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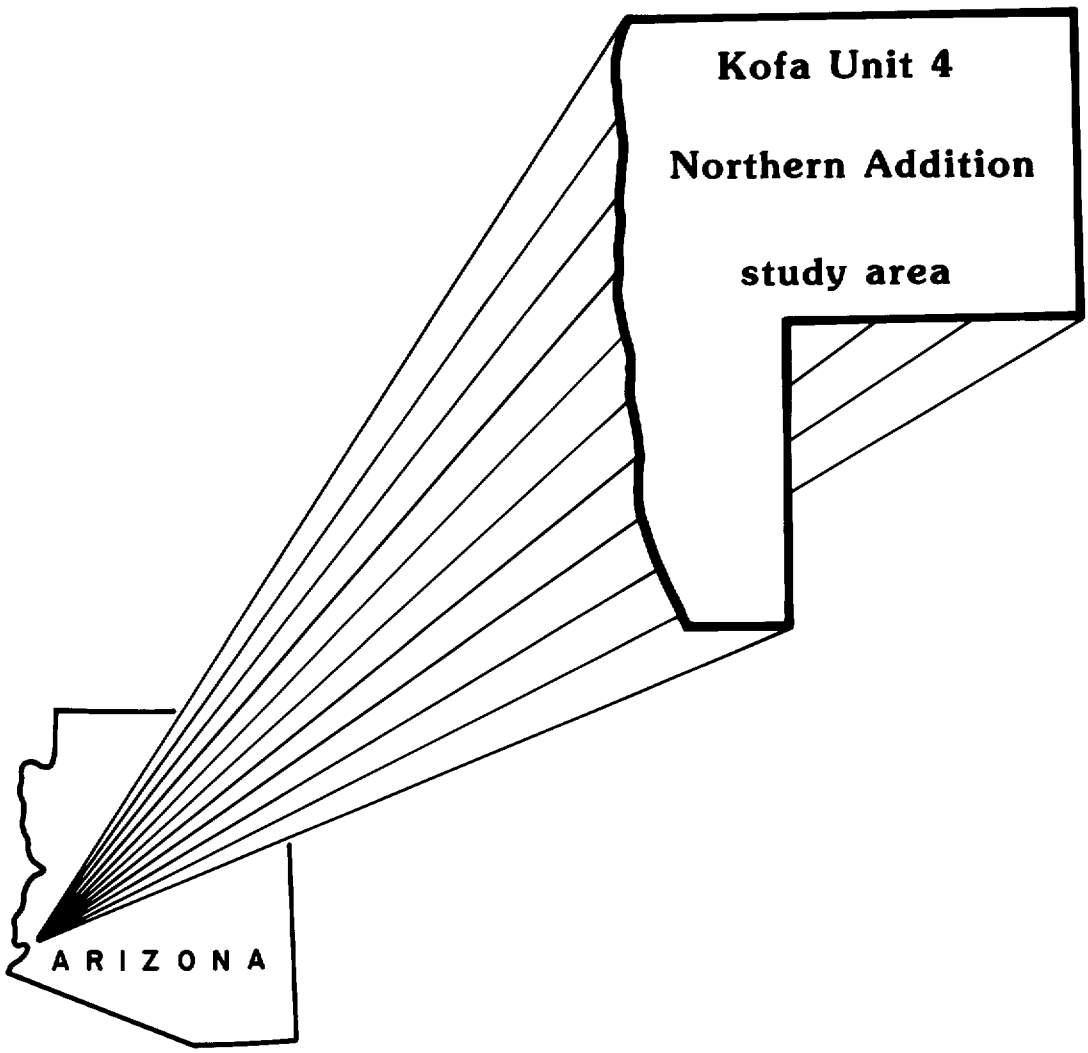
Mineral Land Assessment
Open File Report/1989

Mineral Resources of a Part of the Kofa Unit 4 Northern Addition Wilderness Study Area (AZ-050-033), Yuma County, Arizona



BUREAU OF MINES
UNITED STATES DEPARTMENT OF THE INTERIOR

MINERAL RESOURCES OF A PART OF THE KOFA UNIT 4 NORTHERN ADDITION WILDERNESS STUDY AREA (AZ-050-033), YUMA COUNTY, ARIZONA

by

Diann D. Gese

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1989

Intermountain Field Operations Center,
Denver, Colorado

UNITED STATES DEPARTMENT OF THE INTERIOR
Manual Lujan, Jr., Secretary

BUREAU OF MINES
T S Ary, Director

PREFACE

The Federal Land Policy and Management Act of 1976 (Public Law 94-579) requires the U.S. Geological Suvey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of a part of the Kofa Unit 4 Northern Addition Wilderness Study Area (AZ-050-033), Yuma County, Arizona.

