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Cowlesite, a New Ca-Zeolite

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Abstract

Cowlesite occurs in amygdules in basalts at Goble, Beech Creek and Spray, Oregon; near Superior, Arizona; Monte Lake, British Columbia; Capitol Peak, Washington; and Table Mountain, Colorado. It is associated with such zeolites as analcime, chabazite, garronite, heulandite, levyne, mordenite, phillipsite, stilbite, and thomsonite. Easily confused with thomsonite, cowlesite forms soft, exceedingly thin, pointed blades with one perfect cleavage, and white-to-gray crystal clusters. Microprobe analyses from the seven known localities gave compositions nearly identical with that from the type area, Goble, Oregon: SiO_2 42.73, Al_2O_3 24.32, CaO 12.86, Na_2O 0.70, and H_2O (by weight loss on heating to 600°C) 22.8 wt percent: giving the formula $Ca_{0.96}Na_{0.09}Al_2Si_3O_{10}\cdot 5\text{-}6H_2O$.

The Al + Si = ½ O, the water loss at low temperature, and the low density (d = 2.14 gm/cm^3) suggest cowlesite is a zeolite. Optically the crystals have straight extinction, negative $2V$ near 50°, and $\alpha = 1.512$, $\beta = 1.515$, $\gamma = 1.517$. Although single crystals have not been obtained, consideration of the optical properties and the X-ray powder diffraction data suggest that cowlesite is orthorhombic. Preliminary indexing of the powder data give a unit cell with $a = 11.27(1)$, $b = 15.25(1)$, and $c = 12.61(3)$. The strongest lines of the X-ray powder pattern (d value in Å; relative intensity; indices) are: 15.2 **100** *010*; 7.62 **15** *020*; 508 **17** *030*; 3.81 **35** *040*; 3.75 **15** *300*; 3.052 **20** *050*; 2.964 **35** *051*; 2.934 **2** *331*. The name honors Mr. John Cowles of Rainier, Oregon.

Introduction

It is becoming a rarity for investigators to be able to describe a new mineral, not from a single locality, but from seven! The mineral described here was found by R. W. Tschernich in 1971 at the well known zeolite locality near Goble, Oregon. After being unable to match the X-ray powder pattern with any known zeolite, he sent the material to W. S. Wise for further work. Electron microprobe analyses showed that the anhydrous composition was similar to that of scolecite, although the habit resembled that of thomsonite. Shortly afterward Robert Mudra of Mesa, Arizona, sent unknown material from a locality near Superior, Arizona, that proved to be the same mineral. As soon as we were able to characterize the mineral through physical properties and distinguish it from thomsonite, it was discovered by collectors at several more localities. It was found at Capitol Peak, Washington, by Robert Boggs; at Monte Lake, British Columbia, and the Beech Creek quarry, Grant County, Oregon, by Robert and Mary Hillsdon; at Spray, Oregon, by Russell Kenaga, Jr.; and in a collection from Table Mountain, Colorado.

This paper will describe the characteristics of this new mineral, which we propose to name cowlesite, and will show that it is a new zeolite species.

Occurrences

Goble, Oregon

Cowlesite occurs sparsely in small vugs in late Eocene basalts, exposed by road cuts 0.4 miles northwest of Goble, Columbia County, Oregon. The cowlesite forms thin, gray, blue-gray to white cavity linings, growing as radially oriented blades. These linings are commonly 0.5 mm thick, but a few sprays of blades up to 2 mm have been found. Only a few cavities contain sprays of delicate, single blades (see Fig. 1). None of the blades are thicker than 2 μm.

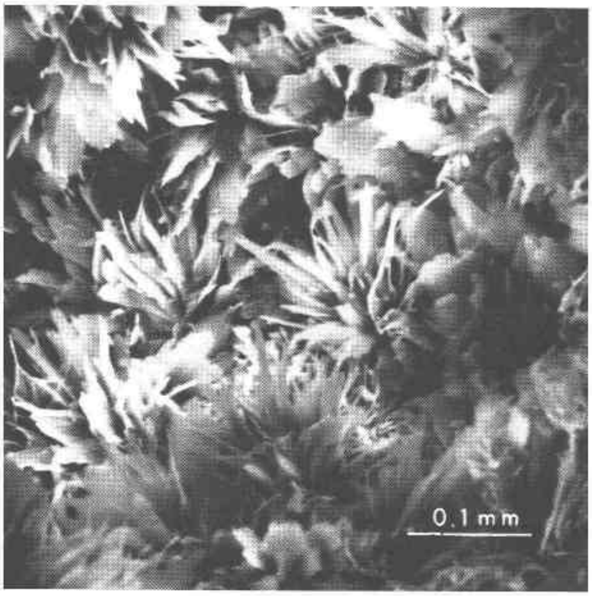

FIG. 1. Scanning electron micrograph of loosely arranged individual crystals of cowlesite from Goble, Oregon.

