

# GANOPHYLLITE AND ZINCIAN AMPHIBOLE FROM FRANKLIN FURNACE, NEW JERSEY.\*

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## GANOPHYLLITE

### INTRODUCTION

The mineral ganophyllite was first described by Axel Hamberg<sup>1</sup> from Pajsberg, Sweden, associated with caryopilite, barite, lead, rhodonite, calcite, garnet, manganophyllite and pyrophanite.

Later small needle-like crystals associated with rhodonite and axinite from Franklin Furnace were investigated by Esper S. Larsen and Earl V. Shannon<sup>2</sup> who showed that these crystals were identical with the Swedish ganophyllite. This mineral had previously been listed as occurring at Franklin Furnace by Charles Palache.<sup>3</sup> The mineral has also been reported by A. F. Rogers from a large boulder of manganese ore at San Jose, California. Rogers' determination, however, was based on a comparison of optical data with those given for ganophyllite by Hamberg, but now shown by Larsen<sup>4</sup> to be much in error.

Some time ago Mr. R. B. Gage of Trenton, New Jersey, brought the writer several specimens of a very coarse platy brown mineral (U. S. N. M. No. R-6724, C-5096, C-5097) found on the picking belt at the zinc mine at Franklin. This material resembles a coarse form of ferroschallerite and was at first believed to be that mineral. Optical examination, however, showed it to be distinct from ferroschallerite and chemical examination revealed the mineral as ganophyllite.

### CHEMICAL PROPERTIES

Abundant pure material in the form of a clear brown cleavage plates was available for chemical investigation.

The analysis carried out by standard methods gave the results given below. With this are given the results of Hamberg's analysis on the Pajsberg mineral. The analysis of the Franklin ganophyllite by E. V. Shannon<sup>5</sup> was unfortunately made on a sample weighing but .0735 gram and cannot, therefore, be considered as of more than determinative value.

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<sup>1</sup> *Geol. Fören. Förhandl.*, vol. 12, pp. 586-598, 1890.

<sup>2</sup> *Am. Mineral.*, vol. 9, pp. 238-240, 1924.

<sup>3</sup> *Am. Jour. Sci.*, vol. 29, p. 187, 1910.

<sup>4</sup> *Op. cit.*, p. 239.

<sup>5</sup> *Op. cit.*, p. 239.

## ANALYSES OF GANOPHYLLITE

	I	II
SiO <sub>2</sub>	44.36	39.67
Al <sub>2</sub> O <sub>3</sub>	11.40	7.95
Fe <sub>2</sub> O <sub>3</sub>	None	0.90
FeO	0.09	—
CaO	2.64	1.11
MgO	3.82	0.20
MnO	24.24	33.15
Na <sub>2</sub> O	2.86	2.18
K <sub>2</sub> O	0.26	2.70
H <sub>2</sub> O	10.72	9.79
PbO?	—	0.20
	100.39	97.85

I Ganophyllite. Franklin (U. S. N. M. No. R-6724) New Jersey. W. F. Foshag, *analyst*.

II Ganophyllite. Pajsberg, Sweden. A. Hamberg, *analyst*.

From the results on the Franklin mineral the formula derived is approximately  $(5\text{Mn}, \text{Mg}, \text{Ca}, \text{Na}_2, \text{K}_2, \text{Fe})\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 7\text{SiO} \cdot 5\text{H}_2\text{O}$ . It is evident, however, from a comparison of the two analyses that ganophyllite is quite variable in its composition.

Ganophyllite is decomposed by dilute hydrochloric acid with separation of skeletons of silica. Before the blowpipe the mineral turns pale brown and fuses quietly to a pale brown bead. In the closed tube it gives off water and becomes shiny black.

## PHYSICAL AND OPTICAL PROPERTIES

The color when fresh is a light cinnamon brown but on exposure it gradually darkens to an almost biotite black. The freshest thin cleavages are very pale hair brown, almost colorless. Oxidation clouds and darkens the color. The luster is pearly on the cleavage face and vitreous to somewhat resinous across the cleavage.

