TWO PHOSPHATES FROM DEHRN;[1] DEHRNITE AND CRANDALLITE

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In the course of the study of wardite and the associated phosphates from Utah, the authors secured from the late Colonel Roebling a specimen of the kalkwavellite from Dehrn, described in 1869 by Kosmann and the present paper is the result of a study of this specimen.

The specimen is a brecciated phosphorite and the fragments are coated with a white vitreous crust, averaging about one-half millimeter in thickness, of a finely crystalline mineral; perched on these crusts in the cavities are numerous aggregates of radiating needles, some of them five millimeters long. The specimen is about six centimeters long and nearly half as thick and the crusts and spherulites each make up several per cent of the specimen.

DEHRNITE

The crystalline crusts that coat the fractures of the phosphate rock failed to agree with any known mineral in composition although similar to the meteoritic calcium-sodium phosphate merrillite except that the soda is approximately half replaced by water and carbon dioxide. The same mineral was also found in small amounts associated with the wardite of the Utah locality. The name dehrnite is proposed for the mineral from the locality.

This mineral forms grayish or greenish white crusts of fibrous to bladed crystals. The individual crystals were not suitable for goniometric measurement.

Dehrnite has a hardness of about 5 and a specific gravity of 3.04 as determined by floating crystals in a heavy solution. It fuses readily to a white enamel (F = 2), and on further heating to a white opaque bead. It has a perfect basal cleavage, and a hexagonal outline. It is uniaxial, negative, and $\omega = 1.622$, $\epsilon = 1.614$.

About half a gram of carefully purified mineral was available for the analysis. This material contained a few per cent of impurities mostly the phosphorite rock. Most of the grains are clear but some

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are much clouded from minute gas cavities. The crusts show a concentric structure with thin layers of a slightly different index of refraction from the average.

The analysis by Shannon and the ratios are given below.

ANALYSIS AND RATIOS OF DEHRNITE

	Per cent	Ratios	
Insol.	0.12		
CaO	50.88	.907	1.00×7
Al_2O_3	tr.		
P_2O_5	37.12	.261	1.01×2
K_2O	1.20	.013	
Na_2O	7.11	.115	99×1
H_2O+ 112°	1.52	.093	
H_2O- 112°	0.16	.034	98×1
CO_2	1.49		
F, Cl	none		
	99.60		

The phosphate from the Utah locality occurs in minute, zoned, hexagonal prisms or plates in the porous parts of the "wardite" specimens. It is uniaxial negative, and the indices of refraction of the main, central part are: $\omega = 1.640$; $\epsilon = 1.633$; those of the outer zone are: $\omega = 1.600$; $\epsilon = 1.586$.

ANALYSES AND THEORETICAL COMPOSITIONS OF DEHRNITE

	1. Utah	2. Dehrn	3. $7CaO \cdot Na_2O \cdot 2P_2O_5 \cdot H_2O$	4. $7CaO \cdot \frac{1}{2}Na_2O \cdot \frac{1}{2}K_2O \cdot 2P_2O_5 \cdot H_2O$	5. $6CaO \cdot Na_2O \cdot 2P_2O_5 \cdot H_2O$	$6CaO \cdot \frac{1}{2}Na_2O \cdot \frac{1}{2}K_2O \cdot 2P_2O_5 \cdot H_2O$
Insol.		0.12				
Al_2O_3	1.0	tr.				
CaO	47.7	50.88	51.85	50.77	48.01	46.94
MgO	0.8					
Na_2O	4.4	7.11	8.20	4.02	8.86	4.33
K_2O	5.9	1.20		6.09		6.56
P_2O_5	35.7	37.12	37.57	36.79	40.56	39.66
H_2O+	1.9	1.52	2.38	2.33	2.57	2.51
H_2O-		0.16				
CO_2	3.3	1.49				
F, Cl	—	none				
Sum	100.7	99.60	100.0	100.0	100.0	100.0

The analysis of the Utah mineral by Shannon is given in Column 1, that of the mineral from Dehrn in Column 2, the theoretical composition ($7CaO \cdot Na_2O \cdot 2P_2O_5 \cdot H_2O$) in Column 3, and for the mineral with equal molecular proportions of soda and potash in Column 4. In Column 5 is given the theoretical composition for $6CaO \cdot Na_2O \cdot 2P_2O_5 \cdot H_2O$, and in Column 6 that for $6CaO \cdot \frac{1}{2}Na_2O \cdot \frac{1}{2}K_2O \cdot 2P_2O_5 \cdot H_2O$.

