

	I.	Molecular ratio	II.
Copper.....	67.51%	—1.068 or 7.026	67.14%
Iron.....	8.49	—0.152 or 1.	8.43
Sulfur.....	24.88	—0.778 or 5.112	24.16
Total.....	<u>100.88</u>		<u>99.73</u>
Sp. gr.....	5.28		5.248

An analysis of "bornite" from Ragisvaara¹ is given for comparison in II. The formula corresponding to the above analyses is $7\text{Cu}_2\text{S}\cdot\text{Fe}_2\text{S}_3$. From the evidence shown by the examination of polished surfaces it is clear that we are here dealing with a mixture of bornite and chalcocite and it is only a chance that the ratios of these two in the mixture permit the deduction of such a simple chemical formula. The Ragisvaara mineral is no doubt also a mixture. It is plainly unsafe to use occurrence of material of the same composition at two widely separated localities as a criterion of its definite character, for both may be mixtures.

As the relative amounts of chalcocite and bornite in the pieces analyzed are uncertain, it is impossible to decide whether the bornite has the formula indicated by the best modern analyses, $5\text{Cu}_2\text{S}\cdot\text{Fe}_2\text{S}_3$, or favors the view of Kraus and Goldsberry² that bornite is variable in the ratio of Cu_2S to Fe_2S_3 .

This intergrowth might be interpreted as derived from a natural cubic cuprous sulfide possessing a perfect octahedral cleavage, by the alteration, in part, to bornite. In view of the relations between the two minerals shown on mineragraphic study, however, the writer is inclined to interpret the mixture as partial alteration of unusually cleavable bornite to chalcocite.

CRISTOBALITE IN THE SPHERULITIC OBSIDIAN FROM YELLOWSTONE NATIONAL PARK³

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The various forms of silica furnish us with the best and most complete example of polymorphism. In addition to the common minerals, quartz, chalcedony, and opal, we have the compara-

¹ Dana, System of Mineralogy, p. 77.

² *Am. J. Sci.*, 37, 539. 1914.

³ [This article represents an interesting demonstration of the value of even the simplest of the modern optical methods in the recognition of the less common minerals. ED.]

tively rare high-temperature forms, tridymite and cristobalite. The rarest of all the known silica minerals is the pseudo-isometric cristobalite, found at only a half-dozen localities in the world, and until recently not known from the United States, with the possible exception of a doubtful occurrence in a meteorite from Kendall County, Texas. In 1918, however, the writer¹ described cristobalite from two localities in California.

The object of this note is to place on record the occurrence of this interesting mineral at a third American locality. A specimen of spherulitic obsidian from the Yellowstone National Park, collected by Mr. D. F. Meiklejohn some years ago, and now in the petrographic collections of Stanford University, contains cristobalite in appreciable amounts. The exact locality of the specimen is not given, but it is presumably from Obsidian Cliff. Tridymite has been described from this locality by Iddings.²

The cristobalite occurs in a black obsidian containing numerous gray spherulites ranging from about a millimeter to a centimeter in diameter. The glass is colorless in fragments and contains minute, slender rod-shaped microlites. Its refractive index is 1.480, which proves that it is a rhyolitic obsidian high in silica.

Some of the spherulites are solid but most of them are more or less hollow, and are to be classed as lithophysae, as they show a tendency to have their contents arranged in concentric shells. The only prominent minerals of the hollow spherulites or lithophysae are short branching rods of orthoclase ($n = 1.523$), with free ends, and the cristobalite, the two being intimately associated.

The cristobalite occurs in minute (average size = 0.3 mm.) spherical aggregates and is fairly abundant. It is subtranslucent with an enamel-like appearance, which seems to be characteristic of cristobalite for I have noted it in five different occurrence. Under the microscope it is faintly birefringent with a complicated mosaic structure and shows polysynthetic twinning in spots. The refractive index is 1.485 ± 0.005 . The fact that its index is distinctly greater than that of a liquid with an index of 1.480 positively distinguishes it from tridymite, as shown by Fenner.³ On heating the cristobalite to a rather high temperature by means of a blowpipe, it may be seen to be semi-transparent when viewed with a hand lens; and, on cooling, it suddenly becomes sub-trans-

¹ *Am. J. Sci.* [4], 45, 222-226, March, 1918.

² *Seventh Ann. Rept. U. S. Geol. Survey*, 267, 1888.

³ *Am. J. Sci.* [4] 36, 331-384, 1913.

lucent. This is doubtless due to the change of β -cristobalite to α -cristobalite, which, according to Fenner, takes place at a temperature varying from 198 to 240° C. This simple blowpipe test may be of service in identifying cristobalite, a mineral which otherwise can only be distinguished by optical tests, and one which may have consequently been overlooked many times.

Since cristobalite is a form of silica, one would expect to find it in the persilicic (so-called acid) rocks, but all the earlier described occurrences are in andesite, auganite, or basalt. Tridymite, on the other hand, is found in rhyolite and trachyte as well as in the medio-silicic rocks. The Yellowstone Park occurrence, together with the writer's recent identification of the mineral in the rhyolitic obsidians of two localities in California, proves that cristobalite as well as tridymite is characteristic of the persilicic volcanic rocks, for, of the five American occurrences known, three are in rhyolitic obsidians. It is believed that a careful search in obsidians and related rocks will reveal the presence of cristobalite in many additional specimens.

MASSIVE LAUMONTITE FROM MONTANA

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Laumontite is a mineral of the zeolite group which is ordinarily found in the form of well-developed crystals associated with related minerals as an alteration product in cavities in basic igneous rocks. The mineral is rarely found massive and is seldom present in any great quantity. Some time ago Dr. E. S. Larsen turned over to the writer a specimen of a massive earthy material with the statement that its optical properties identified it as laumontite. The mineral had been sent to the U. S. Geological Survey by Mr. Chas. P. Farnquist of Spokane, Wash., who gives the locality as near Wolf Creek Station, Lewis & Clarke Co., Mont. There are said to be several veins solidly filled with the mineral in a distance of 5 meters, the individual veins reaching a thickness of 0.6 m. In appearance the specimen resembles a compact altho somewhat friable sandy clay of a dirty grayish

¹ Published by permission of the Secretary of the Smithsonian Institution. [In contrast to the preceding article this one shows how optical methods led to the correct identification of a very unusual form of a fairly common mineral. Ed.]