This open-file report summarizes the results of a Bureau of Mines wilderness study. The report is preliminary and has not been edited or reviewed for conformity with the Bureau of Mines editorial standards. This study was conducted by personnel from the Resource Evaluation Branch, Intermountain Field Operations Center, P.O. Box 25086, Denver Federal Center, Denver, CO 80225.

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UNIT OF MEASURE ABBREVIATIONS IN THIS REPORT

°C	degree Celsius
ft	foot
mi	mile
meq/g	milliequivalents per gram
ppb	part per billion
ppm	part per million
%	percent
st	short ton (2,000 pounds)
ft^2	square foot
oz	troy ounce
oz/st	troy ounce per short ton

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by

Diann D. Gese, Bureau of Mines

SUMMARY

At the request of the Bureau of Land Management, and as authorized by the Federal Land Policy and Management Act of 1976 (Public Law 94-579), the Bureau of Mines conducted a mineral survey in April 1988, on 1,380 acres of the 1,900-acre Kofa Unit 4 Northern Addition Wilderness Study Area, Yuma County, Arizona.

Inferred subeconomic resources of approximately 733,000 st of 60% to 98% combined zeolites (mordenite and clinoptilolite) were measured in the study area. Tests show that these zeolites may have commerical value in water purification. Zeolites have been mined approximately 1,500 feet west of the study area boundary.

Previous geophysical and geological studies indicate that geothermal resources may exist at depth in the area studied. A geothermal gradient of 2.1°C/100 feet was measured in a dry well approximately one mile northwest of the study area. Sand and gravel occurs along the west and north sides of the study area, and similar deposits occur outside the study area much closer to local markets.

INTRODUCTION

In April 1988, the Bureau of Mines, in cooperation with the U.S. Geological Survey (USGS), conducted a mineral investigation of a part of the Kofa Unit 4 Northern Addition Wilderness Study Area (WSA) in southwest Arizona, on lands administered by the Bureau of Land Management (BLM), Yuma District Office. The Kofa Unit 4 Northern Addition WSA comprised 1,900 acres;

the Bureau studied 1,380 acres deemed preliminarily suitable for inclusion in the National Wilderness Preservation System. "Study area" (SA) as used in this report refers only to the smaller area. The Bureau surveys and studies mines, prospects, and mineralized areas to appraise reserves and identified subeconomic mineral resources. The USGS studies and assesses the potential for undiscovered mineral resources based on regional geological, geochemical, and geophysical surveys. This report presents the results of the Bureau's study, which was completed prior to the USGS assessment. The USGS will publish the results of their studies. A joint report, to be published by the USGS, will integrate and summarize the results of both surveys.

Geographic setting

The Kofa Unit 4 Northern Addition SA comprises 1,380 acres adjacent to part of the west boundary of the Kofa National Wildlife Refuge in southwest Yuma County, Arizona (fig. 1). The study area is approximately 28 mi south of Quartzsite, Arizona, and 57 mi north of Yuma. Access to the SA boundary is by secondary roads from U.S. Highway 95.

The SA is in the Sonoran Desert section of the southern Basin and Range physiographic province along the northern end of the Castle Dome Mountains and the divide between La Posa and Castle Dome Plains. The topography is hilly along the west part and becomes more rugged toward the east along the mountain range. Elevations range from 2,159 ft on one of the mountain ridges to 1,600 ft along the northwest boundary.

Previous investigations

Little has been published about the Kofa Unit 4 Northern Addition SA. Wilson (1933) studied the geology and mineral deposits of southern Yuma County in the early 1930's and later revised the geologic map of Yuma County (Wilson,

