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HOEGBOMITE FROM VIRGINIA[1]

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INTRODUCTION

Based on microscopic study of thin sections of the magmatic iron ores from the Routevare region, Lapland, Axel Gavelin[2] published in 1916 a comprehensive paper on the occurrence of "a new rock-forming mineral," which he named hoegbomite in honor of Professor A. G. Högbom of the University of Upsala. According to Gavelin the hoegbomite occurs chiefly in the iron-rich but silicate-free types of the iron ores. In addition to the predominant minerals, magnetite and ilmenite, hoegbomite is associated with pleonaste and corundum, and subordinate hydrargillite and pyrrhotite. Amphibole and chlorite sometimes occur as minor silicate constituents.

The present paper directs attention to the occurrence of hoegbomite in the spinel emery of the Virginia area[3] located near Whittles, a station on the main line of the Southern Railway, in Pittsylvania County. Thus far hoegbomite has not been reported outside the Routevare area, hence its occurrence in this country is not without interest.

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* While this article was going through the press announcement was made of the sudden death of Dr. Watson on November 10, 1924. A memorial sketch is being prepared by Professor Ries which will appear in an early issue of this journal.—EDITOR.

[1] Presented at the Washington meeting of the Mineralogical Society of America, December 29, 1923.

[2] Hoegbomite: A new rock-forming mineral from the Routevare area in Lapland. *Bull. Geol. Inst., University of Upsala*, **15**, 289-316, 1916.

[3] Watson, Thomas L., and Steiger, Geo.: Titanium-bearing corundum spinellite (rock emery); a preliminary statement of its occurrence and composition in Virginia. *Jour. Wash. Acad. Sci.*, **8**, 665-676, 1918.

Watson, Thomas L.: A contribution to the geology of the Virginia emery deposits. *Econ. Geol.*, **18**, 53-76, 1923.

HOEGBOMITE FROM THE ROUTEVARE AREA, LAPLAND

The properties of hoegbomite from Lapland as determined by Gavelin are summarized below.

PHYSICAL PROPERTIES.—Color in thin sections brown, in grains or powder black and not distinguishable from the principal associated minerals. Cleavage parallel to the base, not well defined. Brittle, conchoidal fracture, luster metallic-adamantine. $H=6.5$ and sp. gr. about 3.81. Weakly magnetic. Hexagonal (rhombohedral). Sometimes idiomorphic with well developed prismatic and pyramidal faces; base usually best developed. Axial ratio, $a:c=1:1.56$. Twinning parallel to the base; sometimes repeated.

OPTICAL PROPERTIES.—Refraction and double refraction strong. Refractive indices: $\omega=1.853$; $\epsilon=1.803$; double refraction: $\omega-\epsilon=0.050$. Basal sections isotropic. Uniaxial, negative (−). Pleochroism distinct, suggesting biotite but weaker; $\epsilon=$ light yellow-brown, $\omega=$ dark brown; absorption: $\omega>\epsilon$.

CHEMICAL PROPERTIES.—Insoluble in acids. An analysis calculated to 100% on an SiO_2-free basis gave:

ANALYSIS OF HOEGBOMITE FROM THE ROUTEVARE REGION, LAPLAND

	Per cent	Ratios	
TiO_2	5.53	.069	.069
Al_2O_3	61.19	.600	.711
Fe_2O_3	17.41	.109	
Cr_2O_3	0.29	.002	
MgO	15.44	.386	.388
MnO	0.14	.002	
	100.00		

From this analysis Gavelin deduced the formula $RO.2R_2O_3$, with TiO_2. The analysis shows the same constituents as pleonaste, except that TiO_2 is larger in amount. No appreciable amount of water is present and the iron occurs in the *ic* form (Fe_2O_3). Chemically the mineral represents a pleonaste with slightly increased MgO, and the FeO oxidized and partly replaced by TiO_2. Gavelin interprets the mineral as a mixture equivalent to 60 per cent of the micaceous iron group and 40 per cent of magnesium spinel; being closest physically to the former, but chemically to the spinel group.

Like the associated pleonaste and corundum, Gavelin regards the hoegbomite as a primary magmatic mineral, but states that in some cases it gives the impression of having been secondarily formed at the expense of pleonaste.

HOEGBOMITE IN THE VIRGINIA EMERY[4]

In a recent petrographic study of the Virginia emery, the writer noted a brown mineral, rather abundant in some thin sections and absent in others, whose optical properties correspond reasonably well with those determined by Gavelin for hoegbomite.

