilderness extends from just north of the East Verde River, to Eisenhauer Canyon on the south. Near the eastern Wilderness boundary, on gold-bearing quartz veins in a variety of igneous rocks of Precambrian age, are the Casterson, Collom, Crackerjack, Gowan, and House Mines (Plate 2). Except for the Gowan vein, which is traceable for possibly a half mile (800 m), the veins in these mines pinch out along strike within a few hundred feet (tens of meters), but extend deeper than the limits of development. They appear to fill tension gashes related to nearby major faults.

Sunflower

The Sunflower mercury district (Plate 1) is in an east-northeast-trending belt of Precambrian schist (Ransome, 1915) of the Alder Group near the southeast corner of the Wilderness. Just inside the Wilderness, volcanic rocks cover the schist. The Cornucopia, Gold Creek, Mercuria, Oneida, Pine Butte, Pine Mountain, and Sunflower Mines (Plate 2) are near the Wilderness. Although on the mercury trend, the Storey Mine inside the Wilderness, is a silver-lead-gold deposit. Lithology or stratigraphy, rather than structure appears to have controlled ore deposition.

Mining Claims

A patented claim, the Blue Lode(?), is located inside the Wilderness in sec. 10, T. 9 N., R. 7 E. Large blocks of unpatented claims are at Copper Mountain, Copper Camp Creek, Mineral Canyon, Horseshoe Dam, Sunflower, and House Creek. Because few old claim descriptions are definitive, many mines and prospects cannot be correlated with claims.

Known Mineralized Areas

Copper Mountain

Just south of the East Verde River, and 1 to 5 mi (1.6 to 8 km) inside the Wilderness, the Copper Mountain group consists of a block of over 100 claims. Several miles of bulldozer roads, a 110- by 60- by 100-ft-deep (32- by 20- by 30-m-deep) open cut, and many old workings that are caved except for three short adits occur within the claim block. West of Bullfrog Canyon, silver is dominant in faults and sheared quartz veins in graywackes and siltstones near major faults. East of Bullfrog Canyon, the copper minerals chalcopyrite, bornite, and copper oxides are dominant, occurring as disseminations, blebs, and disseminations in quartz veins. Country rocks are mafic volcanics.

Mineral Canyon

A network of bulldozer roads covers the spur ridge on the north side of Mineral Canyon and extends into the Wilderness. A block of 56 claims covering this area has been known variously as the Big Penny and Big Bear group.

Freeport Exploration Co., Miami Copper Co., Phelps Dodge Corp., Phoenix Ventures, Pinal Copper Corp., and Viola Mac examined the property between 1957 and 1977. Disseminated copper oxides, occur in a brecciated complex of intermediate volcanic and plutonic rocks near a major fault intersection. The mineralized zone extends at least 1,500 ft (460 m) into the Wilderness.

Copper Camp Creek

Copper oxides are found at the Copper Cliff group of 22 claims in the center of the southern quarter of the Wilderness. Over a dozen pits and trenches, a 60-ft (20-m) shaft, and a 390-ft (120-m) adit are in the mineralized zone. Drilling was proposed by the claim owners in 1972, and recommended by a U.S. Forest Service examiner (U.S.F.S., 1973), but never carried out. Country rocks are Alder Group, mostly of volcanic derivation.

Horseshoe Dam

Low-grade uranium occurrences are present in Tertiary lake-basin sediments east of Horseshoe Dam. Two blocks of 150 claims each have been located, and at least three holes drilled. Some of these claims are in the RARE II area. A sample taken across a 4 in. (10 cm) bed assayed 165-ppm U_3O_8, but the next highest assay from beds in this basin was only 18 ppm.

