

FC
USGS
OFR
79-764

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

MASSIVE ZUNYITE ROCK FROM WESTERN ELKO COUNTY, NEVADA

By

Robert R. Coats, Jerry Consul, and Sara T. Neil
U.S. Geological Survey, Menlo Park, California 94025

Prepared in cooperation with the
Nevada Bureau of Mines and Geology

U.S. Geological Survey
Open-file Report 79-764
1979

UNIVERSITY OF UTAH
RESEARCH INSTITUTE
EARTH SCIENCE LAB.

This report is preliminary and
has not been edited or reviewed
for conformity with Geological
Survey standards and nomenclature.

Table of Contents

	<u>Page</u>
What is zunyite? -----	1
The zunyite lode -----	2
Significance of massive zunyite rock -----	5
References -----	6

Illustration

Figure 1. Sketch map showing the location of the zunyite lode - 2a

WHAT IS ZUNYITE?

Zunyite is a hydroxy-fluoro-chloro silicate of aluminum. The formula most recently proposed for it (Bartl, 1970; Louisnathan and Gibbs, 1972) is $\text{Al}_{12}(\text{OH},\text{F})_{18}[\text{AlO}_4][\text{Si}_5\text{O}_{16}]\text{Cl}$. Zunyite has been known for nearly a hundred years, but the number of localities where it has been described is very small. It first attracted attention because of the glassy luster of isolated euhedral tetrahedral crystals. The chemical composition indicates its remarkably high Al/Si atomic ration of 13/5, as compared, for instance, with minerals of the andalusite group, in which the ratio is 2/1. Only mullite, of the common alumino-silicate minerals, which is exceedingly rare as a natural mineral, though produced artificially in enormous quantities as a high-temperature refractory material, has a higher Al/Si ratio: 3/1.

Zunyite was originally described from the Zuni mine, near Silverton, Colo. (Hillebrand, 1885). It was subsequently found in the adjacent Red Mountain district, Ouray County, Colo. (Penfield, 1893), and in Bonanza district of Saguache County, Colo. (Burbank, 1932). Zunyite also is present in the Tintic district of Utah (Lovering and Stringham, 1945) where it occurs as a fissure filling and an impregnation of the wall rock, a silicified tuff. In all these areas it occurs disseminated in igneous rocks as an alteration product of feldspars, or as a gangue mineral in metalliferous veins, or both.

The age of the rocks in which it has been found ranges from Precambrian in South Africa (Nel, 1930) to Tertiary, in many occurrences in Colorado, Utah, and Nevada. Commonly it is found in altered and silicified igneous rocks, but the South African occurrence is in aluminous shale.

The complete and exhaustive review of fluorine resources in the United States (Shawe, 1976) does not consider the possibility of zunyite as a source of fluorine, perhaps because of the rarity of zunyite, although consideration is given to topaz and phosphate rock. Many of the known occurrences of zunyite in the United States are listed by Hall (1978). Noteworthy is the general close correlation between the occurrences of topaz, zunyite, fluorspar deposits, and fluorine-rich igneous rocks in the United States. Hall also illustrates the common association of alunite and zunyite, which has been noted also by Kashkai and Aliev (1960) and by many earlier workers in the U.S.S.R.

The regional distribution of zunyite occurrences in the United States is markedly similar to that of high-fluorine silicic volcanic rocks (Coats and others, 1963) and of fluorspar deposits (Peters, 1958; Shawe, 1976). Fluorite has been described as an accessory mineral from a number of zunyite deposits in the U.S.S.R., and this association suggests that fluorspar deposits may be found in the same general region as the zunyite lode here described.

