This agrees rather closely with the formula $3Al_2O_3.2SiO_2.9H_2O$, but the sample is so fine grained that its homogeneity cannot be vouched for and it may be a mixture of silica and gibbsite.

Summary

Chalcoalumite from Bisbee, Arizona, occurs as turquois green crusts up to several millimeters thick completely coating stalactites and related deposits of limonite and copper carbonates. It has a hardness of about 2 ½, a specific gravity of 2.29, and a fusibility of 5. It is made up of matted fibers. It is probably triclinic, has several perfect cleavages, and the more coarsely crystalline outer crust if powdered is partly in laths that have terminal faces making angles of about 60° with the length. Twins with the twinning plane parallel to the long edge of the laths and nearly normal to the laths are rather common. The mineral is optically +, $2V$ is rather small, $\rho > \nu$ is strong, $\alpha = 1.523$, $\beta = 1.525$, $\gamma = 1.532$. The laths give no sharp extinction in white light but they have negative elongation and extinguish at about 40° to the length. Turned on the long edge they show negative elongation and strong dispersion with extinction at an angle of about 32° to the length. The mineral has the composition $CuO.2Al_2O_3.SO_3.9H_2O$ or $CuSO_4.4Al(OH)_3.3H_2O$.

XONOTLITE AND PECTOLITE IN A DIABASE PEGMATITE FROM MINNESOTA*

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Introduction

A discovery of considerable amounts of xonotlite in the Pigeon Point region of Cook County, Minnesota, was described in a recent number of The American Mineralogist.[1] An additional occurrence was found during the summer of 1924 over a hundred miles from the first. Pectolite, an associated mineral, is new to the state of Minnesota. This deposit has certain similarities and also

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[1] Schwartz, G. M., An occurrence of xonotlite in Minnesota: *Am. Min.*, **9**, 32-33 (1924).

certain distinct differences from the other, and is instructive as to the origin and associations of the mineral.[2]

Field Relations

The material was found in a vein dipping a few degrees west in a big bluff of intrusive diabase on the coast of Lake Superior about five miles east of Two Harbors.[3] This bluff formerly stood as a bold cliff over 200 feet high, but the face has been blasted down to form a road bed for the new lake shore highway. The vein was exposed by the blasting and the material was apparently only slightly weathered as it was covered by scores of feet of diabase.

The diabase is a coarse black rock and is one of the many Keweenawan basic intrusives included in the Beaver Bay diabase series of the Minnesota coast. The sill transgresses across the rhyolite flows which are just above water level at the southwest end of the exposure and rise to a height of 125 feet above the lake to the northeast, although the normal dip of the flows is about 12 degrees to the southeast. However, the areal extent of the intrusive is great and it may be conveniently referred to as a sill. The vein in which the xonotlite was found may be traced along the face for 200 feet or more.

Xonotlite and Associated Minerals

The xonotlite formed the core of two specimens, one about $2\times3\times4$ inches, and the other $2\frac{1}{2}\times3\times6$ inches. These were obviously broken and doubtless much more of the material has been covered up by the blasting. The outside of the specimens consists of large black augite grains enclosing lath-like forms of greenish material, thus giving a very coarse diabasic texture to the outer part of the fragments. The core consists mainly of a dense, light pinkish mass of xonotlite, penetrated around the outside by augite crystals and more or less intergrown with the various minerals of the border. The xonotlite exhibits the usual hard and tough properties which, with the pinkish color and dense nature, serve to identify it in hand specimen. This material apparently

[2] After this paper was submitted for publication the writer, through the courtesy of Dr. Walter F. Hunt, was permitted to see the paper by E. V. Shannon which appeared in the January issue of this magazine. The association of the mineral with diabase is apparently a common one. The associated minerals in the Virginia occurrence are of the same general type as those of the Minnesota occurrences. Possibly the pale bluish-green fibrous silicate noted by Shannon is prehnite.

[3] On shore near center line of Sec. 22, T. 53 N., R. 10 W.

retains its pink color on exposure whereas the mineral from Cook County quickly fades to a dull gray on exposure. An analysis is given in the following table.