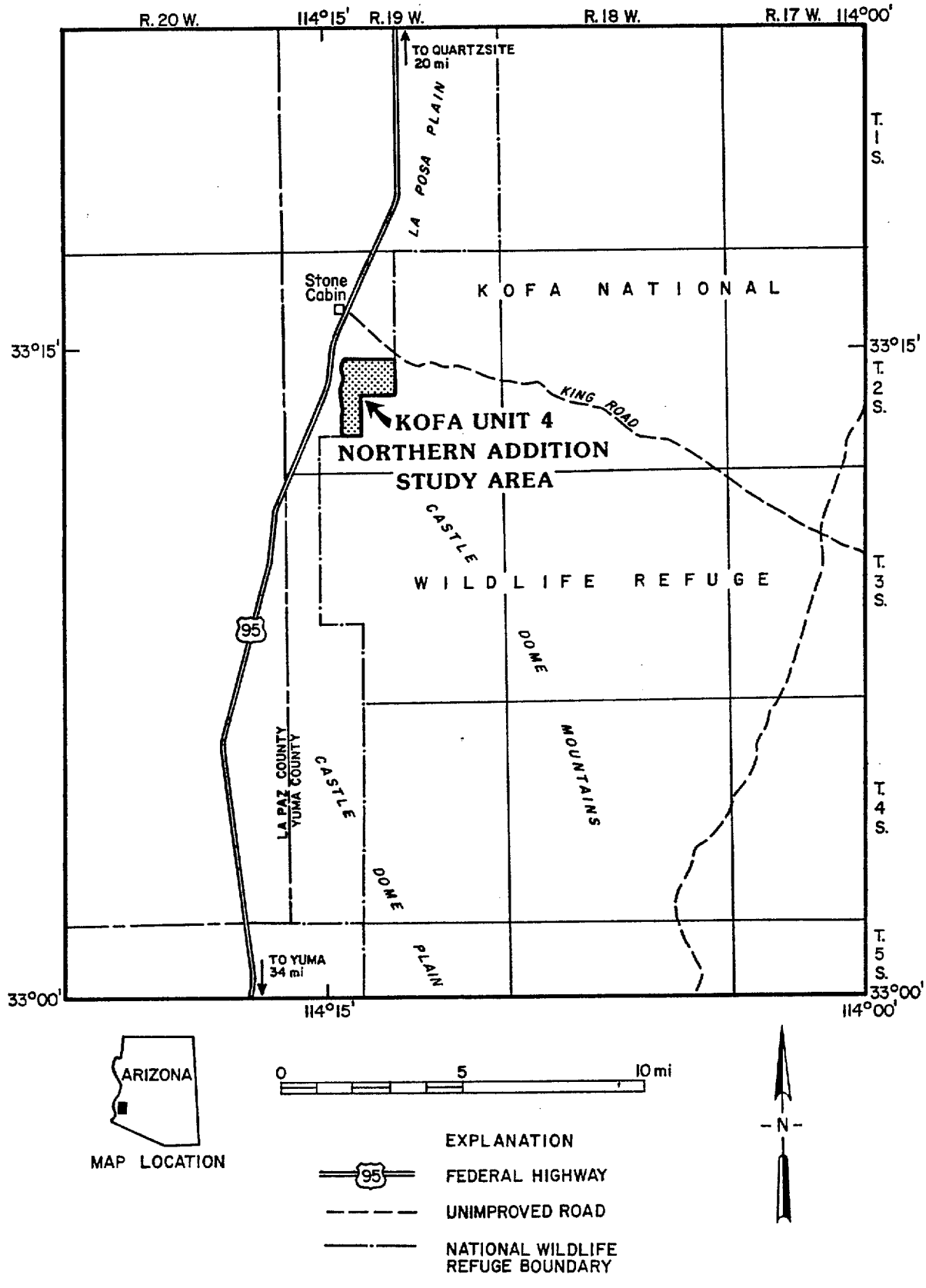

Figure 1.--Index map of the Kofa Unit 4 Northern Addition study area, Yuma County, Arizona.

1960). The geology, energy, and mineral resources of the SA are discussed in Krason and others' (1982) report on the Kofa Resource Area. Three samples were taken from the study area during Adrian and others' (1986) reconnaissance geochemical survey of the Kofa National Wildlife Refuge and proposed additions. Most recently, the USGS mapped the geology and assessed the mineral resources of the Kofa National Wildlife Refuge adjacent to the SA (Bagby and others, 1987).

Methods of investigation

Pertinent published and unpublished literature were reviewed prior to the field investigation. Files at the BLM State Office in Phoenix, Arizona, were checked for patented and unpatented mining claim locations and oil and gas, coal, and geothermal leases and lease applications. Persons having knowledge of mineral occurrences and mining activities in and near the study area were contacted.