Both analyses agree closely with the formula $7CaO \cdot Na_2O \cdot 2P_2O_5 \cdot H_2O$ but they are not very different from the simpler formula $6CaO \cdot (Na, K)_2O \cdot 2P_2O_5 \cdot H_2O$. The Dehrn mineral is nearly a pure soda dehrnite while the Utah mineral has nearly as large a molecular proportion of K_2O as of Na_2O.

The formula $6CaO \cdot Na_2O \cdot 2P_2O_5 \cdot H_2O$ is similar to that assigned to merrillite ($6CaO \cdot 2Na_2O \cdot 2P_2O_5$) and as the optical properties of this mineral and merrillite are similar, the former seems to be a merrillite in which half the Na_2O is replaced by H_2O.

The optical properties of the hydrous phosphates from the two localities and of merrillite are given below for comparison. All are uniaxial and probably hexagonal.

	Dehrnite			Merrillite
	Dehrn	Utah		
		Border	Core	meteorite
ω	1.622	1.600	1.640	1.623
ϵ	1.614	1.586	1.633	1.620
Sp. gr.	3.04			3.10

Crandallite

The white fibrous aggregates, later than and attached to the dehrnite crusts are no doubt the mineral analyzed by Kosmann and called kalkwavellite. It seems to be identical with crandallite, described in 1917 by Loughlin and Schaller.[2] The kalkwavellite name is misleading as the mineral has neither chemical nor optical similarity to wavellite and the authors propose that the name crandallite be retained for the species.

Crandallite occurs in creamy-white rather brittle prismatic fibers that radiate from a center to form rosettes up to 10 millimeters across. It has a perfect cleavage parallel to the length. It

[2] Loughlin, G. F., and Schaller, W. T. Crandallite, a new Mineral, *Am. J. Sc.*, (4) **43**, 69–74, 1917.

is optically positive, has a moderate axial angle, and its indices of refraction are: $\alpha=1.59$, $\gamma=1.60$; X is parallel to the elongation and Z is sensibly perpendicular to the cleavage. The mineral is probably orthorhombic and the elongation may be taken as c and the cleavage as (100). The optical orientation then becomes $X=c$, $Z=a$.

The crandallite needles carry very numerous minute inclusions, many of them with cuneiform shape.

The crandallite is fusible at about 2 to 3 to a white enamel. On further heating the mineral swells away from the matrix and finally fuses to a white bead. It is difficultly soluble in nitric and hydrochloric acids, both before and after ignition.

An analysis of the spherulites that carried an abundant but uncertain quantity of inclusions of unknown character was made by Shannon and is shown in column 1, the ratios in column 2, the analysis by Kosmann in column 3, that of Schaller on the Utah mineral in column 4, and the theoretical composition of $CaO\cdot 2Al_2O_3\cdot P_2O_5\cdot 6H_2O$ in column 5.

ANALYSES AND RATIOS OF CRANDALLITE

	Shannon	Mol. ratios of 1		Kosmann[a]	Utah Crandallite	Theoretical
SiO_2	4.92					
Al_2O_3	37.52	410	104×2	35.65	38.71	40.03
P_2O_5	25.24	198	100×1	28.39	27.09	27.82
CaO	11.04	162	82×1	14.86	7.50	10.98
SrO					2.21	
MgO	0.24				0.94	
H_2O	17.90				18.86	21.17
H_2O-	1.00	1166	95×6	21.09	1.29	
CO_2	2.54				3.80	
SO_3					3.80	
	100.40			99.99	104.20	100.00

[a] Deducting 15 per cent of impurities.

The analyses agree rather closely with the formula $CaO\cdot 2Al_2O_3\cdot P_2O_5\cdot 6H_2O$. The mineral is too intimately admixed with a considerable amount of impurities to permit an entirely satisfactory interpretation of its composition or accurate determination of any of its properties.