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NOTES ON THE COMPOSITION OF TALC.[1]

WILLIAM F. FOSHAG, *U. S. National Museum*, AND EDGAR T. WHERRY, *Bureau of Chemistry*

The chemical constitution of talc is a problem that has engaged the attention of a number of investigators without the studies having led to a satisfactory solution. The analyses show a variation in the ratios Mg:Si from 1:1 to 4:3 and in the water content from 3 to over 7 percent. What this variation is due to is difficult to determine with our present data; altho the possibility of admixture is not entirely excluded, examination as to the homogeneity of the material analyzed seems rarely to have been made. The theoretical compositions for several ratios are here tabulated in order of increasing water content:

THEORETICAL COMPOSITIONS OF TALCS

H_2O:MgO:SiO_2=	1:4:5	1:3:4	2:4:5
H_2O	3.7	4.7	7.2
MgO	33.6	31.8	32.3
SiO_2	63.5	63.5	60.5
	100.00	100.0	100.0

Material with approximately the composition given in the last column has recently been assigned the name "gavite."[2] Two occurrences of talc of low silica and high water content have been studied in the National Museum laboratory, with special reference to the latter constituent.

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[1] Published by permission of the Secretary of the Smithsonian Institution. This paper was presented in abstract at the Chicago meeting of the Mineralogical Society of America, December 29, 1920, but the manuscript was mislaid and has only recently been found.

[2] *Atti. Soc. Ital. Sci. Nat.*, **57**, 131-155, 1918; abstract in *Am. Min.*, 4, 132, 1919.

Some specimens of talc collected by Mr. Earl V. Shannon, of the Department of Geology, at the old Atwater serpentine quarry of the Westfield Marble Company in Russell, Massachusetts were investigated. The talc occurs as patches of silvery flakes of a light green color in a massive dark green serpentine and is evidently derived from some other mineral, probably olivine. The plates possess a good basal cleavage. The material for analysis was carefully selected, crushed and screened, and examined with a hand lens. Many of the fragments showed inclusions of magnetite. These were removed with a strong magnet and the sample, after further grinding, was examined with the petrographic microscope and found to be homogeneous.

The results of the analysis of this material, carried out by standard methods, and the calculated ratios are given below.

ANALYSIS AND RATIOS OF TALC FROM RUSSELL, MASS.

H_2O-	0.50		
H_2O+	7.28	420	4.00
SiO_2	56.86	937	9.00
Al_2O_3	1.00		
Fe_2O_3	none		
FeO	2.40	33	
MnO	none		
CaO	0.46		
MgO	31.74	793	8.00
	100.24		

After standing for 23 days over sulfuric acid the mineral lost but 0.5 percent of water. Heated to dull red heat it lost 4.04 percent without losing its optical homogeneity. The water retained amounted to 3.24 or the theoretical amount required by the ordinary talc formula.

The feature of particular interest in this connection is the slight change which is produced in the optical properties by the loss of the first portion of water. The refractive indices of the original material, determined by the immersion method, are somewhat variable, as follows: α=from 1.540 to 1.545±0.005, $\beta=\gamma$=from 1.575 to 1.585±0.003. Approximately the same values were obtained on the material from which the "loosely bound" water had been driven. The optic axial angle, 2E=20° ±5°, also remained essentially the same. The homogeneity of the material was destroyed, however, when the firmly bound water was driven off.

A second specimen investigated was collected by Mr. M. Vonsen near Porterville, California. It occurs as small seams up to three centimeters in thickness with typical vein structure. The plates are arranged normal to the walls and meet in the center to form a suture. This talc is accompanied by calcite. The sample selected for analysis appeared homogeneous; its optical properties are as follows: axial angle small; negative; acute bisectrix normal to the plates; $\alpha = 1.545$, $\beta = \gamma = 1.574$. The refractive indices again vary somewhat from grain to grain. The analysis and calculated ratios are given in the following table:

Analysis and Ratios of Talc from Porterville, Calif.

H_2O-	0.28		
H_2O+	7.76	431	4
SiO_2	57.44	957	9
Al_2O_3	none		
Fe_2O_3	none		
FeO	1.85	26	
CaO	1.14	20	
MgO	31.74	793	8
	100.21		

Over sulfuric acid the mineral lost but 0.28 percent upon 23 days exposure. Lack of suitable material made it impossible to study the change upon dehydration.