The Virginia emery[5] is a corundum-bearing magnetite spinellite. It is a dense and black fine-grained interlocking aggregate of green spinel (pleonaste-hercynite), ilmenitiferous magnetite, and corundum, with more or less of the brown mineral hoegbomite. Silicate minerals are usually lacking in the high grade emery, except for chlorite developed marginally about the emery bodies and scant sillimanite as fine fibers in the emery. Except for occasional segregations of coarse corundum the minerals of the emery are megascopically indistinguishable, and for most of the rock are less than 0.1 mm. in diameter, but in the coarsest textured emery they may reach 2 mm. in size.

Green spinel is the predominant mineral and frequently makes up 50 per cent or more of the rock. It carries inclusions both of magnetite and corundum, the former being frequently so abundant as to obscure the substance of the spinel. It frequently shows distinct rims of a brown cryptocrystalline material, identified as the mineral hoegbomite. Magnetite ranks next to spinel in quantity but is usually much less abundant. It is developed both interstitially and as inclusions in the spinel and corundum. It is partly older and partly younger than spinel. The older magnetite forms fine almost dust-like inclusions in spinel, while the younger or second generation is in distinct crystal grains up to 0.4 mm. in diameter (Plates I and II).

Corundum exceeds magnetite in some slides but is absent in others, being subject to wide variation in amount. It bears no relationship to hoegbomite. Inclusions of spinel and magnetite

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[4] It is a pleasure to make grateful acknowledgment to Dr. C. S. Ross of the U. S. Geological Survey, for kindly measuring the refractive indices of the hoegbomite and for helpful suggestions made during the course of this study.

[5] For a discussion of the geology, including occurrence, composition, structure, etc., of the emery, see Watson, Thomas L., A contribution to the geology of the Virginia emery deposits, *Econ. Geol.*, **18**, 53-76, 1923.

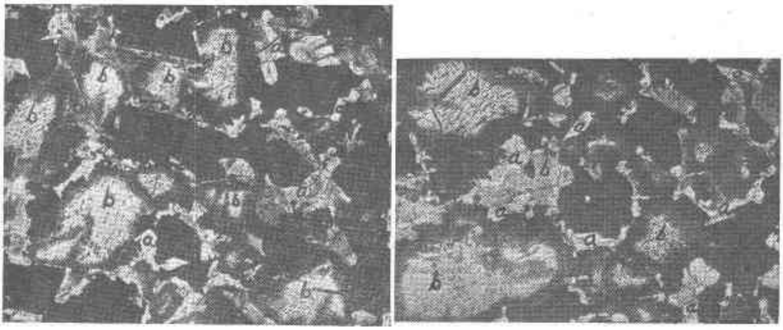

Plate I. Microphotographs of Virginia rock-emery showing hoegbomite: (a) crystalline hoegbomite of prismatic habit and cryptocrystalline hoegbomite as brown borders rimming (b) spinel with magnetite inclusions. Black areas magnetite. (C. S. Ross, Photo.)

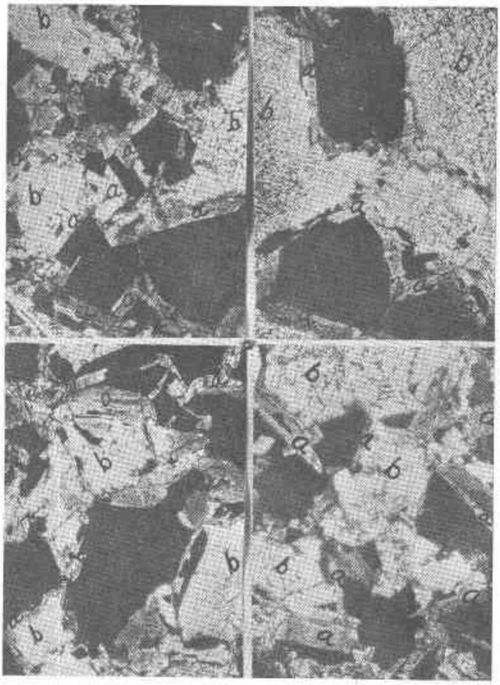

Plate II. Microphotographs of Virginia rock emery showing hoegbomite: Same as Plate I. Observe in each plate intimate relationship in some cases of the crystalline prismatic hoegbomite and the cryptocrystalline brown borders of hoegbomite about spinel. x52. (J. K. Roberts, Photo.)

occur in it, the latter being so abundant at times as to nearly obscure the substance of the corundum. Hoegbomite is absent from many of the thin sections. It is intimately associated with the spinel and magnetite, but not with the corundum. The crystalline type is older than the interstitial or second generation magnetite and the cryptocrystalline type which occurs as brown rims bordering spinel is younger than the latter.