Past and Present Mining Activity and Production Data

Gold was discovered in about 1875 near Payson, and the Payson mining district had its peak between 1881 and 1886 (Lausen and Wilson, 1925). Production from that period was not recorded. The district was more or less idle until the 1930's, after which there was sporadic production. Between 1938 and 1956 the Casterson, Collom, Crackerjack, and Gowan Mines produced (USBM Files):

gold:	199 oz	(6,190 g)
silver:	426 oz	(13.2 kg)
copper:	17,596 lb	(7,990 kg)

In 1967, 33.5 tons (30.4 t) of ore containing 938 lb (426 kg) of copper and 485 oz (15.1 kg) of silver were produced from the Copper Mountain open cut (USFS files).

Exploration for copper has been moderately active at Mineral Canyon from 1956 to 1977, at Copper Mountain from 1964 to present, at Copper Camp Creek from 1955 to 1972, and at Eisenhauer Canyon in 1957. Increasing precious metal prices have spurred renewed activity at several properties near Payson.

Mercury was discovered in the Sunflower mining district in October, 1911, (Ransome, 1915), which has remained intermittantly active until the present, although there has been little production since the 1960's. At present the only activity is at the Sunflower Mine.

The Pine Mountain and Sunflower Mines were the major mercury producers near the Wilderness. Other properties combined have contributed minor quantities of mercury. The Storey (Tri-Metals) Mine produced no mercury, and various mercury mines produced gold, silver, and copper. Recorded production (USBM and USFS Files except as noted) from 1913 to 1965 is:

mercury:	3,973 flasks	(137 t)	(Beckman and Kerns, 1965)
gold:	764 oz	(23.8 kg)	
silver:	1,095 oz	(34.1 kg)	
copper:	2,140 lb	(970 kg)	
lead:	27,650 lb	(12.5 t)	

Resource Estimates

Deposits in, or within a half mile (0.8 km) of the Wilderness or RARE II area are listed here. Estimates are based on Bureau of Mines mapping and 570 Bureau of Mines samples taken in area. At the time of the study—1979 to 1981—all resources except the Storey Mine were sub-economic.

Payson District

Combined inferred resources of the Casterson and Collom Mines, just outside the Wilderness, are 52,000 tons (47,000 t) containing 0.07 oz of gold and 0.7 oz of silver per ton (2.3 g of gold and 25 g of silver per metric ton).

Copper Mountain has a moderate size copper-silver resource entirely inside the Wilderness. The mineralized area is 8,000 by 200 ft (2,400 by 60 m) with high-grade spots.

Mineral Canyon has a moderate size copper resource which is partly inside the Wilderness. The mineralized area is 3,000 by 800 ft (900 by 240 m).

Sunflower District

The Sunflower Mine has an inferred resource of 26,000 tons (24,000 t) containing 0.14-percent mercury just outside the Wilderness, and an inferred resource of 3,600 tons (3,300 t) containing 0.21-percent mercury just inside the Wilderness.

Inside the Wilderness, the Storey Mine has an inferred resource of 78,000 tons (71,000 t) containing 0.06 oz of gold and 1.9 oz of silver per ton (2.1 g of gold and 65 g of silver per metric ton) and 3.9-percent lead. This resource is calculated from surface exposures, as the workings are all caved. The known production has been subtracted from the calculated resource, however, any unrecorded production which may have occurred would also subtract from the quantity stated.

Copper Camp Creek has a moderate size copper resource entirely inside the Wilderness. The mineralized area is 3,000 by 200 ft (900 by 60 m).

ASSESSMENT OF MINERAL-RESOURCE POTENTIAL

This is a preliminary assessment based on Bureau of Mines data gathered during this investigation. Figure 2 shows the areas determined to have mineral-resource potential. For purposes of this report the following definitons are used: small resources/reserves - less than 100,000 tons (91,000 t), medium-size resources/reserves - 100,000 to one million tons (91,000 to 910,000 t), large resources/reserves-more than 1 million tons (910,000 t).

The Mazatzal Wilderness has copper, mercury, silver, gold, and lead resources. Dense chaparall and rugged terrain inhibit prospecting now, as in the past, and exploration would be difficult and costly.

