GRAFTONITE FROM GREENWOOD, MAINE*

JEWELL J. GLASS AND JOSEPH J. FAHEY,
U. S. Geological Survey, Washington, D.C.

ABSTRACT

A specimen of graftonite from Greenwood, Maine, permitted a detailed study of this little known mineral, and established a third locality for this iron, manganese, calcium phosphate.

The optical properties of the Greenwood material showed a slightly higher refringence than the type material from Grafton, N.H., but the birefringence, 0.024, and the optical axial angle, $+2V$ 55°, are the same. Indices: $\alpha=1.709$, $\beta=1.714$, $\gamma=1.733$.

Chemical analysis shows an isomorphous variation in the proportions of iron, manganese, and calcium, but conforms to the established formula for graftonite, $3(Fe, Mg, Ca)O \cdot P_2O_5$.

INTRODUCTION

During the summer of 1936 Mr. Ernest W. Sniffen of Hampton, Virginia, obtained a specimen of a mineral thought to be triphylite, which he submitted to the U. S. Geological Survey for identification. Optical observations (by J. J. G.) indicated that the mineral was graftonite, and qualitative chemical tests (by J. J. F.) showed it to be an anhydrous iron, manganese, calcium phosphate. Through the courtesty of Mr. Sniffen, permission was granted to make a detailed study of the specimen.

This new occurrence establishes a third locality for graftonite, which has previously been recorded from only two localities, both in Grafton County, New Hampshire. The original locality described by Penfield[1] is the Melvin Mountain mine near the village of Grafton, and the other locality described by Berman[2] is the Palermo mica mine on Bald Face Mountain, one and a half miles south of North Groton.

The specimen described in this paper came from the Tamminen-Wassinen Ledge, on Noyes Mountain, near Greenwood, Maine. The geology, and a great number of the minerals from that locality were described by Landes[3] in his paper on pegmatites of central Main. The graftonite is massive, showing no crystal faces, and the specimen measures about 2.5 by 2 by 1.5 cm. On one side is a compact assemblage of quartz, albite, muscovite, chlorite, calcite, pyrite, sphalerite, and arsenopyrite, with an occasional grain of triphylite.

* Published by permission of the Director, U. S. Geological Survey.

[1] Penfield, S. L., On graftonite, a new mineral from Grafton, New Hampshire, and its intergrowth with triphylite: *Am. Jour. Sci.*, vol. **9**, p. 20, 1900.

[2] Berman, Harry, Graftonite from a new locality in New Hampshire: *Am. Mineral.*, vol. **12**, p. 170, 1927.

[3] Landes, K. K., The paragenesis of the granite pegmatites of central Maine: *Am. Mineral.*, vol. **10**, pp. 399–411, 1925.

Physical and Optical Properties

The graftonite is homogeneous, ocher-salmon colored, and unaltered except for a few patches of dark staining from oxidation of the iron and manganese. The luster is vitreous to resinous. In appearance it resembles salmon-colored varieties of lithiophilite and triplite. The graftonite shows no response to ultra-violet radiation.

Unlike the graftonite described by Penfield and Berman, the specimen from Maine does not show on visual inspection the banded structure due to alternating layers of graftonite and triphylite. Microscopic examination of a polished surface by reflected light, however, shows a few sets of very narrow parallel bands of another mineral which in thin section and in crushed fragments are seen to have the optical properties of triphylite. These bands of triphylite are very insignificant and are present only in parts of the graftonite.

The specific gravity of the graftonite was found to be 3.771 on massive material and 3.796 (at 25°C.) on a powdered sample, which is somewhat higher than that (3.672) reported by Penfield. The hardness is between 4 and 5.

Before the blowpipe flame the graftonite fuses easily to a glassy black bead, feebly magnetic. Heated in the closed tube, only a slightly visible quantity of water is given off, and at red heat the mineral fuses. It is readily soluble in cold 1:1 hydrochloric acid, cold 1:1 nitric acid and hot 1:1 sulphuric acid.

Although neither Penfield nor Berman make any mention of cleavage, close inspection of crushed fragments reveals a small proportion of flat cleavage plates, and on a few of these a straight edge indicates a second and less perfect cleavage. A thin section of unknown orientation crystallographically, but almost normal to the negative obtuse bisectrix, shows a number of well developed continuous cleavage lines and a second set of much poorer and interrupted cleavage lines oblique to the other cleavage. The second poorer cleavage is also shown on the right side of Berman's Fig. 1. The optic axial plane is oblique to the traces of both cleavages, as seen in this thin section. The few minute bands of triphylite are nearly parallel to the better cleavage.

The optical properties of the graftonite indicate monoclinic symmetry, as extinction on straight-edged cleavage fragments is parallel on some and inclined 30° on others. The plane of the optic axes is nearly parallel to some elongated cleavage pieces, as seen in crushed material. The positive acute bisectrix, Z, is not quite normal to the cleavage. Observed

2V is about 55° to 60°; calculated 2V = 55°. The indices of refraction are: $\alpha = 1.709$, $\beta = 1.714$, $\gamma = 1.733$, B = .024. (See Table 1.)

