AUGELITE FROM MONO COUNTY, CALIFORNIA

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Augelite, basic aluminum phosphate, was discovered in the andalusite orebody of the Mono County Mine of Champion Sillimanite, Inc., during the summer of 1934 by the writer while engaged in a field study of the geology and mineralogy of the deposit, and was subsequently identified in the mineralogy laboratory at Stanford University. The andalusite mine is located on the west slope of White Mountain in California, and was briefly described by P. F. Kerr[1] in 1932.

DESCRIPTION OF MONO COUNTY AUGELITE

The augelite occurs in white, colorless, to yellowish cleavable masses. In the largest specimen found individual cleavages can be traced for over two inches although part of this distance represents an intergrowth of augelite with other minerals; other specimens are smaller, grading down to microscopic dimensions. The luster is vitreous. Cleavage is perfect parallel to the prism $m\{110\}$ in two directions at angles of about 67° and 113°, and less perfect in a third direction parallel to the dome $x\{\bar{1}01\}$ at an angle of $77\frac{1}{2}°$ to the prism. Figure 1 shows the plan and clinographic projection of a cleavable mass of augelite. In constructing the clinographic projection, the plan has been rotated through the customary angle, 18° 26′; the unusual foreshortening of the prism face is caused by the fact that in the axial ratio of augelite, *a* is greater than *b*.

Cleavage angles of augelite from this new locality measured on the reflection goniometer average for the prism cleavage $mm(110 \wedge \bar{1}10)$ 66° 57′ as compared with the value of 66° 46′ recorded by Prior and Spencer;[2] for the angle between the prism and dome $mx(110 \wedge \bar{1}01)$, 77° 43′ as compared with the recorded value of 77° 35′. Measurements on the poorer domal cleavage vary $\pm\frac{1}{2}°$ from recorded values because of poorer reflections, but those on the perfect prism cleavage are relatively constant and differ from previously recorded values by only 11 minutes. The domal cleavage is generally not prominent in hand specimens.

[1] Kerr, P. F., The occurrence of andalusite and related minerals at White Mountain, California: *Econ. Geol.*, vol. **27**, pp. 614–642, 1932.

[2] Prior, G. T., and Spencer, L. J., Augelite: *Mineral. Mag.*, vol **11**, pp. 16–23, 1895.

Hardness of the Mono County mineral is about 5. Optical properties agree very closely with those given by Prior and Spencer for Bolivian augelite. Chemical tests prove the mineral to be an aluminum phosphate. The mineral is infusible, and water is given off when it is heated in the closed tube. A determination

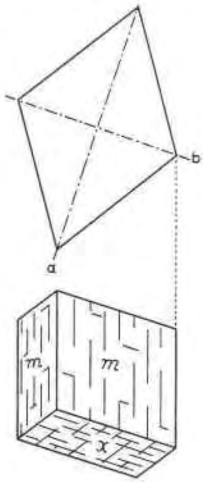

FIG. 1. Plan and clinographic projection of augelite cleavages $m\{110\}$ and $x\{\bar{1}01\}$.

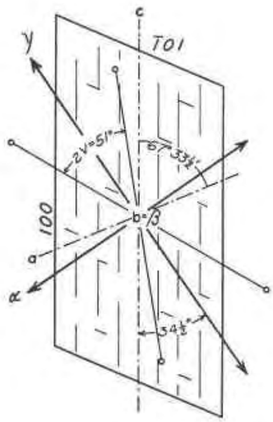

FIG. 2. Optical orientation diagram of augelite. Section parallel to $\{010\}$.

of the water content by the Penfield method gave a value of 12.23% compared with the theoretical value of 13.51%. Only 0.17 gram augelite was used in this determination, and this material may have contained impurities; so the result checks as closely as can be expected.

The specific gravity of larger masses of the augelite is high because of an admixture of intergrown minerals. Determination of the specific gravity by the pycnometer method, using small, pure fragments of the augelite carefully sorted under a hand lens, gave a value of 2.67, slightly less than the published value of 2.696 given for Bolivian augelite. Amount of material used was 0.9289 gram.

The extinction angle is $34\frac{1}{2}°$ in the obtuse angle measured on an oriented section cut parallel to *b*(010) (see orientation diagram, Fig. 2). Indices, determined by immersion in index liquids using light passed through a Wratten E22 filter, vary only one or two figures in the third place from those found by Prior and Spencer using the prism method. Fragments showing an optic axis figure were used in determining n_β. The axial angle 2V was computed from 2E, obtained by measuring the distance between the isogyres of an interference figure in an oriented section cut perpendicular to the acute bisectrix. Some cleavage fragments show the emergence of an optic axis just beyond the field of view.