Gold

Gold has been mined from quartz veins in Precambrian rocks lying near the Deadman, Verde, and Sheep Mountain faults mapped by Wrucke and Conway (in preparation) and the Payson granite. Except for the Gowan vein, these veins persist only a few hundred feet (tens of meters) along strike. No pinching of the veins down-dip was observed by the Bureau of Mines, nor was it reported by Lausen and Wilson (1925). Only free-milling gold was recoverable when the Payson district was active; therefore, development rarely proceeded more than tens of feet below the oxidized part of the vein. Vein configuration and proximity to the faults mentioned suggest that these veins filled tension gashes related to fault movement.

A moderate potential for gold exists in small- to medium-size, high - to moderate-grade veins in Precambrian rocks near these faults. Gold is expected as a byproduct of copper or mercury deposits.

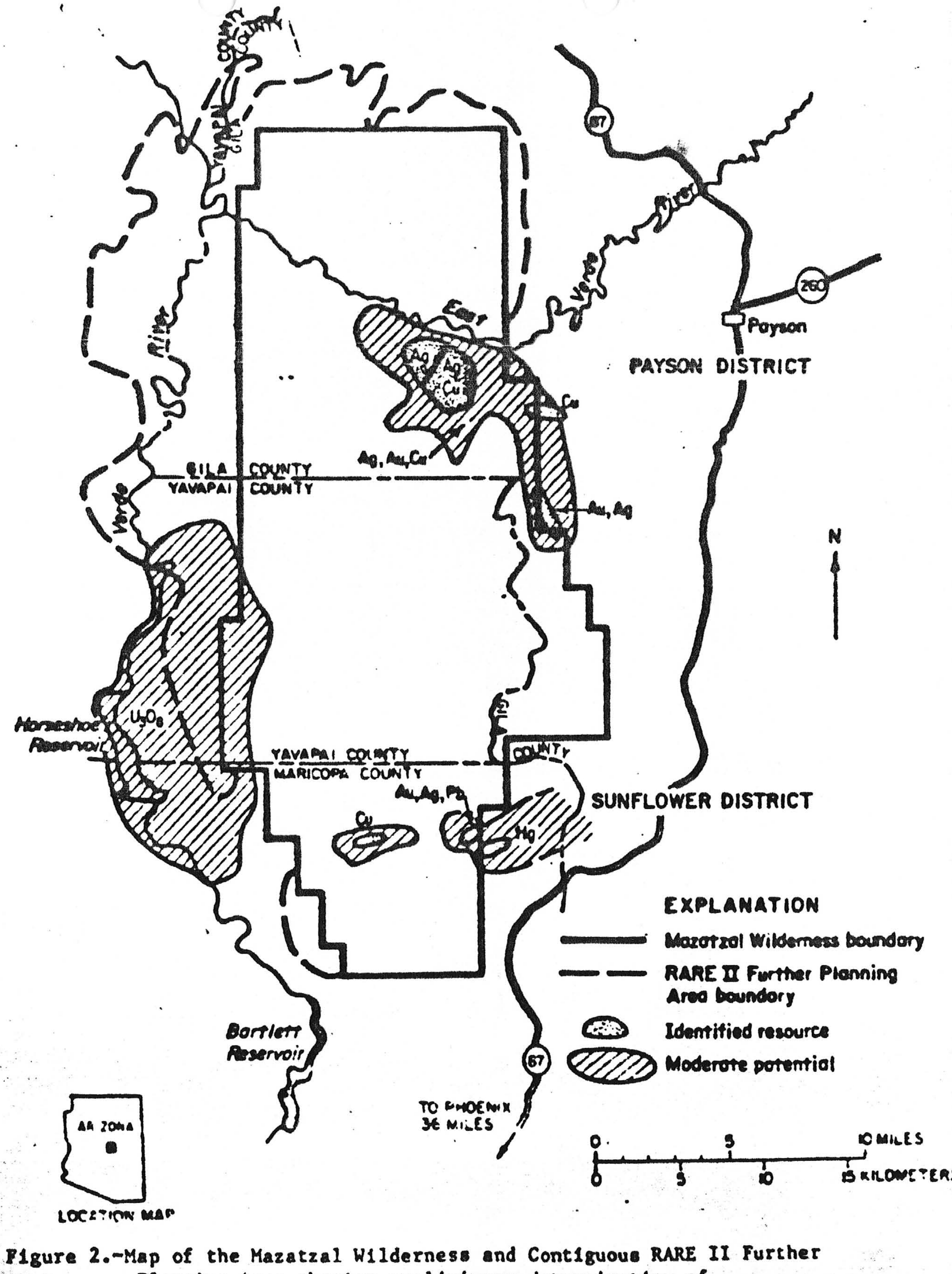


Figure 2.-Map of the Mazatzal Wilderness and Contiguous RARE II Further Planning Area showing preliminary determination of mineral-resource potential.

Silver

Silver accompanies gold in the vein systems described above, and would be a byproduct of mining copper or mercury deposits. Relationships of silver to copper are unclear west of Bullfrog Canyon in the sedimentary sequence of the Copper Mountain deposit. With this exception, silver potential is related directly to gold, mercury, and copper potential.

Copper