Two Bureau geologists spent 2 days in the field and collected 6 rock-chip, 3 random, and 2 grab samples (table 1). All samples were analyzed by X-ray diffraction by the Mineral Lab, Lakewood, CO., to determine their mineral compositions. Samples containing over 60% combined zeolites were sent to the Bureau's Research Center in Reno, NV, for further testing to determine the material's suitablility for industrial uses (tables 2-8).

Tonnages for three zeolite deposits that occur in the SA were calculated by multiplying the area of a deposit times its thickness, and dividing the resulting volume by a tonnage factor of 15. The area of zeolite outcrop mapped in the field was estimated by using a planimeter; the thickness was measured in the field. Areas and thicknesses used to calculate the zeolite resources at the three deposits in this report are given in table 9.

Complete analytical results for all samples are available for public inspection at the Bureau of Mines, Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, CO.

Geologic setting

The SA is part of the northern Castle Dome Mountains which consist of Miocene- and Oligocene-age calc-alkaline flow units and tuffs that overlie Mesozoic-age metasedimentary rocks. Wilson (1933; 1960) mapped the Tertiary-Mesozoic contact as being unconformable, but more recent work by Logan and Hirsch (1982, p. 599-600) suggests the contact to be a low-angle normal fault, or detachment fault. Dacite and rhyolite porphyry dikes cut the metasedimentary rocks and host mineral deposits in the Castle Dome mining district. Rock units that crop out in the SA include Miocene and Oligocene welded and nonwelded tuff, rhyolitic to rhyodacitic in composition, which are overlain by Miocene rhyolite and rhyodacite lava flows. Gently sloping Quaternary-age alluvium forms broad plains along the west boundary. (See Bagby and others, 1987; Logan and Hirsch, 1982.)

Mining history

The study area is about 11 mi north-northwest of the Castle Dome mining district and about 12 mi southwest of the Kofa district. Production history for both mining districts is mainly from Keith (1978). The Castle Dome district was organized in 1863 (Wilson, 1933, p. 85) after argentiferous galena-fluorite-barite fissure veins in metamorphosed Mesozoic sedimentary rocks were discovered. The district was active almost continuously up to 1974 and has produced some 119,000 st of ore containing more than 10,500 st of lead, 478,000 oz of silver, and 38 st of zinc. Small amounts of gold and copper were recovered as byproducts. Between 1902 and 1913, 3,300 st of

fluorspar were produced and used for flux at a portland cement plant and potash recovery.

The main producer in the Kofa district in the Kofa Mountains, the King of Arizona Mine, was discovered in 1896. Mineralization in the district consists mainly of fine-grained gold and silver in quartz and brecciated wall rock with minor copper and lead in the Mesozoic sediments. Total production from 1896 through 1954 was 779,000 st of ore containing 226,654 oz of gold and 103,257 oz of silver. Placer operations produced an additional 2,500 oz of gold and 500 oz of silver.

Zeolites have been mined by open-pit methods and stockpiled along the western boundary of the study area by the Yuma Zeolite Corp., Phoenix, AZ. The mine was inactive at the time of this investigation (April 1988). A group of lode claims staked for zeolites, extends into the study area in secs. 20 and 29, T. 2 S., R. 19 W. (fig. 2).

ENERGY RESOURCES

There are no oil or gas leases or lease applications in the Kofa Unit 4 Northern Addition SA. Host rocks in the SA are unfavorable for oil or gas accumulation; therefore, Ryder (1983, p. C19-20) rated the hydrocarbon potential of the study area as low to zero.

The SA is in a region that previous geophysical and geological studies indicate may contain significant shallow geothermal resources. The study area is near the center of a large negative residual Bouguer gravity anomaly. Pre-Tertiary rocks crop out around, but not within the gravity low, which may indicate a large silicic batholith at depth, the source of the Oligocene-Miocene volcanic rocks in the region. A large silicic batholithic complex would be a likely candidate for a shallow, dry rock, regional heat source. A