No euhedral crystals have been found at this new locality, but careful examination of mining operations may lead to their discovery. Only a small number of specimens of the massive material have been found, but further search of the dumps and of operating faces is expected to reveal others. The mineral has been mistaken for barite by the ore sorters, and it also greatly resembles feldspar; both of the latter minerals would be discarded in sorting andalusite ore.

The following tabulation summarizes the properties of Mono County augelite as compared with data from Prior and Spencer for Bolivian augelite:

Machacamarca, Bolivia	Mono County, California
Crystals of the monoclinic prismatic class	Massive
Cleavage in 3 directions	Cleavage in 3 directions
mm $(110\wedge\bar{1}10)$ 66°46′	*mm* 66°57′
mx $(110\wedge\bar{1}01)$ 77°35′	*mx* 77°43′
H. 4.5 to 5	H. 5
Density 2.696	Sp. Gr. 2.67
Chemical composition	Qualitative tests for Al, PO_4, H_2O
$AlPO_4\cdot Al(OH)_3$ (13.51% water)	(12.23% water by Penfield method)
Biaxial negative	Biaxial negative
$2V=51°$	$2V=52°$
$c\wedge\gamma=34°$	$c\wedge\gamma=34\frac{1}{2}°$
$n_\gamma=1.588$	$n_\gamma=1.587\pm.001$
$n_\beta=1.576$	$n_\beta=1.575\pm.001$
$n_\alpha=1.574$	$n_\alpha=1.572\pm.001$
Birefringence .014	Birefringence $.015\pm.002$

Since properties of Machacamarca augelite agree so closely with those of the Mono County mineral, there can be no doubt that the two minerals are the same.

Mode of Occurrence

Augelite in the Mono County Mine of Champion Sillimanite Inc., occurs as a hydrothermal mineral deposited from the widespread hydrothermal solutions that acted upon the andalusite deposit subsequent to the formation of andalusite, corundum, diaspore, topaz, and other minerals of the pyrometasomatic stage of the deposit. The augelite is directly associated and intergrown with lazulite, rutile, barite, pyrophyllite, muscovite, alunite, and quartz, and the same hand specimens show residual andalusite and corundum.

In some specimens a yellow-brown, dull alteration product has formed in the augelite. This material seen in thin section penetrates the augelite along cleavages, and to a lesser extent cuts across the cleavage. The mineral is a gray color in thin section, has an aggregate structure, high double refraction, and very high relief. Its aggregate character and scarcity prevent its identification.

Other Occurrences of Augelite

Augelite was first named and described from the iron mine of Westanå, Skåne, Sweden, in 1868 by C. W. Blomstrand.[3] His material was massive without euhedral crystals, and no geometrical or optical properties were listed. In the same article Blomstrand also named from the Westanå locality three other aluminum phosphate minerals: berlinite, trolleite, and attacolite. Only augelite has been substantiated by discovery of crystalline material in other localities, and the other three are still regarded as indefinite or doubtful species. Hintze[4] lists trolleite as a definite species, and cites Blomstrand's original data, but does not mention berlinite or attacolite.

Augelite was not fully substantiated as a new species until 1895 when Prior and Spencer described small, euhedral, monoclinic crystals of augelite from Machacamarca, Bolivia. The augelite occurred associated with bournonite and octahedral pyrite.

The mineral has subsequently been reported from three other Bolivian localities: Tatasi,[5] Portugalete,[5] and Oruro.[6] Associated minerals in the silver mines of Tatasi are pyrite, siderite, gypsum, calcite, pyrophyllite, kaolin, and sphalerite in the jamesonite "feather" ore. The specimens from Oruro showed a mass of auge-

[3] Blomstrand, C. W., *Öfversigt af K. Vet. Akad. Forhändlinger, Stockholm:* vol. **25,** p. 199, 1868. (Article not seen.)

[4] Hintze, C., Handbuch der Mineralogie, Erster Band, **1933.**

[5] Spencer, L. J., Augelite from Tatasi and Portugalete, Bolivia: *Mineral. Mag.*, vol. **12,** pp. 1–5, 1898.

[6] Spencer, L. J., Augelite from Oruro, Bolivia: *Mineral. Mag.*, vol. **14,** pp. 323, 1907.

lite, arsenopyrite, quartz, pyrite, and stannite crystals coating a matrix of massive quartz, pyrite, and tetrahedrite. Spencer points out that augelite may not be as rare a mineral in Bolivia as has previously appeared, for augelite crystals greatly resemble barite in form, and can be distinguished only by measurement of crystal angles, cleavage, or optical properties.

The original Swedish discovery and the Bolivian localities make five previously known occurrences of augelite. This note records the first discovery of augelite in North America, and also shows a mineral association entirely different from previous occurrences.

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