Some copper may be syngenetic with Precambrian volcanic-sedimentary rocks (upper Alder Group and Yavapai(?) Group), but if so, it is very spotty. Concentrations of copper from the Payson granite and the possible older sources are localized in brecciated zones related to intersection of the Verde and Deadman Fault, intersection of the Sheep Mountain Fault and local faults related to Tertiary plugs, or in permeable host rocks near major faults and the granite.

A moderate potential for copper exists in medium-size, low- to moderate-grade deposits in basic- to intermediate-volcanic rocks of Precambrian age which are near structural intersections and the Payson granite. A moderate potential for copper in small, high-grade deposits exists in Precambrian basic- to intermediate-volcanic rocks. The Mazatzal Wilderness and RARE II area is not a porphyry copper environment. Some copper would be a byproduct of mining gold-silver veins, and rarely might be recovered from mercury deposits.

Mercury

Alder Group rocks are the only host in this area for more than trace amounts of mercury. Quartz-sericite or chlorite schists are favored, probably due to permeability of the beds, or between the beds. The mercury, probably derived from the Payson granite and remobilized by the heat from Tertiary stocks, was driven along permeable paths in the Alder Group beds. Deposition was probably a function of temperature.

A moderate potential for mercury in small, low- to moderate-grade deposits exists in the Precambrian Alder Group in proximity to the Payson granite, Sheep Mountain Fault and a Tertiary stock, which is to say within the present Sunflower district.