Analyses of Minerals

	1	2	3	4
SiO_2	48.60	42.00	42.80	48.90
Al_2O_3	0.67	22.39	19.92	9.54
FeO	1.35	3.01	2.82	0.96
MgO	0.20	0.07	0.72	0.11
CaO	46.12	27.56	28.76	31.44
Na_2O	n.d.	n.d.	n.d.	4.62
K_2O	n.d.	n.d.	n.d.	0.38
H_2O	3.10	4.70	5.02	4.28
	100.04	99.73	100.04	100.23
Sp. G.	2.655	2.827	2.845	

1. Xonotlite from vein in diabase bluff on Lake Superior, Sec. 22, T. 53 N., R. 10 W. J. W. McCarthy, analyst.

2. Prehnite from Sec. 35, T. 64 N., R. 5 E., Cook County, Minn. (Called diopside, *Am. Min.*, **9**, 32.) J. W. McCarthy, analyst.

3. Prehnite, same specimen as No. 1. J. W. McCarthy, analyst.

4. Fibrous aggregate of prehnite and pectolite. Analysts, J. W. McCarthy and R. J. Leonard.

Thin sections show that the xonotlite is made up of a very fine interlocking mat of fibers, much like the mineral from Cook County, but the fibers are distinctly smaller. Scattered through the xonotlite are occasional spherulitic aggregates of prehnite and remarkable radiating aggregates of fibrous pectolite.

Much of the material intergrown with augite has a light green color and a sheaf-like structure. It appears to correspond with the material described as diopside which formed the border of xonotlite nodules from Cook County.[4] However, the indices were found to be below those of diopside and a detailed examination and analysis proved the mineral from both locations to be prehnite. The analyses are given in the table and correspond closely with the analyses of the mineral cited by Dana.[5] Associated with the prehnite in the Two Harbors material are perfect radiating aggregates of pectolite. (See Fig. 1). Scattered throughout the areas of prehnite and pectolite is a dusty material with a slightly greenish luster in reflected light. This is apparently kaolinite and it may be

[4] *Am. Min.*, **9**, 32-33 (1924).

[5] System of Mineralogy, p. 531.

seen to outline the former plagioclase laths at places. The lath-like forms of the former plagioclase grains are easily seen in hand specimens and in plain light microscopically, but largely disappear in polarized light, due to the complex and messy nature of the alteration products. Associated with the augite of the border material are small amounts of magnetite surrounded by dusty areas of leucoxene, thus suggesting an original content of ilmenite. Small amounts of chlorite are also scattered through the slides and an occasional grain of apatite remains embedded in the secondary material.

Fig 1

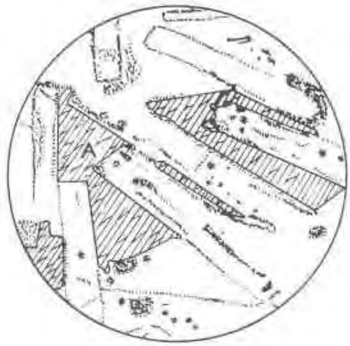

Fig. 2

Figure 1. Sketch of a thin section from the diabasic pegmatite border surrounding the xonotlite masses. Augite (A) remains perfectly fresh whereas plagioclase and probably other primary minerals have altered to pectolite (Pe), prehnite (Pr), and kaolinite (K). Polarized Light, Mag. X 8.

Figure 2. Sketch of a thin section from same material as Figure 1. Note the sharp boundaries of augite (A) penetrated by laths which are in part outlined by dusty kaolinite. The laths consist of pectolite, prehnite, kaolinite and chlorite. Plain Light, Mag. X 8.

It seems obvious from the texture of the material surrounding the xonotlite that plagioclase once formed an important part of the material, but only one slide showed remnants of the feldspar. In the others the plagioclase, which was probably of a calcic variety, has completely altered to a mixture of prehnite, pectolite and kaolinite. (See Fig. 2). The almost perfectly fresh nature of the augite is noteworthy in view of the nearly complete disappearance of the feldspar.