In about 90 percent of the vugs in which cowlesite has grown, it is the only zeolite. In the remaining vugs it occurs in the following sequence: apophyllite (earliest), analcime, cowlesite, garronite, phillipsite, levyne, and thomsonite.

Superior, Arizona

Cowlesite fills tiny vesicles in the outer margins of olivine basalt bombs and scoria fragments in an exhumed, middle Tertiary cinder cone 5½ miles south of Superior, Pinal County, Arizona. In the lower part of the cone cowlesite is abundant and closely associated with thomsonite, chabazite, analcime, and calcite. Higher in the exposure the main zeolites are mordenite, thomsonite, and chabazite.

The vesicles about 1 mm in diameter are filled with white blades, having grown radially inward. Larger vesicles contain compact balls of blades up to 1.5 mm in diameter. Figure 2, a SEM photograph of a broken cavity lining, shows cowlesite blades up to 1 mm in length and 1 μm in thickness with the typical cleavage.

Monte Lake, British Columbia

Samples of basalt scoria and breccias from road cuts along logging roads south of Monte Lake, southern British Columbia, contain fairly abundant cowlesite. Although cowlesite does not appear with any other zeolite in any single vug, other closely associated zeolites are analcime, thomsonite, ferrierite, levyne, stilbite, heulandite, and chabazite.

The cowlesite forms gray to blue-gray linings about 0.5 mm thick in vugs about 5 mm across. Many such linings are globular from the merging of solid sprays of blades. Individual crystals are small and not easily discernible.

Capitol Peak, Washington

One small specimen containing cowlesite was found at Capitol Peak, Thurston County, near Olympia, Washington. The cowlesite occurs directly with no other zeolites, but in nearby vugs levyne, chabazite, stilbite (variety epidesmine), and mordenite have been found.

This cowlesite occurs in delicate white sprays of blades 0.25 mm long, as well as cavity linings with the same thickness. The zeolite appears to have grown at least partially at the same time as an iron smectite clay.

Beech Creek, Oregon

Cowlesite occurs in cavities in basalt at the well known Beech Creek Quarry, Grant County, Oregon. Although analcime, levyne (with its offretite overgrowth), phillipsite, thomsonite, heulandite, stilbite, chabazite, and mesolite all occur at this locality, cowlesite has only been found with levyne.

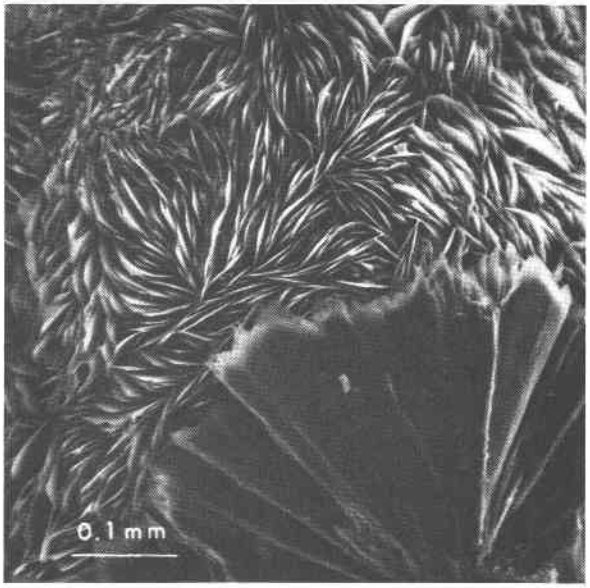

FIG. 2. Scanning electron micrograph of the broken edge of a compact cavity lining of cowlesite from Superior, Arizona. The break is along the perfect (010) cleavage.

The cowlesite clearly preceded the levyne, which generally was one of the earliest zeolites to form.

The cowlesite forms gray to blue-gray linings up to 0.3 mm thick and compact balls of radiating blades. Terminations project above the lining surface, giving it a rough appearance.