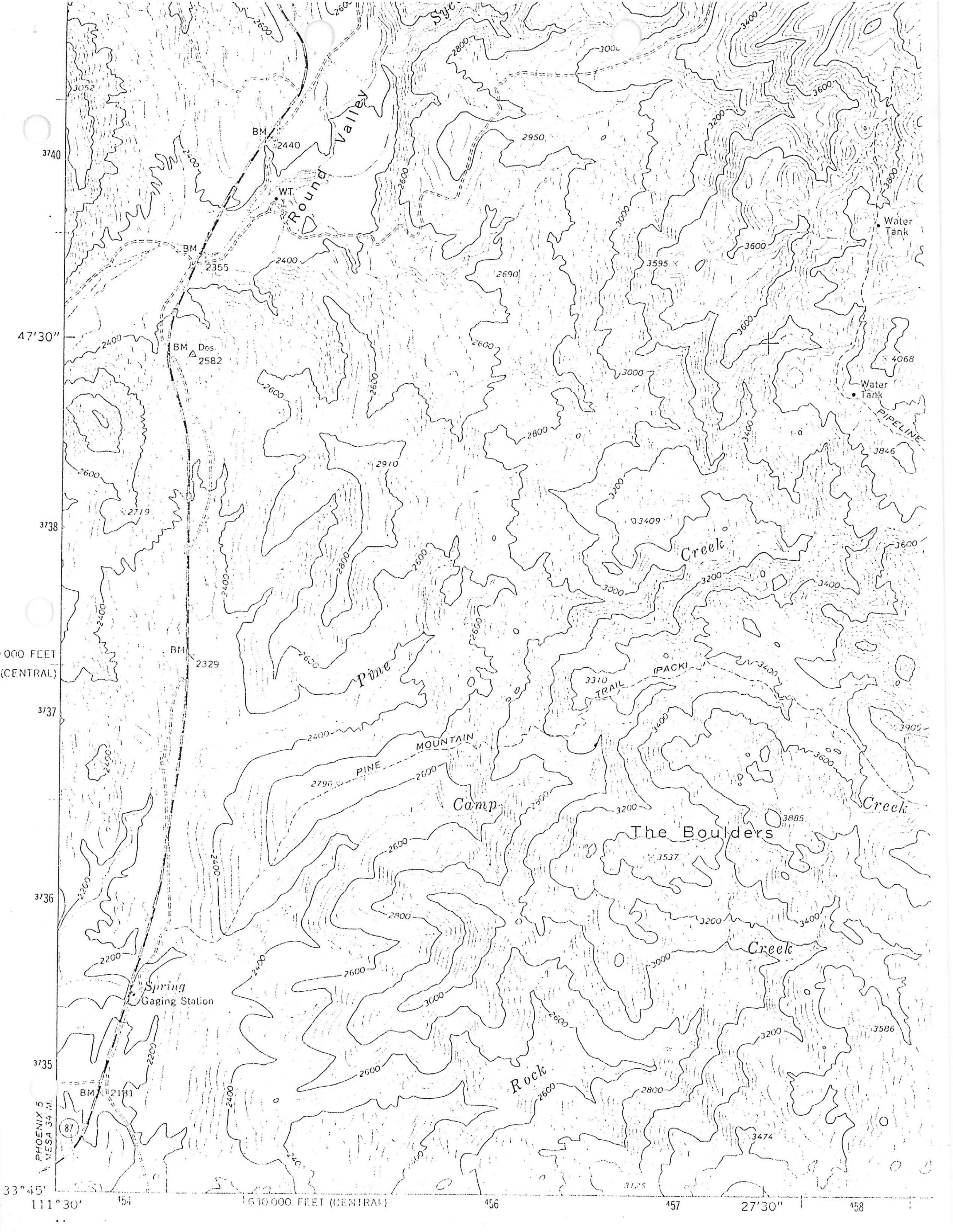
Lead

Lead is a major constituent of the Storey and Stingy Lady veins, but is otherwise uncommon in the Mazatzal Wilderness and RARE II area. These veins are short along strike, but their behavior along dip is unknown. Both are near major faults; the Storey is near the Payson granite, and the Stingy Lady within it.