THE ZUNYITE LODGE

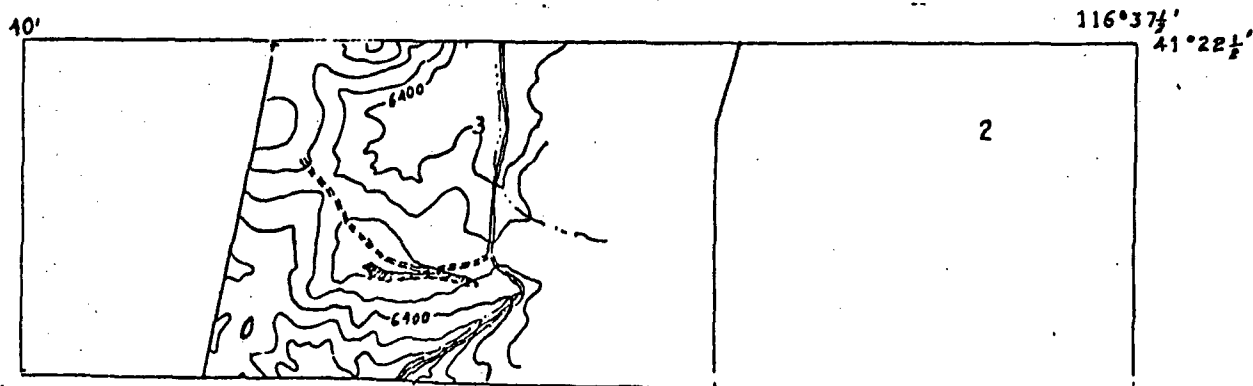
The zunyite lode that is the subject of this report crops out in the Scraper Springs 7-1/2 minute quadrangle, Elko County, Nev., in the south half of sec. 3, T. 40 N., R. 47 E. (fig. 1). Because of its resistance to mechanical and chemical attack, it forms a small ridge, precisely on the divide between the drainage basins of Rock Creek, to the south, and Milligan Creek to the north at an elevation between 6,440 and 6,480 ft (fig. 1). It is 12 mi north of Nevada Highway 18, by the road that has furnished access from Squaw Valley to the Owyhee Desert for about a century. Outcrops and distribution of coarse debris suggest that its total length is approximately 1,200 ft. Its general trend is about N. 80° W. At the extreme western end, where it appears to be widest, it crops out in a bold, cliffy eminence, that rises about 5 ft above the gentler slopes of the ridge to the north, and in cliffs as much as 10 ft high, above the steeper slope to the south. The width appears to range from 10 to 60 ft, but the lower, southern margin is obscured by talus from the higher portions; thus a precise estimate of size will have to await artificial excavation to disclose the contacts. No easy way of estimating grade is apparent; bulk specific gravities are unreliable, because of the porosity of some of the best zunyite rock, and the fact that its true specific gravity, near 2.88, differs but little from the 2.65 of the associated quartz.

The zunyite lode, seen from a distance, appears dazzlingly white, a nearer view shows that the color may range from very light gray to very light pinkish gray. The outstanding feature is the exceedingly fine grain size of the zunyite rock which has the appearance of unglazed porcelain. Where zunyite, with more or less quartz, has replaced the country rock, traces of the original porphyritic texture remain; an occasional rounded grain of quartz, with subsequent overgrowth, indicates that some of the rocks were dacitic. Occasional specimens with angular grains of quartz concentrated in certain layers suggest the former presence of tuffs.

The country rock in which the zunyite lode is developed is generally a sequence of hornblendes- and augite-andesite and tuffs, which, in this area, are pervasively propylitized, and locally silicified, particularly in the vicinity of the zunyite lode. Radiometric ages have not yet been determined for these andesitic rocks, but similar rocks occupy a wide swath of territory on the south side of the Owyhee Desert, eastward from the zunyite locality for several miles. They are believed to be correlatable with the similar andesitic rocks that have been described under the name "andesites of Cornucopia" (Coats, 1967) from the Cornucopia mining district, where they form the wall rocks of the Cornucopia silver deposits. They may also be correlatable with the "Volcanic and sedimentary rocks of Jones Creek" (Coats, 1971) in the Owyhee quadrangle, where they are somewhat less extensively propylitized, than those of Cornucopia. No ore deposits have yet been reported from them.