Under the microscope ganophyllite is biaxial, negative, with a medium axial angle.  $\alpha = 1.545$ ,  $\beta = 1.586$ ,  $\gamma = 1.589$ . Dispersion moderate,  $r$  less than  $v$ . Plane of the optic axes and the acute bisectrix are normal to the cleavage.

Cleavage micaceous, perfect. Hd.  $3\frac{1}{2}$ . G. 2.878. Very brittle.

## OCCURRENCE

The association of this ganophyllite is totally dissimilar from that previously reported. In these specimens the ganophyllite occurs in large masses as much as four centimeters across showing perfect cleavage. It is associated with coarse gray massive quartz, coarse pink feldspar and deep greenish black cleavages of soda amphibole (U. S. N. M. No. C-5097); or as broad cleavage masses with cleavages of amphibole in

calcite and barite (U. S. N. M. No. R-6724). The specimens suggest that the ganophyllite occurs in calcite at or near its contact with pegmatite.

A third form of Franklin ganophyllite is to be noted: In veins in franklinite ore, eight millimeters across made up of reticulated rods with longitudinal cleavage (U. S. N. M. No. 97499). Associated with the ganophyllite in these veins are a few rod-like crystals of pale green willemite.

#### RELATIONSHIP

The chemical formula usually assigned to the Swedish ganophyllite is  $7\text{MnO} \cdot \text{Al}_2\text{O}_3 \cdot 8\text{SiO}_2 \cdot 6\text{H}_2\text{O}$ . The Franklin mineral is approximately  $5\text{MnO} \cdot \text{Al}_2\text{O}_3 \cdot 7\text{SiO}_2 \cdot 5\text{H}_2\text{O}$ . It is evident that the chemical composition of ganophyllite is variable.

Ganophyllite has been classed in the zeolitic division, largely on the basis of its low alumina content and the zeolitic behavior of its water. Its platy habit and brittle nature suggest a chloritic or brittle mica mineral and it is, in fact, entirely analogous to some of the leptochlorites, particularly stilpnomelane. Below is a comparison of the Franklin and Swedish ganophyllite with stilpnomelane from Lane's quarry, Westfield, Connecticut, as well as with the Swedish mineral ekmannite.

MOLECULAR RATIOS OF GANOPHYLLITE, STILPNOMELANE AND EKMANNITE

	I	II	III	IV
SiO <sub>2</sub>	.7386	.6612	.7310	.6683
Al <sub>2</sub> O <sub>3</sub>	.1115	.0772	.0464	.0497
Fe <sub>2</sub> O <sub>3</sub>	—	.0056	.0334	.0225
FeO	.0012	—	.3244	.3559
CaO	.0471	.0198	—	—
MgO	.0947	.0050	.2073	.1895
MnO	.3418	.4950	.0123	.1005
Na <sub>2</sub> O	.0461	.0352	—	—
K <sub>2</sub> O	.0028	.0287	—	—
H <sub>2</sub> O	.5950	.5439	.6930	.5961

I Franklin, N. J. Col. I. Table 1.

II Pajsberg, Sweden. Col. II. Table 1.

III Stilpnomelane. E. V. Shannon, *Proc. U. S. Nat. Mus.*, vol. 57, p. 400, 1920.<sup>a</sup>

IV Ekmanite, Grythyttte, Sweden. Anal. No. 3, *Dana*, p. 662.

<sup>a</sup> SiO<sub>2</sub> 44.08; Al<sub>2</sub>O<sub>3</sub> 4.74; Fe<sub>2</sub>O<sub>3</sub> 5.27; FeO 23.31; MgO 8.36; CaO tr.; MnO .87; H<sub>2</sub>O 12.49.

Combining these ratios we have the following relationships between these four minerals.

	(R <sub>1</sub> R <sub>2</sub> )O	R <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	H <sub>2</sub> O
Ganophyllite No. 1	.5537	.1115	.7376	.5950
Ganophyllite No. 2	.5937	.0823	.6612	.5439
Stilpnomelane No. 3	.5440	.0798	.7310	.6930
Ekmannite No. 4	.6459	.0722	.6683	.5961

It is evident from this table that the two ganophyllite ratios agree as well with those of stilpnomelane and ekmannite as they do with each other. These minerals are variable in composition and probably represent members of an isomorphous series in which ganophyllite is a manganese member; stilpnomelane an iron member and ekmannite an intermediate member.