As will be seen from the above data the water behaves in an unusual manner. One molecule of water is given off, at a high temperature, without bringing about any detectable change in the optical properties of the mineral. It differs, therefore from the so-called dissolved water, the characteristic feature of which is, that it is given off continuously with corresponding changes in the optical properties of the mineral. In common with dissolved water, however, the water of the talc studied appears to be present in molecular proportions. Other analyses of talc show a continuous series of gradation from $Mg:H_2O = 3:1$ to $3:2$, but do not go beyond these limits. Some analyses of talc show water content below the theoretical amount required for $Mg:H_2O = 3:1$, but this can perhaps be attributed to the method of determining the water: by ignition loss without a correction for the oxidation of the ferrous iron, which results in a low value.

Larsen and Wherry[3] have described a leverrierite from Colorado that behaved in a manner similar to the talc. In this case, however, a large amount of water was given off at temperatures below 110°C, while the temperature required to drive off the first portion of the water from the talc was a dull red heat. The optical properties of the leverrierite up to the point of complete dehydration showed no appreciable change.

The constitution of talc containing only firmly bound water and approximating in composition the 1:4:5 ratio has been investigated by Clarke and Schneider.[4] The driving out of the water resulted in setting free practically ¼ of the silica present, showing the mineral to be an acid metasilicate, representing as it were an enstatite with every fourth magnesium atom replaced by hydrogen. Neither enstatite nor this type of talc are appreciably dissolved by acids. In the case of the talc described above as well as the "gavite," the mineral is readily decomposed. The driving out of the loosely bound water, on the other hand, does not liberate any silica nor produce any marked change in the mineral here under investigation.

Talc belongs to the small but interesting group of minerals of such a low degree of hardness—lying at 1 or 1.5 in the standard scale of hardness—that they have a greasy feel and at the same time exhibit an eminent pinacoidal cleavage. Other noteworthy members of this group are: graphite, molybdenite, tetradymite, orpiment, nagyagite and pyrophyllite. Of these only graphite has been studied as to its crystal structure by X-rays, but the others are undoubtedly more or less analogous in structure. In the direction perpendicular to the cleavage face such substances are held together chiefly by electro-static forces rather than by valence forces (which yield much harder crystals; compare diamond).

Most of these are formed in nature at such high temperatures that they would hardly be expected to take up water; altho a hydrous arsenic sulfide corresponding to orpiment $+1H_2O$ has been reported, and pyrophyllite may carry several percent excess water.

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[3] *J. Wash. Acad. Sci.*, **7**, 208, 1917.

[4] *Am. J. Sci.*, **40**, 306, 1890.

But if the temperature of formation were low enough, more or less water might readily become interlayered with the normal mineral molecules, in the direction of the perfect cleavage. The properties of this water should be intermediate between those of water (hydrogen or hydroxyl) held by valence forces in the compound, and those of water held as such by surface forces. The temperature at which the water would escape should be greater than the boiling point of free water yet less than that required to break down the compound. Its presence should render the molecules more susceptible to attack by reagents. Its escape would result only in a slight shrinking together, in the pinacoidal direction, of the solid layers and hence should not produce any marked change in optical properties. These features are shown so definitely by the two talcs here studied, that their excess water is considered to be thus held, i. e., by electrostatic attraction between the mineral layers in the cleavage direction. The new mineral "gavite" as well as the long known mineral "picrosmine," are so analogous in composition to the talcs described above as to leave no doubt that they are similar, and as such do not deserve the rank of distinct mineral species. It is therefore suggested that these two names be dropped and that these minerals be included under the species talc.

NOTE ON GARNET FROM A PEGMATITE IN IDAHO[1]

Earl V. Shannon, *U. S. National Museum*

While studying black sands from the Idaho gold placer mines the writer recognized that the garnet occurring in these concentrates was of two kinds, distinguished by a pronounced difference in color. The first of these, which is brown red in color was called almandite. The other garnet is rose red in color and in a recent publication it was stated that this was probably a magnesian variety high in the pyrope molecule, and perhaps derived from basic magnesian metamorphic rocks. This idea was a result of the writer's observation of a garnet of similar color and appearance in an amphibolite schist derived from large diabase sills in the Avery Quadrangle in the Northern part of the state. A number of specimens of garnet in matrix from Idaho have since been examined and it seems that this rose colored garnet is the

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