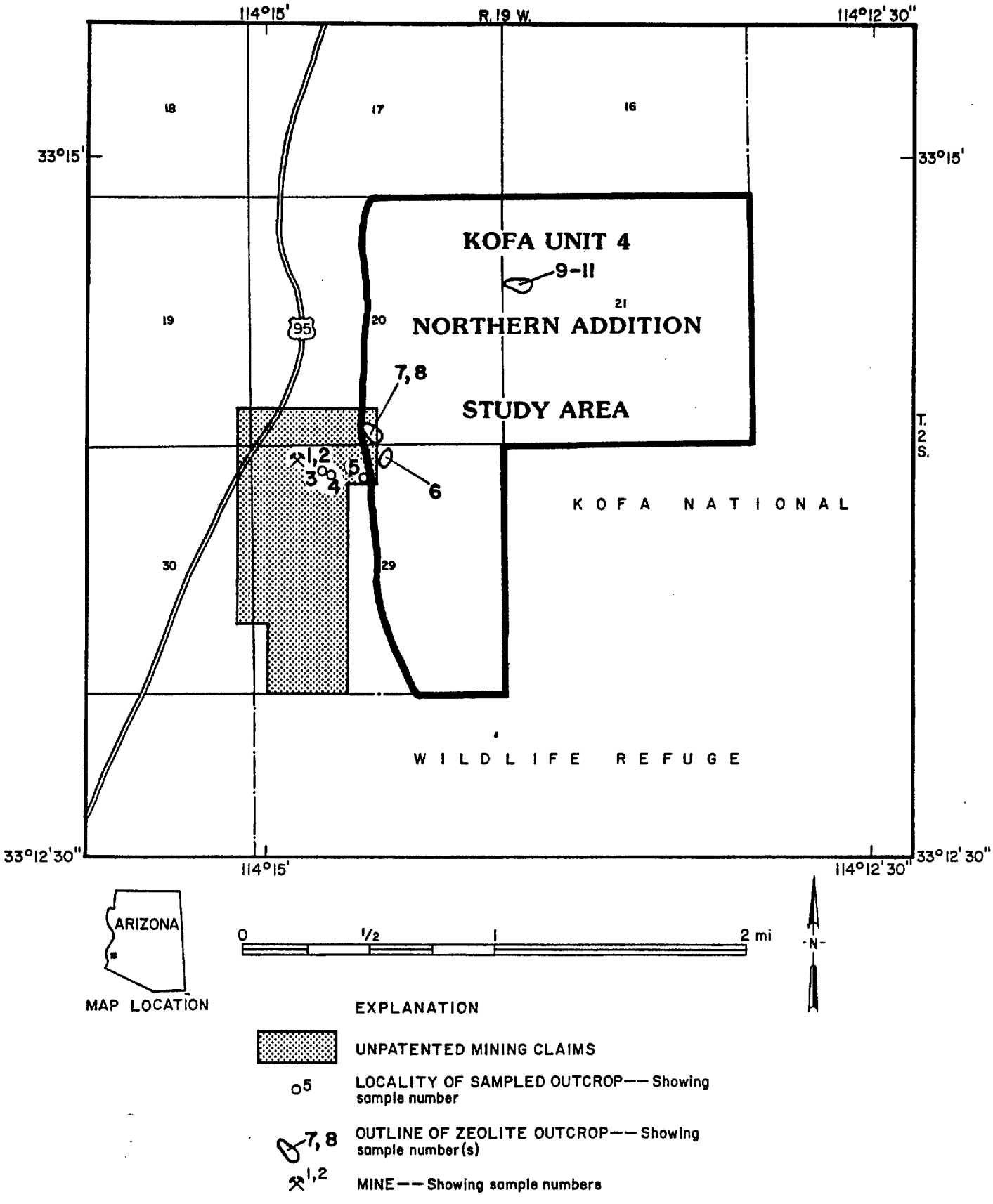

Figure 2.--Sample locality map of the Kofa Unit 4 Northern Addition study area, Yuma County, Arizona.

depth-to-Curie isotherm analysis indicates a 500°C isothermal surface at a depth of 4 to 5 mi. (See Gutmann, 1981.) Warm wells exist in the vicinity and Shearer (1979) measured an average geothermal gradient of 2.1°C/100 ft in a 1,040-ft-deep dry drill hole at Stone Cabin, approximatley 1 mi northwest of the SA.

RESULTS OF FIELD INVESTIGATION

Zeolites (mordenite and clinoptilolite) are the only minerals of economic interest known to occur in the SA. The zeolites occur in a Tertiary-age green-colored rhyolite tuff that crops out along the western boundary.

Zeolites are a group of naturally occurring aluminosilicates whose framework structure contains interconnected cavities filled with water molecules and exchangeable cations (Sheppard and Gude, 1982, p. 1). The absorption, catalytic, dehydration, and ion-exchange properties of zeolites are the basis for their numerous commercial applications in agriculture, energy conservation, mining and metallurgy, and pollution control.