Figure 1

LOCATION OF THE ZUNYITE LODE



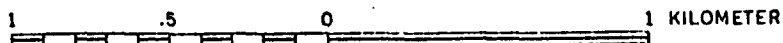
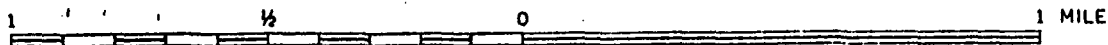
Topography from USGS
Scraper Springs quadrangle, 1977

Geology by
R. R. Coats
1972, 1978

ZUNYITE LODE

Hatched, solid rock; dotted, float

SCALE 1:24 000



CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

Figure 1. Sketch map showing the location of the zunyite lode.

The textures suggest replacement in several stages. The earliest is apparently the replacement of andesitic and dacitic country rocks by an intimate intergrowth of quartz and zunyite, having as much as 75 percent zunyite by volume. (Volume percentages are difficult to estimate from the thin section because of the Holmes effect--the anisotropic quartz prisms, as much as 0.05 mm long, obscure the presence of overlying and underlying isotropic zunyite ranging in grain size from 0.2-0.15 mm.) The zunyite-quartz mixture was succeeded by somewhat finer grained, nearly pure zunyite, with an average grain size of about 0.04 mm. This zunyite is typically represented by the analyzed sample 75NC104, which is essentially pure zunyite, with minute amounts of rutile, which lends a grayish tone. The fine-grain gray zunyite is replaced by still finer grained and whiter zunyite, of a grain size ranging downward from 0.02 mm to micron-sized grains. In some places, this finest grained zunyite appears to form cauliflower-shaped nodules, invading the coarser zunyite. In a few places, the coarse, zunyite-quartz rock is cut by veinlets, up to 2 in. across, of dense, white zunyite or mixtures of zunyite and quartz. It should be emphasized that while large masses of rock that will run better than 75 percent by volume zunyite can be selected, some parts of such masses may consist of essentially pure zunyite, and others of a mixture of zunyite and quartz, closely intergrown, and very fine grained. No way of selecting the pure zunyite from the quartz-zunyite mixtures on the basis of appearance alone is readily apparent.

Two samples of zunyite were analyzed in the laboratories of the Branch of Analytical Laboratories of the U.S. Geological Survey, in Menlo Park, by Jerry Consul and Sara T. Neil, with the following results.

Chemical analysis of two samples of zunyite.

	<u>74NC103</u>	<u>74NC104</u>
SiO ₂	26.78 percent	26.44 percent
Al ₂ O ₃	58.14	58.33
H ₂ O ⁺	9.47	9.79
H ₂ O ⁻	.08	.02
Total C as percent CO ₂	.16	.05
Cl	2.57	2.33
F	5.43	5.23
	<hr/>	<hr/>
-O Cl, F	2.85	2.72
	<hr/>	<hr/>
	99.78	99.47

Note: SiO₂ and Al₂O₃ determined by Inductively Coupled Plasma Optical Emission Spectrometry

X-ray diffraction patterns were prepared on a diffractometer, using Cu/Na radiation, a chart speed of 1 in./min, and a goniometer speed of 1 degree/minute. Fluorite was used as an internal standard and each sample was run twice, once with increasing 2θ and once with decreasing 2θ . The values in the table are the means of the values for the two directions of scan. Because of differences in the proportion of standard and the conditions of sensitivity corresponding to full-scale deflection, a few of the peaks were too broad for accurate measurement on some patterns. Dimensions are in Angstrom units.

74NC103	74NC104
7.98	8.008
4.175	4.178
4.001	3.997
2.825	2.829
2.663	2.665
2.447	2.449
2.342	bd
2.111	2.112
1.999	1.999
1.850	1.849
1.802	1.803
1.631	1.632
bd	1.599

The symbol bd stands for broad peak.

