

A PECULIAR BLUE-GREEN AMPHIBOLE FROM THE
METAMORPHIC IRON FORMATION OF THE
EASTERN MESABI RANGE, MINNESOTA

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In the extreme eastern part of the Mesabi Iron Range of Minnesota an amphibole occurs which seems to be sufficiently peculiar, both in its optical properties and chemical composition, to deserve a special description. The exact location of its occurrence is near the now abandoned mining place Babbitt, southeast of its mining office, in the NW $\frac{1}{4}$ of section 17, T.60 N., R.12 W. There the iron formation is in contact with granite and is highly metamorphosed. The blue-green amphibole is associated with grünerite and quartz and, in a few instances, with diopsidic pyroxene and garnet. At the contact the plagioclase and the quartz of the granite contain numerous inclusions of the amphibole.

As a rule, the amphibole is fibrous and forms a felty aggregate. Occasionally, however, well defined blades occur. These blades were well suited for optical examination and as the blue-green amphibole was free of grünerite and only associated and intergrown with quartz, a separation by means of heavy liquids and the electromagnet was possible and material of sufficient purity was thus obtained for chemical analysis.

OPTICAL PROPERTIES

The amphibole has a strong pleochroism, X being light-yellow, Y peagreen, Z deep blue-green. This blue-green color is the most characteristic and distinctive property of the mineral. In sections, blades and fibres often have a curved appearance, the curves being almost semi-circular in shape. The extinction angle on (010) is about 16° . Accurate measurement is rendered difficult by poor cleavage.

The refractive indices for sodium light, measured by immersion liquids, were found to be as follows: $\alpha=1.670$, $\beta=1.690$, $\gamma=1.696$ (all ± 0.001 to 0.002), optically negative. The axial angle is rather small for an amphibole. In sections and in fragments perpendicular to the acute bisectrix, the axes were always clearly visible at the edges of the field of view. Hence $2E$ must be about 100° and $2V$ about 54° .

CHEMICAL INVESTIGATION

The results of a chemical analysis on the purified material is shown in the following table.

ANALYSIS OF AMPHIBOLE FROM BABBITT, MINNESOTA

	Percentages	Ratios
SiO ₂	48.76	.809
Al ₂ O ₃	11.15	.109
Fe ₂ O ₃	7.92	.049
FeO	21.72	.302
MnO	trace	
CaO	6.16	.110
MgO	0.38	.009
K ₂ O	0.58	.006
Na ₂ O	1.67	.027
H ₂ O*	1.89	.105

100.23

* Above 110°

Specific gravity 3.29.

The high percentage of silica is surprising. It is certainly not due to an admixture of quartz. Although an absolutely perfect separation of quartz from amphibole was impossible, repeated examination of the powder under the microscope showed that the adhering quartz was less than one per cent. This would reduce the indicated silica content less than one half of one per cent. Furthermore, the precipitate of silica was carefully tested for impurities and these subtracted, so that the given percentage is the portion of the precipitate which was soluble in hydrofluoric acid.

A recent X-Ray study of tremolite by B. E. Warren¹ seems to establish the composition of tremolite as H₂Ca₂Mg₅(SiO₃)₈. Furthermore, according to Warren, "Rotation photographs of cleavage fragments around the *c* axis of tremolite, kupfferite, actinolite, hornblende and grünerite show a remarkable similarity in both the positions and the intensities of the spots" (p. 57). Therefore, the probable constitution of any amphibole should be found by replacing some of the atoms of tremolite by those occurring in the respective amphibole, as suggested by Warren with regard to grünerite.

¹ B. E. Warren, The structure of tremolite, H₂Ca₂Mg₅(SiO₃)₈, *Zeits. f. Krystallographie*, 72, 1929, Heft 1, Sept., pp. 42-57.

Dr. A. N. Winchell, who called the writer's attention to this publication, was kind enough to calculate the molecules of the Babbitt amphibole, resulting possibly from such replacements. These calculations would give the following percentages of molecules:

2.1%	$H_2Ca_2Mg_5Si_8O_{24}$
56.0%	$H_2Ca_2Fe_5Si_8O_{24}$
5.6%	$H_2Fe_7Si_8O_{24}$
26.1%	$H_2(Na, K)_2(Fe, Al)_4Si_8O_{24}$ (?)
10.2%	$H_2Al_10Si_4O_{24}$ (?)

After the formation of these molecules there still remains a small amount of alumina and the water content shows a slight discrepancy. Dr. Winchell writes: "I have suggested two molecules containing trivalent bases, but these are only tentative." It is to be hoped that the continued studies of Warren may also throw new light on the structure of the Babbitt amphibole.

No amphibole similar to the above is known to the writer. There is some remote similarity to the hudsonite of Cornwall, N. Y.,² "The pleochroism is pronounced . . . and Z is green with a slight tinge of blue" (p. 229). The percentage of ferrous and ferric iron and of alumina is almost the same. The amount of lime and magnesia is somewhat greater. A considerable difference may be noted in the alkalis whose sum is 4.40% compared with 2.25% in the Babbitt amphibole. The percentage of silica, however, is much lower, 36.86% in the former and 48.76% in the latter.

Up to the present the amphibole is known only from Babbitt and seems to be restricted to the vicinity of the granite. It occurs frequently as a contact border. The writer saw it also two feet above the granite, while at a distance of four feet grünerite was the only amphibole present. Whether or not it occurs farther away from the intrusive mass cannot be decided at present. The mineral association will be dealt with more fully in the Journal of Geology.

Of frequent occurrence is another green amphibole with a bluish tinge in the metamorphosed iron formations of the Mesabi Range, of the Marquette district and of the Penokee area. This amphibole is either associated with grünerite or with monoclinic pyroxene.

² S. Weidman, Note on the Amphibole Hudsonite previously called a Pyroxene. *Am. J. Sci.*, 15, 1903, p. 227.

However, the blue shade is never so pronounced, nor is the axial angle as small as that of the Babbitt amphibole.

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