Spray, Oregon

With a zeolite assemblage similar to that at Beech Creek, the basalts exposed in road cuts 10 miles northeast of Spray, Wheeler County, Oregon, also contain sparse cowlesite. Analcime, levyne (with offretite overgrowths), phillipsite, thomsonite, chabazite, mesolite, and apophyllite all occur in fair abundance at this locality. Cowlesite appears in cavities with no other zeolites.

Individual sprays about 0.5 mm high with delicate individual crystals have grown on globular clay cavity linings (see Figs. 3 and 4). As in all localities the crystals are very thin blades with sharp terminations.

Table Mountain, Colorado

Several specimens of zeolite-bearing shoshonite from Table Mountain, near Golden, Colorado, were found to contain small rosettes (radius of about 1.5 mm) and white blades with sharp terminations, which proved to be cowlesite. The cowlesite was not found to occur in the same vug with other zeolites. The assemblage from Table Mountain includes laumontite, stilbite, thomsonite, chabazite, analcime, apophyllite, mesolite, natrolite, scolecite, levyne (with an overgrowth of offretite) (Sheppard *et al,* 1974; Cross and Hillebrand, 1885) and recently identified garronite.

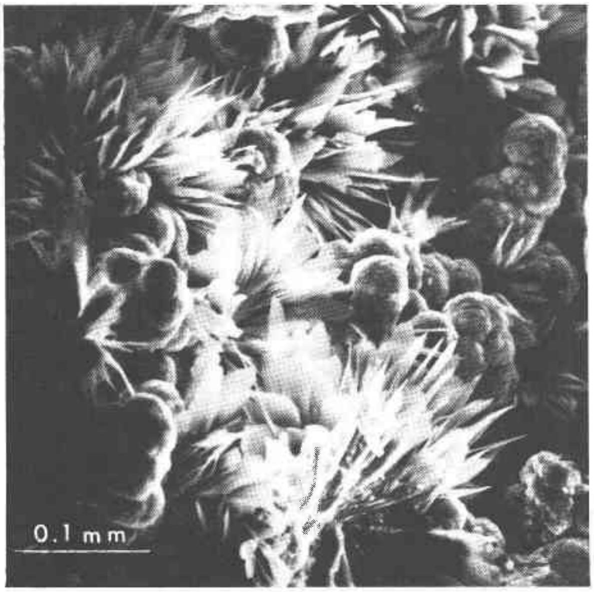

FIG. 3. Scanning electron micrograph of cowlesite crystals and balls of smectite clay from Spray, Oregon.

FIG. 4. Scanning electron micrography, showing individual crystals of cowlesite from Spray, Oregon. Compare the crystal in lower right corner with Figure 5a.

Physical Properties

Cowlesite from all seven localities is colorless or white. The gray to blue-gray of the cavity linings results from the color of the vug walls showing through transparent crystals. Since both thomsonite and cowlesite form lath-shaped crystals, they are similar in appearance, and for this reason cowlesite has gone unnoticed even in actively collected zeolite localities. The criteria used to distinguish between them involve surface characteristics and cleavage.

The surface of thomsonite vug linings appears relatively smooth from the flat crystal terminations, but a cowlesite lining appears rough (under 30× magnification) from the sharply pointed blades. Thomsonite intergrowths are extremely tough for a zeolite and have a hardness of 5 to 5½. In contrast cowlesite intergrowths are easily cleaved and have a hardness and mechanical behavior much like gypsum.

Density determinations, using a Berman torsion microbalance and immersion in toluene, on clusters from Goble weighing 14 to 20 mg gave an average value of 2.14 (±0.02) gm/cm^3. A 48 mg specimen of cowlesite from Superior has a density of 2.12 (±0.01) gm/cm^3.

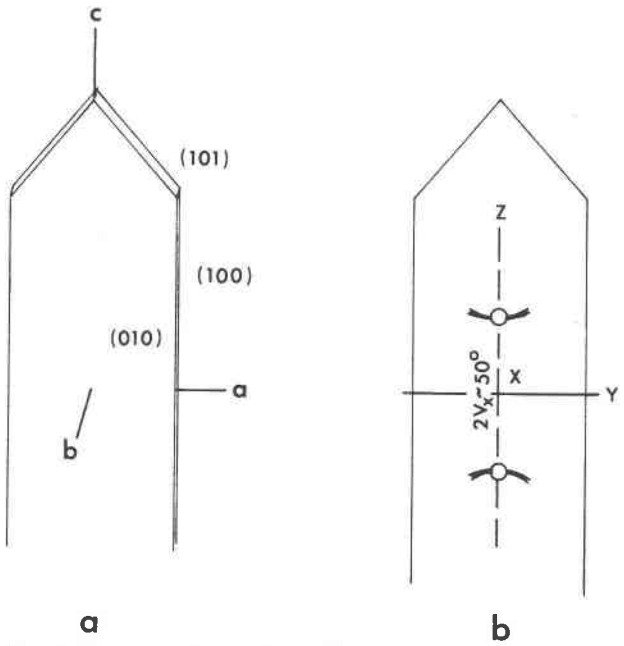

FIG. 5. Summary of crystallographic and optical orientations of cowlesite.