Ganophyllite shows some resemblance to manganophyllite but has less alumina and less alkalis. The Pajsberg mineral shows a somewhat closer relationship to manganophyllite than does the Franklin ganophyllite.

#### ZINCIAN AMPHIBOLE

##### GENERAL

The amphibole associated with the ganophyllite resembles ordinary hornblende but an optical examination suggested a sodic amphibole near riebeckite. An analysis shows this mineral to be a zincian sodic amphibole. This amphibole is intimately associated with the ganophyllite, occurring as prismatic crystals of a dark green to black color in ganophyllite, quartz or calcite. The largest crystal is four centimeters long and one centimeter broad. The crystals show a round outline but without definite terminations. The cleavage angle ( $m \wedge m$ ) is  $124^{\circ} 13'$ .

#### CHEMICAL PROPERTIES

An analysis of the pure mineral gave the following results:

ANALYSIS OF ZINCIAN AMPHIBOLE, FRANKLIN, N. J. (U. S. N. M. No. C-5097)  
W. F. Foshag, analyst

	Per cent		Per cent
SiO <sub>2</sub>	53.20	ZnO	4.70
TiO <sub>2</sub>	0.12	MnO	2.97
Al <sub>2</sub> O <sub>3</sub>	5.37	CaO	3.36
Fe <sub>2</sub> O <sub>3</sub>	8.03	Na <sub>2</sub> O	4.35
FeO	4.46	K <sub>2</sub> O	0.21
MgO	11.12	H <sub>2</sub> O	1.79
		Sum	99.63

The amphibole, therefore, is not an ordinary amphibole but shows an unusual amount of zinc and manganese. Harry Berman and E. S. Larsen<sup>6</sup> have proposed as the general formula of the alkali amphiboles the following:  $(Ca, Na)_2 Na_{0-1} Mg(Mg, Al)_4 (Al, Si)_2 Si_6 O_{22} (O, OH, F)_2$ . This is a modification of the general formulas proposed by W. Kunitz<sup>7</sup> and B. E. Warren.<sup>8</sup>

With these formulas the analysis of the Franklin mineral agrees reasonably well as the following ratios show:

RATIOS OF ZINCIAN AMPHIBOLE

Si	.8823	.8823	8 × .1104
Ti	.0015		
Al	.1050	.2071	2 × .1035
Fe'''	.1006		
Fe''	.0621		
Mg	.2758	.3379	3 × .1129
Zn	.0577		
Mn	.0419		
Ca	.0599	.3043	3 × .1014
Na	.1404		
K	.0044		
(O, OH)	2.7452	2.7452	24 × .1131

The formula for the Franklin mineral may then be written as follows:  $(Na, Ca, Zn, Mn)_3 (Mg, Fe'')_3 (Al, Fe''')_2 Si_6 O_{22} (O, OH)_2$ .

#### PHYSICAL AND OPTICAL PROPERTIES

The color of the Franklin amphibole is that of ordinary hornblende, a dark greenish black. The pleochroism, as is given below, is that of the sodic amphiboles. The mineral is biaxial, negative, with a medium large axial angle. Dispersion strong,  $r$  less than  $v$ .  $\alpha = 1.665$ ; olive green;  $28^\circ$  to  $c$ .  $\beta = 1.673$ ; dark sage green.  $\gamma = 1.676$ ; dark olive green =  $b$ .

#### OCCURRENCE

Like the ganophyllite, the amphibole occurs both in the calcite-barite matrix and in the quartz-feldspar matrix. To judge from its chemical composition and relationship the amphibole and ganophyllite are both of the same period of mineralization.

<sup>6</sup> *Am. Mineral.*, vol. 16, pp. 140-144, 1931.

<sup>7</sup> *Neues Jahrb. Min., Beil. Bd.*, Abt. A, 60, pp. 171-250, 1929.

<sup>8</sup> *Zeit. Krist.*, vol. 72, pp. 493-517, 1930.