The ratios of the above minerals vary widely. Likewise the paragenesis of the minerals seems not to be a definite one, but is subject to variation. Frequently the order is magnetite (first generation as inclusions in spinel and corundum), corundum, spinel, hoegbomite, and magnetite (second generation as interstitial crystal grains).

The ore-bodies occur near the intrusive contact of granite with mica schists, and are intimately associated with granite pegmatites. They occur both in the schist and in the granite and are of igneous contact metamorphic origin.

HOEGBOMITE.—The brown mineral (hoegbomite) in the Virginia spinellite is developed in microscopic size only, and is never visible megascopically. Moreover it is not a constant constituent of the rock, but is absent from many thin sections studied and fairly abundant in others. From a large number of measurements made, the mineral varied in size between 0.03 mm. and 0.003 mm. in length, and 0.010 and 0.002 mm. in width, with an average of 0.012 mm. (length) and 0.005 mm. (width). It is intimately associated with spinel and magnetite, but not with corundum. Indeed it has its chief development in those thin sections which contain little or no corundum.

Optically, the brown mineral in the Virginia rock agrees fairly closely with the description of hoegbomite given by Gavelin[6] and has been so identified. It is regretted that a chemical analysis of the hoegbomite in the Virginia rock has not been made, for it would be of special value in this study.

As developed in the Virginia rock, hoegbomite occurs in two forms, each brown in color, with at times an undoubted transition from one form to the other shown. One form is composed of crystalline material, usually prismatic in habit, occurring in euhedral shapes as single individuals and aggregates, sometimes as shreds and irregular grains. Cross fracture is sometimes de-

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[6] *Op. cit.*, pp. 289-316. Attempts to secure some of the Routevare material for comparative study have proved thus far unsuccessful.

veloped. The mineral is most intimately associated with spinel and magnetite both interstitially and as inclosures, but usually exhibits sharp contacts molded against the other minerals both of which are primary. Since the interstitial or second generation magnetite is an original mineral in the rock, the euhedral relations of the crystalline hoegbomite, which is older than interstitial magnetite, must also be original or primary.

The mineral is insoluble in acid. Refractive indices[7]: $\omega = 1.848$, $\epsilon = 1.817$; double refraction: $\omega - \epsilon = 0.031$, a lower value than that given by Gavelin for the original mineral from the Routevare region. Uniaxial, negative (−). Pleochroism somewhat variable; ϵ = light yellow brown to nearly colorless, ω = dark brown; absorption $\omega > \epsilon$. Basal cleavage; general appearance micaceous.

The other form of hoegbomite is developed as alteration rims or borders about the spinel individuals into which they grade, but outwardly are sharply molded against the other minerals, especially magnetite. It is an alteration from spinel, and is composed of cryptocrystalline material of fairly high birefringence and a mean index of 1.850 ± 0.01, as determined by Dr. Ross. This is a little higher than the mean of the crystalline material, but, as Ross states, "this is to be expected as it includes limonitic pigment. In measuring the index one gets an aggregate effect that does not quite represent the value for pure cryptocrystalline material."

In many cases where the crystalline and cryptocrystalline hoegbomite are in contact, transition from one to the other is observed microscopically, the cryptocrystalline material becoming more crystalline toward the outer edge and the two areas frequently extinguishing together. The cryptocrystalline material composing the brown rims is definitely derived from spinel, but whether it represents *alteration* subsequent to complete crystallization of the rock rather than true *reaction rims* developed after spinel formed but before crystallization was complete, the writer is in doubt. Concerning the latter, Ross has properly raised the question whether the alteration may "have been a deuteric phenomenon followed by crystallization of residual magma into the crystalline hoegbomite and interstitial magnetite."

There are certain microscopic features of the cryptocrystalline material composing the brown rims which when considered singly

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[7] Measured by Dr. C. S. Ross, U. S. Geological Survey, Washington, D. C.

might readily be explained on the basis of either of the above explanations. For the following reasons chiefly, the writer has been inclined to regard the brown rims as alteration subsequent to complete crystallization of the rock: (1) the material composing the brown rims shows an irregular inner margin which gradually fades inwardly into the substance of the spinel as contrasted with usually a sharp outer margin molded against the magnetite, etc.; (2) the inclusions of minute black granules of magnetite which usually crowd the substance of the green spinel also occur at times in the substance of the brown rims.

On the other hand, magnetite as well as spinel is an original mineral in the rock and, since crystalline hoegbomite which shows euhedral relations to magnetite is older than magnetite, it must also be original. Again since the cryptocrystalline substance of the brown rims is transitional into the crystalline hoegbomite, it likewise must have developed earlier than the interstitial magnetite. Whether it started with the alteration of spinel and ended with the crystallization of crystalline hoegbomite, or whether it began with crystallization of the former and ended with the alteration of spinel is an open question.