Indices of refraction were measured in freshly standardized immersion oils, with sodium light, using an inference monochromator, stopped to a slit width of 10 millicrons. The uncertainties indicated reflect the compositional variability within grains of the zunyite.

74NC103	74NC104
n 1.582-1.584	1.572-1.575

Because of the fine grain size, and the fact that in the massive zunyite rock the crystals are closely intergrown, the megascopically visible tetrahedral crystal form which early attracted attention to it in other occurrences has not been recognized here. In thin section, the zunyite is strongly zoned, the zones lying parallel to the tetrahedral faces, and in most crystals, may be as little as 0.001 mm (1 micron) in width. Because of this zoning, only average indices of refraction can be determined; the d-spacings determined by x-ray diffractometer also represent the average material of small samples. It is probable that compositional differences within a single grain of zunyite may be greater than the differences from one hand-specimen to another.

The specific gravities of the analyzed samples were measured by Archimedes method, and by Westphal balance, immersing them in diluted methylene iodide.

	74NC103	74NC104
Archimedean method	2.58	2.803
Westphal balance	2.73	2.7125

The samples measured by immersion in heavy liquid were milligram sized, the ones measured by immersion in water were hand specimen sized.

The color of freshly broken surfaces ranges from very pale-pinkish gray 5YR 7/1 to 5YR 8.5/1.

SIGNIFICANCE OF MASSIVE ZUNYITE ROCK

The significance of zunyite may well be a double one; it is possibly significant as a mineral resource in its own right. Rock containing zunyite, diaspore, sericite, and quartz formed as a replacement of rhyolite and its tuffs in the Ishidoriya district, Japan, is used for refractory material (Masui and Shimizu, 1944, in Japanese; F. Z. Yoshida in Chem. Abstracts, sec. 8, no 78a, 1949). Zunyite, according to Meyer and Hemley (1967) is a mineral characteristic of advanced argillic alteration. It has been recorded in the deepest and most intensely altered zones at Cerro de Pasco (Graton and Bowditch, 1932) and at Butte (Meyer and Hemley, 1967) but also in a porphyry copper in Puerto Rico (Hildebrand, 1961). In the U.S.S.R., Loginov (1944, 1945, 1951) has described the association of zunyite with the Kabansk deposit of massive pyrite in the Urals. Kashkai and Aliev (1960) have described the wide distribution of zunyite-bearing rocks in the U.S.S.R., and Kashkai (1970) in his two-volume work on alunite, has mentioned the close association between alunite and zunyite in many localities. Dietrich (1965) has described an occurrence from Azrou-Melloul, Morocco, and Turco (1962) has described the new occurrence of zunyite at Beni-Embarek in Algiers, and some synthetic work he has done on the genesis of zunyite.

We wish to acknowledge the help of Tom Ovenshine and Mike Churkin, who arranged for the translation of several important articles and parts of articles from Russian by George Soleimani, to whom also our thanks are due. William Sanders of the U.S.G.S. library in Menlo Park has been very helpful in obtaining copies of articles published in obscure journals and foreign languages.