Clinoptilolite and mordenite can both be used for the removal of sulfur dioxide (SO_2) and other pollutants from stack gases of oil- and coal-burning power plants, and water and carbon dioxide from gaseous hydrocarbons. These zeolites also can be used as dietary supplements in animals. Clinoptilolite is used in the removal of radioactive cesium and strontium from nuclear installations' waste streams, the extraction of ammoniacal nitrogen (NH_4^+) from sewage and agricultural effluents, and as heat exchangers. Mordenite can be used as an oxygen generator and in lightweight brick contruction. (See Mumpton, 1978; 1983.)

Three zeolite deposits in the SA (fig. 2, samples 6-11) are inferred subeconomic resources containing approximately 733,000 tons of 60% to 98%

combined zeolites (mordenite and clinoptilolite; tables 3 and 9). Clinoptilolite and mordenite were the major constituents with minor quartz (table 3). Tests indicate that the ammonium-ion exchange capacity, important in radioactive and waste water treatment, of the zeolites was relatively low, ranging from 0.54 meq/g to 0.96 meq/g (table 6). Most commercial zeolites have exchange capacities between 1 and 2 meq/g. However, the zeolites may have commercial value because some of the samples purified water containing 200 ppm to 1,000 ppm lead (Pb^{2+}) to drinking water standards of less than 50 ppb (table 7). In addition to being used in water purification, additional testing could determine other uses for these zeolites.

All three deposits are exposed at the surface and are up to 25 ft thick, suitable for open-pit mining. The crushed and sized product could then be easily trucked the 57 mi to Yuma for distribution.

Sand and gravel occurs along the west and north sides of the study area, and similar deposits occur outside the SA much closer to local markets.

CONCLUSIONS

A measured resource of approximately 733,000 tons of 60% to 98% combined zeolites (mordenite and clinoptilolite) was identified in the study area. Tests show these zeolites may have commercial value in water purification. Previous geophysical studies indicate that geothermal resources may exist in the study area. A geothermal gradient of 2.1°C/100 feet was measured in a dry well approximately one mile northwest of the SA. Sand and gravel occurs in the study area, and similar deposits occur closer to local markets.

REFERENCES

Adrian, B. M., Smith, D. B., Hill, R. H., Roemer, T. A., Vaughn, R. B., and Delaney, T. A., 1986, Analytical results and sample locality maps of stream-sediment, heavy-mineral-concentrate, and rock samples from the Kofa National Wildlife Refuge, Yuma and La Paz Counties, Arizona: U.S. Geological Survey Open-File Report 86-199, 122 p.

Bagby, W. C., Haxel, G. B., Smith, D. B., Kock, R. O., Grubensky, M. J., Sherrod, D. R., and Pickthorn, L. B. G., 1987, Mineral resource assessment of the Kofa Wildlife Refuge, Arizona: U.S. Geological Survey Open-File Report 87-609, 45 p.

Gutman, J. T., 1981, Geologic framework and hot dry rock geothermal potential of the Castle Dome area, Yuma County, Arizona: Los Alamos Scientific Laboratory Report, LA-8723-KDR, UR-66b, 23 p.

Keith, S. B., 1978, Index of mining properties in Yuma County, Arizona: Arizona Bureau of Geology and Mineral Technology Bulletin 192, 185 p.

Krason, Jan, Wodzicki, Antoni, and Cruver, S. K., 1982, Geology, energy and mineral resources assessment of the Kofa area, Arizona: unpublished report prepared for the U.S. Bureau of Land Management, Phoenix, Arizona, 207 p.

Logan, R. E., and Hirsch, D. D., 1982, Geometry of detachment faulting and dike emplacement in the southwestern Castle Dome Mountains, Yuma County, Arizona, in Frost, E. G., and Martin, D. L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River Region, California, Arizona, and Nevada: San Diego, California, Cordilleran Publishers, p. 599-607.

Mumpton, F. A., 1978, Natural zeolites: a new industrial mineral commodity, in Sand, L. B., and Mumpton, F. A., eds., Natural zeolite: occurrence, properties, use: New York, Pergamon Press, p. 3-27.

_____ 1983, Commercial utilization of natural zeolites, in Lefond, S. J., ed., Industrial minerals and rocks; New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., p. 1418-1426.