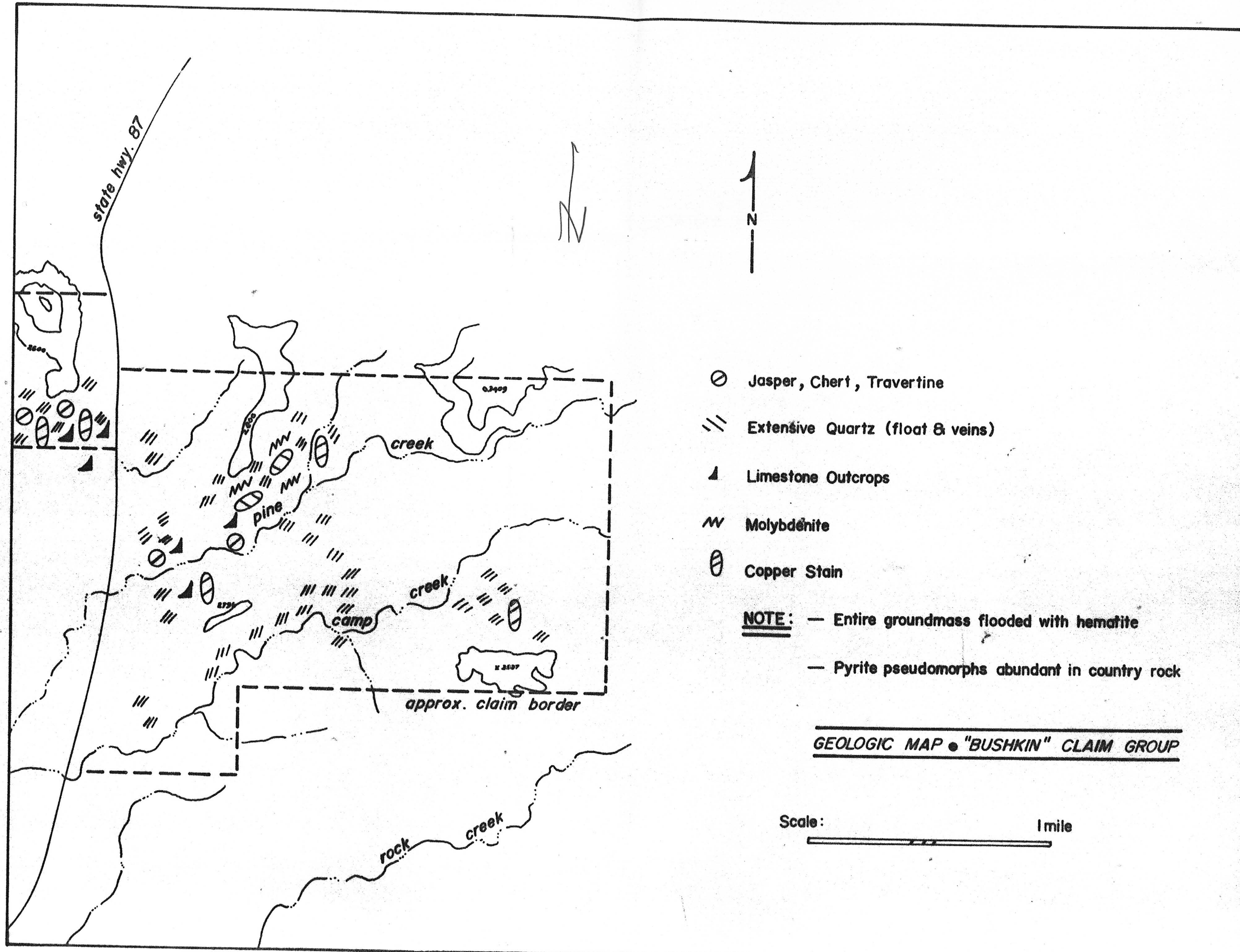
A low potential exists for lead in small, high-grade vein deposits in Precambrian rocks in or near the Payson granite near major faults.

Uranium

Anomalous, but very low-grade uranium is found in tuffaceous sandstones in a Tertiary basin-fill. A moderate potential for uranium in medium-size, low-grade deposits exists in the Tertiary sediments in the Verde River valley, particullarly in the area receiving detritus from the uranium-bearing stock in Tangle Creek.



Round Valley
BM 2440
WT.
BM 2355
BM Dos. 2582
BM 2329
2950
2690
2910
3595
3409
3310
Creek
TRAIL (PACK)
PINE MOUNTAIN
2796
Pine
Camp
Rock
Creek
The Boulders
3885
3537
Creek
3586
3474
3125
Water Tank
Water Tank
4066
PIPELINE
3846
3905
3052
2719
Spring
Gaging Station
BM 2181
87
PHOENIX 5
MESA 34 MI.
3740
47'30"
3738
000 FEET
(CENTRAL)
3737
3736
3735
33°45'
111°30'
454
630 000 FEET (CENTRAL)
456
457
27'30"
458


state hwy. 87
N
creek
pine
camp
creek
approx. claim border
rock
creek
Jasper, Chert, Travertine
Extensive Quartz (float & veins)
Limestone Outcrops
Molybdenite
Copper Stain
NOTE: — Entire groundmass flooded with hematite
— Pyrite pseudomorphs abundant in country rock
GEOLOGIC MAP • "BUSHKIN" CLAIM GROUP
Scale:
1 mile