Spinel with magnetite inclusions crystallized ahead of both hoegbomite and magnetite. The magnetite inclusions so abundant in much of the spinel and to some extent in the substance of the brown rims must have crystallized ahead of the other minerals. This means that two generations of magnetite developed in the rock. Based therefore on the above paragenetic relations of the minerals, the brown borders of cryptocrystalline material might be readily explained as true reaction rims formed after crystallization of spinel but before final crystallization of the rock. In either case it was a deuteric process.

Composition of the Lapland and Virginia spinel

The occurrence of hoegbomite both in Lapland and in Virginia, is in spinel-bearing rocks of igneous origin. In the Lapland rock spinel is subordinate to magnetite; in the Virginia rock it is the dominant mineral with magnetite subordinate. For purposes of comparison chemical analyses showing the composition of the spinel from Lapland and Virginia are as follows:

ANALYSES OF SPINEL FROM LAPLAND AND VIRGINIA

	Lapland	Virginia
SiO_2	0.38	0.92
TiO_2	0.11	0.67
Al_2O_3	61.23	53.52
Fe_2O_3	3.80	10.35
FeO	20.10	24.53
MgO	13.82	10.02
H_2O	0.16	———
	99.60	100.01

Recalculated on a 100 per cent SiO_2-free basis and transformed into molecular percentages of the compounds $MgAl_2O_4$, $FeAl_2O_4$, and $FeFe_2O_4$, the analyses yield the following results:

	Lapland	Virginia
$MgAl_2O_4$	49.56	35.93
$FeAl_2O_4$	44.72	48.20
$FeFe_2O_4$	5.80	15.08

The spinels are thus shown to be mixtures of the same molecules but in different proportions. Magnesium aluminate (spinel proper) molecules predominate in the Lapland spinel, while ferrous aluminate (hercynite) molecules are predominant in the Virginia mineral; the former corresponds to pleonaste, the latter more closely approaches hercynite.

CONCLUSIONS

Optical properties of the crystalline and cryptocrystalline brown material described above, together with the microscopic evidence of transition from one to the other, are reasonable proof of their similarity mineralogically, and they are therefore identified as the mineral hoegbomite.

The paragenetic relations of the crystalline hoegbomite of prismatic habit to magnetite, an original mineral, indicate that it is also an original constituent of the rock and is older than magnetite. If this is correct, the crystalline hoegbomite in the Virginia rock is a primary mineral as determined by Gavelin for the mineral of the Routevare district.

The cryptocrystalline material composing the brown borders of the spinel is a distinct alteration of spinel probably of the reaction rim type formed after the crystallization of the spinel, but before complete crystallization of the rock and was a deuteric process. Its transitional relations to the crystalline hoegbomite are in accord with this view. That somewhat similar relations were recognized by Gavelin for hoegbomite from the Routevare district is indicated in the statement on page (3 ms.) "that in some cases it [hoegbomite] gives the impression of having been secondarily formed at the expense of pleonaste."

SCHALLERITE, A NEW ARSENO-SILICATE MINERAL FROM FRANKLIN FURNACE, NEW JERSEY

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Introduction.—The new mineral herein described is a hydrous arseno-silicate chiefly of manganese. It was discovered by one of the authors, Mr. R. B. Gage, during the early part of 1924 and apparently has been mistaken for bustamite or rhodochrosite, which material in the massive form it resembles a great deal. The specimens secured were small pieces attached to the massive ore; yet, no doubt, this material occurred in considerable quantity, but unfortunately on account of its resemblance to some of the other minerals found at Franklin Furnace, no effort whatever was made to collect it. Consequently, it was crushed with the other zinc ores in the mill. The name *schallerite* is proposed for the mineral after Dr. Waldemar T. Schaller, of the United States Geological Survey, Washington, D. C.

Occurrence.—To date no crystals of schallerite have been seen but the massive material is fairly pure and appears uniform in chemical composition and physical properties. It is light brown with a vitreous, waxy luster. The fractured surface shows cleavage planes with pearly luster.

It can easily be distinguished from willemite, bustamite, rhodonite, rhodochrosite, or friedelite, for which it might be mistaken, by its behavior with acids, also in the closed tube, and by its optical properties. The arsenic coating in the neck of the closed tube is very characteristic. This test together with its appearance is sufficient to identify it.

Schallerite occurs in seams or on cleavage faces in the massive zinc ore. The thickness of these seams is from one-half inch to two inches, and, judging from the appearance of the specimens secured, may cover several square feet. The mineral is firmly attached to the massive ore and its surface is often covered with a thin coating