TABLE 1. COMPILATION OF AVAILABLE OPTICAL DATA ON GRAFTONITE

Locality	Grafton, N.H. Melvin Mt.	Grafton, N.H. Melvin Mt.	Groton, N.H. Baldface Mt.	Greenwood, Me. Noyes Mt.
Data by	Penfield	Larsen	Berman	Glass
Color	Salmon	Salmon-pink	Salmon	Ocher-salmon[a]
α	—	1.700	1.704	1.709
β	—	1.705	1.706	1.714
γ	—	1.724	1.725	1.733
$\gamma - \alpha$	not high	.024	.021	.024
Sign	+	+	+	+
2V	50°–60°	55°±	50°±	55°
Disp.	Distinct	Distinct	$r > v$	$r > v$

[a] Ridgway Color Standard.

The indices of refraction of the material from Greenwood, Maine, are somewhat higher than those of the two samples from Grafton County, New Hampshire. The birefringence of the Greenwood material (0.024) agrees with that determined by Larsen, but is somewhat higher than the value shown by Berman, who gives $\gamma - \alpha$ as 0.021, and 2V = 50°. This angle gives a calculated value of 0.004 for $\beta - \alpha$, whereas his value is 0.002. This suggests that his α value is a little high. The material from Groton, New Hampshire, is described by Berman as having the same banded structure and association with altered triphylite that characterizes the type material from Grafton, New Hampshire, upon which Larsen made his optical determinations. No analysis was made of the Groton material described by Berman, but the optical properties indicate that it is similar in composition to the original graftonite from the type locality.

The fact that the indices of refraction of the graftonite from Greenwood, Maine, are consistently higher than those for the other two specimens is due to the higher manganese and lower calcium content of the mineral.

CHEMICAL ANALYSIS

The purity and abundance of material from Greenwood, Maine, favored a careful and accurate analysis. Selected, fresh, unstained material was used for the analysis and the results are given in Table 2.

TABLE 2. CHEMICAL ANALYSIS OF GRAFTONITE FROM GREENWOOD, MAINE
(Joseph J. Fahey, analyst)

	Per cent	Molecular ratios	
P_2O_5	40.03	.2819 or 1.000	
Al_2O_3	none		
Fe_2O_3	none		
TiO_2	none		
FeO	27.78	.3867	
MnO	25.48	.3592	
CaO	4.71	.0840	
MgO	none		.8454 or 2.999
K_2O	0.05	.0005	
Na_2O	0.16	.0026	
Li_2O	0.37	.0124	
H_2O	0.60		
$CaCO_3$	0.46		
Insol.	0.18		
F	none		
	99.82		

The ratio $RO:P_2O_5$ is 2.999:1.000 or 3:1.
The formula of the mineral is $3(Fe, Mn, Ca)O \cdot P_2O_5$.

Ferrous iron was found to be equivalent to the total iron. This indicates that all the iron is in the ferrous state and that there is none other than divalent manganese in the mineral. Manganese was determined volumetrically in a separate portion by the bismuthate method. The blank correction was equivalent to 0.40 cc. of 0.05 N. permanganate solution. The absence of Al_2O_3 was definitely established by two methods, namely the sodium hydroxide method and the hydrochloric acid-ether method. An excess of ferric nitrate was added to the hydrochloric acid solution of another portion in order to hold P_2O_5 in the ammonia precipitate and allow calcium to remain in solution, where after filtration it was determined in the usual manner. The alkalies were determined by the J. Lawrence Smith method, separating LiCl with ether-alcohol solution as recommended in the Palkin[4] method and modified by Wells and Stevens.[5] Water was determined by the Penfield method, using sodium tungstate as a flux.

Although Penfield's analysis of graftonite from Melvin Mountain shows a ratio of CaO to (FeO+MnO) close to 1:4 (0.1645:0.6755 or 1.00:4.11), the analysis of the graftonite from Maine, with a lower per-

[4] Palkin, J., *Am. Chem. Soc.*, vol. **38**, p. 2326, 1916.
[5] Wells, R. C., and Stevens, R. E., *Ind. and Eng. Chem., Anal. Ed.*, vol. **6**, p. 439, 1935.

centage of CaO (only about half as much) shows that the quantity of CaO is not constant and that all the bases should be grouped together.

The three analyses of graftonite, from two localities, are shown in the following compilation (Table 3).

TABLE 3. COMPILATION OF CHEMICAL ANALYSES OF GRAFTONITE

	1.	2.	3.
P_2O_5	41.20	40.80	40.03
Al_2O_3	—	—	none
Fe_2O_3	—	10.16	none
TiO_2	—	—	none
FeO	30.65	24.28	27.78
MnO	17.62	15.38	25.48
CaO	9.23	7.25	4.71
MgO	0.40	—	none
K_2O	—	0.14	0.05
Na_2O	—	1.15	0.16
Li_2O	0.33	—	0.37
H_2O	0.75	1.17	0.60
$CaCO_3$	—	—	0.46
Insol.	—	—	0.18
F	—	—	none
	100.18	100.33	99.82
G.	3.672	—	3.796 (powder) 3.771 (massive)

1. Graftonite from Melvin Mt., Grafton County, New Hampshire. S. L. Penfield, analyst.
2. Graftonite (partially purified), Melvin Mt., Grafton County, New Hampshire. W. E. Ford, analyst.
3. Graftonite from Greenwood, Oxford County, Maine. J. J. Fahey, analyst.