Ryder, R. T., 1983, Petroleum potential of wilderness lands in Arizona, in Miller, B. W., ed., Petroleum potential of wilderness lands in the western United States: U.S. Geological Survey Circular 902 A-P, p. C1-22.

Shearer, C. R., 1979, Regional terrestrial heat-flow study in Arizona: Socorro, New Mexico, New Mexico Institute of Mining and Technology, unpublished Ph.D. dissertation, 184 p.

Sheppard, R. A., and Gude, A. J., 1982, Mineralogy, chemistry, gas absorption, and NH_4^+-exchange capacity for selected zeolite tuffs from the western U.S., U.S. Geological Survey Open File Report 82-969, 16 p.

Wilson, E. E., 1933, Geology and mineral resources of southern Yuma County, Arizona: Arizona Bureau of Mines Bulletin 134, 236 p.

_____ 1960, Geologic map of Yuma County, Arizona: Arizona Bureau of Mines, scale: 1:375,000.

Table 1.--Descriptions of zeolite samples from the Kofa Unit 4 Northern Addition study area, Yuma County, Arizona.

[Symbol used: ---, not applicable.]

Sample No.	Sample Type	Sample Length (ft)	Description
1	Grab	---	Yuma Zeolite Corp.'s mine, light-green colored zeolite in rhyolite tuff.
2	do.	---	Yuma Zeolite Corp.'s mine; bagged material from stock-pile.
3	Chip	2.0	Weathered, fractured zeolite outcrop.
4	do.	2.0	Do.
5	Random	---	Weathered, fractured, light-green colored zeolite in rhyolite tuff.
6	Chip	4.0	Do.
7	Random	---	Do.
8	Chip	15.0	Do.
9	do.	10.0	Do.
10	Random	---	Do.
11	Chip	2.0	Similar to samples 9 and 10, but not as weathered.

Table 2.--Alkali and alkaline earth contents of nine zeolite samples, Kofa Unit 4 Northern Addition study area, Yuma County, Arizona.

[Symbol used: meq/g, milliequivalents per gram.]

Element	Sample no. 3	4	5	6	7	8	9	10	11
	meq/g								
Ca	0.94	0.26	1.6	0.74	0.60	1.0	0.48	0.74	0.60
K	.46	.43	.46	.51	.38	.36	.49	.64	.59
Mg	.24	.18	.24	.20	.28	.24	.28	.30	.32
Na	.65	1.2	.65	.65	.83	.78	.78	.35	.75

Table 3.--X-ray diffraction results of zeolite samples, Kofa Unit 4 Northern Addition study area, Yuma County, Arizona.

[Samples 1 and 2 analyzed by X-ray diffraction at the Mineral Lab, Lakewood, CO.; samples 3-11 analyzed by X-ray diffraction at the Bureau of Mines, Reno Research Center, Reno, NV. Symbols used: na, not analyzed; %, percent; tr, trace; ---, not detected.]

Sample no.	Minerals				
	Mordenite	Clinoptilolite	Quartz	Clay	Potassium feldspar
	(%)				
1	20	15	20	5	30
2	10	10	5	---	30
3	42	21	6	tr	na
4	60	36	3	tr	na
5	54	16	12	---	na
6	47	38	8	---	na
7	53	42	4	tr	na
8	72	21	7	tr	na
9	61	37	7	tr	na
10	55	32	10	tr	na
11	42	50	4	tr	na

Table 4.--Results of loss on ignition tests of nine zeolite samples, Kofa Unit 4 Northern Addition study area, Yuma County, Arizona.

[Symbol used: <, less than.]

Sample no.	Weight unburned (grams)	Weight burned (grams)	Percent loss	Weight after 3 days open to atmosphere (grams)	Percent gain
3	27.11	24.88	8.2	24.88	0.0
4	32.30	27.58	14.6	27.60	.1
5	45.22	41.02	9.3	41.22	.5
6	27.49	25.54	7.1	25.55	.0
7	38.75	34.18	11.8	34.18	.0
8	29.76	27.48	7.7	27.46	<.1
9	38.88	35.24	9.4	35.21	<.1
10	38.79	35.87	7.5	35.92	.1
11	29.92	27.42	8.3	27.47	.2

Table 5.--Results of inductively coupled plasma analysis of nine zeolite samples, Kofa Unit 4 Northern Addition study area, Yuma County, Arizona.