REFERENCES

- Bartl, H., 1970, Untersuchung der Wasserstoff bindungen in zunyite, $Al_{12}(OH,F)_{18}[AlO_4][Si_5O_{16}]Cl$, durch Neutronenbeugung: Neues Jahrbuch für Mineralogie Monatshefte, no. 12, p. 552-557.
- Burbank, W. S., 1932, Geology and ore deposits of the Bonanza mining district, Colorado: U.S. Geological Survey Professional Paper 160, 166 p.
- Coats, R. R., 1967, Economic significance of revised age relations of rocks in the Cornucopia mining district, Elko County, Nevada: U.S. Geological Survey Circular 549, 4 p.
- Coats, R. R., Gross, W. D., and Rader, L. F., 1963, Distribution of fluorine in unaltered silicic volcanic rocks of the western conterminous United States: Economic Geology, v. 58, p. 941-951.
- Dietrich, J. E., 1965, Zunyite D'Azrou-Melloul: Morocco Service Geologic Notes et Mem., no. 183, p. 105-107.
- Graton, L. C., and Bowditch, S. J., 1936, Alkaline and acid solutions in hypogene zoning at Cerro de Pasco: Economic Geology, v. 31, p. 651-698.
- Hall, R. B., 1978, World nonbauxite aluminum resources--Alunite: U.S. Geological Survey Professional Paper 1076.
- Hildebrand, F. A., 1961, Hydrothermally altered rocks in eastern Puerto Rico: U.S. Geological Survey Professional Paper 424-B, p. 219-221.
- Hillebrand, W. F., 1885, On zunyite and gütermanite, two new minerals from Colorado: Colorado Science Society, Proceedings, v. 1, p. 124-132.
- Kashkai, M. A., 1970, Alunite, ikh genezis i ispol'zovaniye [Alunites, their genesis and utilization]: Moscow, Izvestiya Nedra, v. 1, 400 p., v. 2, 317 p. (Russian with English summary in v. 2, p. 231-239).
- Kashkai, M. A., and Aliev, V. I., 1960, Zunyite and zunyite-bearing rocks (zunit and zunitsoederaxhie porodi): Trudy, Akademiya Nauk Azerbaidzhanskoi SSR, Baku, Institut Geologii. Tom 20, p. 5-35.
- Loginov, V. P., 1944, Hypogene relict minerals in the wall rock of the Kabanskoye pyrite deposit (the middle Urals): Bulletin Akademiya Nauk SSSR Seriya Geol., no. 15, p. 106-112.
- _____, 1945, Zunit ib sodershashchie ego gornye porody Kabanskogo kolchedannogo mestorozhdenia (Zunyite and zunyite-bearing rocks from the Kabansk pyrite deposit (Central Urals): Akademiya Nauk SSSR, Izvestiia Seriya Geologicheskaya, no. 6.
- _____, 1951, Aluminosilititsy Kabanskogo kolchedannogo mestorozhdenia (aluminosilicification in the Kabansk pyrite deposit (Central Urals): Akademiya Nauk SSR, Institut Geologicheskikh Nauk, Trudy Vip 184 Seriya Rudnikh mestorozhdenia, no. 15.

- Louisnathan, S. J., and Gibbs, G. V., 1972, Aluminum-silicon distribution in zunyite: *American Mineralogist*, v. 57, p. 1089-1108.
- Lovering, T. S., and Stringham, Bronson, 1945, Zunyite in Utah: *American Mineralogist*, v. 30, p. 76-77.
- Masui, Junichi, and Shimidzu, Yoshio, 1944, "Kochite," a zunyite-diaspore - sericite rhyolite from Ishidoriya, Iwate Prefecture: *Journal of the Japanese Association of Mineralogists, Petrologists, and Economic Geologists*, v. 32, p. 105-111 (In Japanese). Abstract in *Chemical Abstracts*, 1948, sec. 8, 78a.
- Meyer, Charles, and Hemley, J. J., 1967, Wall rock alteration, in Barnes, H. L., ed., *Hydrothermal ore deposits*: New York, Rinehart and Winston.
- Nel, L. T., 1930, A new occurrence of zunyite near Postmasburg, South Africa: *Mineralogical Magazine*, v. 22, p. 207-221.
- Penfield, S. L., 1893, Mineralogical notes: *American Journal of Science*, 3d ser., v. 45, p. 396-399.
- Peters, W. C., 1958, Geologic characteristics of fluorspar deposits in the western United States: *Economic Geology*, v. 53, p. 663-668.
- Shawe, D. R., ed., 1976, *Geology and resources of fluorine in the United States*: U.S. Geological Survey Professional Paper 933, 99 p.
- Turco, G., 1962, La zunyite: recherches experimentales physico-chimiques en liaison avec l'etude du nouveau gisement de Beni-Embarek: *Bull. Soc. franc. mineral et crist.*, v. 85, p. 407-458.