Crystal Morphology

As illustrated in Figures 1 through 4, the cowlesite crystals are simple and blade-shaped, showing only three forms (see Fig. 5a). Crystals commonly exceed 0.3 mm in length and 0.1 mm in width, but thicknesses are less than 2 μm.

The {010} cleavage is so pronounced that it is impossible to obtain a powder by ordinary grinding with a mortar and pestle.

Optical Properties

Figure 5b summarizes the orientation of principal vibration directions, which suggest orthorhombic symmetry. Refractive indices measured by oil immersion are $\alpha = 1.512$; $\beta = 1.515$; $\gamma = 1.517$ (each ± 0.001). The optic axial angle is negative and varies from 44° to 53°.

Chemistry

Samples of cowlesite from each of the seven localities have been analyzed by electron microprobe methods. Crystal clusters or cavity linings were embedded in epoxy, ground flat, and polished. Under vacuum the surface developed small cracks, probably from dehydration, parallel to the cleavage direction. An accelerating voltage of 15 kilovolts was used for all elements with a sample current of 10 nA. Beam diameters were made as large as samples would allow, commonly 20 μm. Scolecite was used as a standard for Ca, Al, and Si; natrolite, for Na; and K-feldspar for K. Emission data were reduced and interelement effects corrected with a modified version of EMPADR 7 (Rutlidge and Gasparrini, 1969, Department of Geology, University of Toronto).

Cowlesite from each locality was analyzed using 2 to 5 spots, and the averaged results are presented in Table 1. The anhydrous composition is near

TABLE 1. Chemical Analyses of Cowlesite

	Goble, Oregon	Superior, Arizona	Monte Lake, Br. Columbia	Capitol Pk., Washington	Beech Creek, Oregon	Spray, Oregon	Table Mtn., Colorado
SiO_2	42.73	46.37	45.74	44.62	47.72	44.78	43.52
Al_2O_3	24.32	25.87	27.89	28.64	26.68	27.36	23.74
Fe_2O_3	0	0.08	0	0	0	0	0
CaO	12.86	15.12	15.36	13.23	14.29	14.53	10.84
Na_2O	0.70	0.80	0.53	0.97	1.12	0.82	.62
K_2O	0	0.10	0.09	0.07	0	0	.04
Total	80.61	88.34	87.61	87.53	89.81	87.54	78.76
			Cation proportions based on 10 oxygens				
Si	2.986	2.979	2.898	2.878	3.001	2.902	3.078
Al	2.003	1.959	2.083	2.177	1.978	2.090	1.979
Fe	0	.004	0	0	0	0	0
Ca	.963	1.041	1.043	.915	.963	1.009	.821
Na	.095	.099	.066	.121	.137	.103	.084
K	0	.008	.007	.006	0	0	.003

Looked for but not found in any of the samples, Mg, Sr, and Ba.

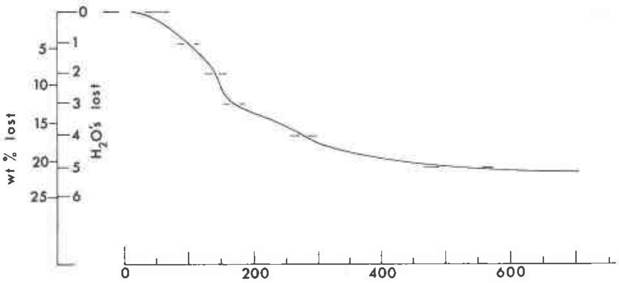

FIG. 6. Thermal gravimetric scan of the dehydration of cowlesite from Superior, Arizona. The sample weighed 48 mg, and the heating rate was 5°C/minute up to 400°C, then 10°C/minute.

$CaAl_2Si_3O_{10}$ with minor substitution of Na_2 for Ca. The (Si+Al)/O ratio of 1/2, coupled with the occurrence and high water content, suggests cowlesite is a zeolite with a (Si,Al) tetrahedral framework structure.