Associated with the specimens containing xonotlite are smaller masses consisting mainly of white radiating fibrous aggregates of pectolite, wih lesser amounts of green to colorless spherulitic aggregates of prehnite. The two minerals are so intimately mixed that they could not be separated, but an analysis of the material (see table of analyses), indicates that the minerals were correctly determined. The structure of the pectolite distinguishes it from prehnite. There is no indication that these masses are pseudomorphous as is the material described above.

Discussion

The texture of the original diabasic material of the vein is much coarser than that of the diabase sill, thus indicating that the vein is in the nature of a diabase pegmatite subsequently altered by hot solutions.

The general mode of occurrence of the xonotlite as the center of somewhat nodular masses surrounded by diabase pegmatite material suggests that the xonotlite was formed about the time of the formation of the pegmatite. However, its hydrous nature suggests that it originated from the hot solutions which followed the vein and resulted in the alteration of plagioclase to a complex mixture of prehnite, pectolite, and kaolinite. It is remarkable that the augite almost completely escaped alteration.

Some of the smaller masses of pectolite and prehnite described above show no remnants of earlier minerals or textures and it seems probable that the material was deposited from solution, rather than formed by alteration of the feldspar.

The xonotlite from Cook County and the occurrence described here show the similarity of a border of prehnite surrounding the xonotlite; both deposits were apparently formed under high temperature conditions as indicated by the sulphides[6] of the Cook County deposit and the pegmatitic nature of the Two Harbors occurrence. Furthermore, both occurrences are in Keweenawan diabase intrusives. The Two Harbors occurrence shows no sulphides but does contain considerable amounts of pectolite which is not found in the Cook County deposit.

So far as known, this is the first occurrence of pectolite reported from Minnesota, though Winchell[7] noted that it had been found on

[6] See Schwartz, G. M., *Am. Min.*, **9,** 32-33 (1924), and a fuller description to appear in *Econ. Geol.* in **1925**.

[7] Winchell, N. H., *11th Ann. Rept. Geol. and Nat. Hist. Survey Minnesota* p. 22, **1883**.

Isle Royale. Prehnite has been reported from several places along the north shore of Lake Superior in Minnesota, and Grout[8] has given an analysis of the mineral from Pine County.

The writer is indebted to the Minnesota School of Mines Experiment Station for analyses, and to Dr. F. F. Grout for much assistance.

[8] Grout, F. F., Contributions to the petrography of the Keweenawan: *Jour. Geol.*, **18**, 654 (1910).

A NEW THEORY OF THE COMPOSITION OF THE ZEOLITES*

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INTRODUCTION

The great similarities in composition between the zeolites and the feldspars have been pointed out many times, but in a summary of previous studies Dana[1] expressed correctly the conclusion reached by all investigators of the subject, as follows: "Unlike the feldspars (in zeolites) . . . calcium and sodium seem to replace one another and an increase in alkali does not go with an increase in silica." The formulas given by Dana and all other authorities known to the writer show that in zeolites alkalies are supposed to replace lime under the control of valence, that is, two atoms of Na or of K are supposed to take the place of one atom of Ca.

It may be worth while to be more specific in regard to the present situation as to the composition of the zeolites. Dana gives the following formulas as representing the composition of the zeolites named:

Thomsonite	$(Na_2, Ca)\ Al_2Si_2O_8.2.5\ H_2O$
Chabazite	$(Ca, Na_2)\ Al_2Si_4O_{12}.6\ H_2O$
Gmelinite	$(Na_2, Ca)\ Al_2Si_4O_{12}.6\ H_2O$
Wellsite	$(Ba, Ca, K_2)\ Al_2Si_3O_{10}.3\ H_2O$
Phillipsite	$(K_2, Ca)\ Al_2Si_4O_{12}.4.5\ H_2O$
Harmotome	$(K_2, Ba)\ Al_2Si_5O_{14}.5\ H_2O$
Stilbite	$(Na_2, Ca)\ Al_2Si_6O_{16}.6\ H_2O$
Mordenite	$3(Ca, Na_2, K_2)\ Al_2Si_{10}O_{24}.20\ H_2O$
Ptilolite	$(Ca, K_2, Na_2)\ Al_2Si_{10}O_{24}.5\ H_2O$

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[1] System of Mineralogy, 6th Ed., p. 570, (**1892**).