[Results in milligram element per gram zeolite. Symbol used: <, less than.]

Element	Sample number								
	3	4	5	6	7	8	9	10	11
Al	65	62	63	65	66	68	67	67	68
Ba	1.1	.520	.230	.210	.670	.250	.670	.600	.770
Be	.006	.006	.008	.008	.007	.008	.006	.007	.008
Bi	.940	.980	1.0	1.0	1.1	1.1	1.1	1.2	1.3
Ca	19	5.1	32	15	12	20	9.6	15	12
Cd	.046	.042	.043	.045	.051	.053	.049	.058	.057
Co	.089	.085	.086	.088	.099	.099	.099	.099	.110
Cr	.370	.320	.400	.390	.600	.520	.420	.450	.480
Cu	.082	.130	<.060	<.060	.790	.097	.087	.270	.077
Fe	16	10	12	12	11	11	12	12	13
K	18	17	18	20	15	14	19	25	23
La	.250	.260	.260	.290	.280	.300	.270	.300	.340
Mg	2.8	2.2	2.8	2.5	3.5	2.8	3.5	3.6	3.9
Mn	.400	.230	.370	.400	.440	.300	.370	.340	.340
Na	15	27	15	15	19	18	18	8	17
Nb	.190	.200	.190	.210	.210	.220	.210	.230	.250
Ni	.110	.300	.520	.300	.810	.560	.260	.260	.330
Pb	.480	.490	.530	.550	.630	.660	.600	.640	.700
Si	338	349	345	355	344	348	341	359	352
Sn	.200	.180	.210	.230	.230	.200	.270	.260	.250
Sr	.140	.170	.230	.086	.130	.160	.180	.130	.170
Ti	1.1	1.0	.740	.820	1.1	.760	1.2	1.2	1.4
V	.150	.220	.130	.190	.190	.190	.210	.190	.200
Y	.060	.053	.081	.075	.057	.075	.056	.060	.068
Zn	.790	.700	.540	.920	.680	1.1	.720	1.0	.990
Zr	.280	.250	.280	.320	.280	.320	.270	.280	.320

Table 6.--Results of ammonia column test of nine zeolite samples, Kofa Unit 4 Northern Addition study area, Yuma County, Arizona.

[The control sample contains 90 percent clinoptilolite. Symbols used: meq/g, milliequivalents per gram; ppm, parts per million.]

Sample no.	Ammonia capacity (meq/g)	Ammonia eluted (meq/g)	Ammonia bleed (ppm)
3	0.93	0.83	5.7
4	.90	.87	10
5	.54	.43	130
6	.74	.63	35
7	.96	.79	12
8	.64	.64	67
9	.82	.82	4.8
10	.76	.70	52
11	.86	.83	98
Control	1.18	1.18	.73

Table 7.--Results of lead column test of nine zeolite samples, Kofa Unit 4 Northern Addition study area, Yuma County, Arizona.

[The control sample contains 90 percent clinoptilolite. Symbols used: meq/g, milliequivalents per gram; ppb, parts per billion; <, less than.]

Sample no.	Lead capacity (meq/g)	Lead eluted (meq/g)	Lead bleed (ppb)
3	0.59	0.21	<5
4	.52	.29	32
5	.26	.09	860
6	.37	.15	<5
7	.55	.22	<5
8	.39	.11	1,300
9	.55	.28	<5
10	.27	.21	8,100
11	.50	.27	24
Control	1.04	.56	6.9

Table 8.--Ratio of mole silicon per mole aluminum data and theoretical capacity of nine zeolite samples, Kofa Unit 4 Northern Addition study area, Yuma County, Arizona.

[The control sample contains 90% clinoptilolite. Symbol used: meq/g, milliequivalent per gram.]

Sample no.	mole silicon/mole aluminum	theoretical capacity meq/g
3	5.0	2.4
4	5.4	2.3
5	5.3	2.3
6	5.3	2.4
7	5.1	2.4
8	5.0	2.5
9	4.8	2.5
10	5.1	2.5
11	5.0	2.5
Control 5.0	5.0	2.3

Table 9.--Data used in calculating zeolite tonnages within the Kofa Unit 4 Northern Addition study area, Yuma County, Arizona.

[Symbol used: ft^2, square foot.]

Sample no.	Area (ft^2)	Thickness (ft)	Short tons
6	240,000	25	399,000
7,8	218,000	15	218,000
9,10,11	87,000	20	116,000