Because the totals for the analyses in Table 1 are considerably less than 100 percent, separate water analyses were performed on samples of 5 to 10 mg by weight loss upon heating to 600°C. Water contents ranged from 21.0 percent (Superior) to 22.8 percent (Goble). These amounts correspond to 5.0 to 5.6 H_2O molecules for each $CaAl_2Si_3O_{10}$. The different totals in Table 1 may correspond to the amount of water lost from the zeolite in vacuum. The Goble material was compact cavity lining, while samples from Superior lost more water in the vacuum.

The water loss on heating is illustrated in Figure 6. Because it was suspected that grinding may allow some water loss, the TGA sample was composed of the entire cavity fillings from the scoria at the Superior locality. This TGA curve and water loss is similar to that of other zeolites (see, for example, Van Reeuwijk, 1972).

It is concluded that the ideal water content is probably 6 H_2O for each $CaAl_2Si_3O_{10}$.

Crystal Geometry

Because of the extreme thinness of individual crystals, it has been impossible to obtain a single crystal of cowlesite. The orthorhombic symmetry indicated by the optical properties was supported by the following observations. A small cluster of blades that were optically homogeneous were oriented with the cleavage plane, (010), normal to an unfiltered Mo-radiation X-ray beam in a precession camera. Streaks and a single pair of spots at 3.15Å were obtained parallel to the blade length. This direction was labelled c^*. Normal to c^* is a fainter streak, but with no spots; this streak was assumed to define a^*. With the beam parallel to the cleavage, a faint row of spots with a spacing of about 15.4Å is normal to c^* and to the cleavage. The right angles suggest orthorhombic symmetry.

X-ray powder diffractometer patterns are difficult to obtain because of strong preferred orientation from the perfect cleavage. However, by combining X-ray data from photographs taken of small clusters with a Gandolfi camera and diffractometer patterns, the X-ray powder data in Table 2 were obtained.

A preliminary indexing (Table 2) of the powder data leads to the following cell dimensions: $a = 11.27(1)$, $b = 15.25(1)$, $c = 12.61(3)$Å.

With a composition of $CaAl_2Si_3O_{10} \cdot 6H_2O$ and a unit cell of these dimensions, Z is 6. The d_{calc} is 2.05 gm/cm³.

Name

The Commission on New Minerals and Mineral Names (IMA) approved the name prior to publication. It is a pleasure to name a new zeolite after Mr. John Cowles of Rainier, Oregon, amateur mineralogist and enthusiastic zeolite collector. His deep interest in zeolite mineralogy has led him to discover several rare zeolites and uncover new zeolite localities in the Pacific Northwest. The name is pronounced KŌLSAIT.

TABLE 2. X-Ray Powder Diffraction Data

hkl	d(calc)*	d(obs)	I/I_0
010	15.24	15.2	100
001	12.61	12.6	5
100	11.27	11.3	5
101	8.40	8.40	10
020	7.62	7.62	15
121	5.65	5.67	7
102	5.50	5.52	5
030	5.08	5.08	17
031	4.71	4.70	7
122	4.46	4.50	3
202	4.20	4.16	5
040	3.81	3.81	35
300	3.76	3.75	15
310	3.65	3.65	10
321	3.26	3.25	5
004	3.15	3.16	10
050	3.049	3.052	20
051	2.964	2.964	35
331	2.938	2.934	25
043	2.824	2.819	5

Pattern continues with nth order 010 lines to 1.525 and several very weak, unindexable lines to 2.50.

*Indexing based on the following unit cell: a=11.27(1), b=15.25(1), c=12.61(3) Å.

Type Specimens

The type specimen (UCSB #6720) as well as nearly 100 mg of loose cavity linings from the Goble locality and a specimen (UCSB #6721) along with several pounds of zeolitic scoria from Superior are in the University of California, Santa Barbara collection. Specimens from these two localities have been deposited with the U. S. National Museum.

Acknowledgments

It is a distinct pleasure to acknowledge Robert Mudra, Robert Boggs, Russel Kenaga, Jr., and Robert and Mary Hillsdon for their keen eyes in spotting the new mineral and for sharing them with us. Dr. George Tunell made some helpful suggestions concerning the data. The Committee on Research, University of California, Santa Barbara, provided computer time for microprobe and X-ray diffraction data reduction. Mr. John Heter aided in obtaining the TGA scan.

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