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NOTES ON SOME BLACK HILLS PHOSPHATES

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A recent collecting trip to the Etta pegmatite, Keystone, South Dakota revealed many interesting phosphate pods, widely and abundantly distributed throughout the quarry dumps.

The parent material appears to be triphylite. Blocks of triphylite, more or less oxidized, are common on the dumps and the alteration products are mainly iron phosphates. Landes (1928) gave an account of the stages of mineralization of the Keystone pegmatites and assigned triphylite to the "magmatic" period of crystallization. Since triphylite appears to be ubiquitous throughout the dumps, it probably originated between the wall zone and the core of the pegmatite which represents by far the greatest volume of the body. Specifically, the Fe-Mn phosphates usually occur between the wall zone and the part of the intermediate zone in which amblygonite begins to appear (Page *et al.*, 1953).

One large nodule, markedly altered, displays many of the oxidation-alkali leaching-hydration products of the primary triphylite. The specimen consists of reddish-brown radiating blades of frondelite-rockbridgeite (identified from x-ray powder data), implanted upon mitridatite, which, in turn, rests upon pulverulent manganese and iron oxides. Several other unidentified phosphates occur as tiny crystals throughout the mass.

Fracture surfaces in the mitridatite display white coatings and tiny glistening colorless spherical radiating laths up to 1 mm across. Careful handpicking resulted in only 2 mg of material for investigation. A powder pattern of the material shows no relationship to any substance in the Powder Data File, 1962. Emission spectrography shows Mg, Ca, Al and P as major constituents, with minor Fe, Mn, Si. Two single crystals studied by means of the Weissenberg technique showed them to be identical with montgomeryite (Table I), a rare hydrated Ca, Al phosphate occurring in variscite nodules at Fairfield, Utah (Larsen, 1940). This apparently represents the first reported occurrence of montgomeryite from a pegmatite.

Fisher (1955) described the occurrence of alluaudite from the Green pegmatite, Pringle, South Dakota. Similar material is moderately abundant on the dumps of the Etta pegmatite, occurring as large green-

TABLE I. SINGLE CRYSTAL AND POWDER DATA OF FAIRFIELD  
AND KEYSTONE MONTGOMERYITE

Cu/Ni radiation, visual I/I<sub>0</sub>, powder camera diameter  
114.6 mm, spinel internal ( $a=8.0833 \text{ \AA}$ )

Fairfield Montgomeryite (Larsen, 1940)			Keystone Montgomeryite		
<i>a</i>	10.01 ± .02 Å		10.11 ± .05 Å		
<i>b</i>	24.15 ± .02		24.3 ± .1		
<i>c</i>	6.26 ± .05		6.31 ± .05		
$\beta$	91°28'		91°33'		
G	2.50		2.46 ± .06 (grad. tube)		
	C2/c		C2/c		
<i>d</i> <sub>hkl</sub> <sup>1</sup>	I/I <sub>0</sub>	hkl	<i>d</i> <sub>hkl</sub> <sup>2</sup>	I/I <sub>0</sub>	hkl
12.0	9	020	11.9	8	020
9.21	4	110	9.20	3	110
6.00	2	040			
5.52	3	021	5.52	3	021
5.10	10	200	5.12	10	200
4.65	5	220	4.64	4	220
4.35	4	150, 041			
3.85	2	240			
3.58	1	151			
3.37	2	—	3.31	1	—
3.241	3	170			
3.125	5	002	3.13	4	002
2.948	4	311	2.94	3	311
2.893	9	171	2.89	9	171
2.612	7	222	2.61	6	222
2.521	1				
2.457	2				
2.384	4				
2.305	2				
2.244	5		2.25	4	
2.166	4				
2.133	1				
2.086	2				
1.962	1				
1.916	2				

<sup>1</sup> About 50 reflections beyond this, each with I/I<sub>0</sub> less than 4.

<sup>2</sup> Missing lines due to extremely small amount of material examined.

ish black blocky masses up to six inches across embedded in quartz and mica. Orientation photographs of "cleavages" of alluaudite failed to reveal any crystallographic continuity.

Alluaudite also occurs abundantly at the Ross Lode, Custer, S. D., associated with triphylite as nodules and is probably more widespread in the South Dakota pegmatites than previously suspected. Much of the material from the Black Hills pegmatites called "barbosalite" by mineral collectors appears to be alluaudite.

Alluaudite from the Etta and Ross (Custer, S. D.) pegmatites contains cavities encrusted with small (up to 0.2 mm) stubby, wine-yellow, prismatic crystals. Single-crystal Weissenberg and powder data show them to be metastrengite with  $a = 5.30 \pm .05$ ,  $b = 9.78 \pm .05$ ,  $c = 8.68 \pm .05$  Å and  $\beta \sim 90^\circ$ .

The more oxidized phosphates, particularly heterosite-purpurite and ferri-sicklerite, are commonly rimmed with reddish-brown, bladed frondelite-rockbridgeite, and nodules consisting of the mineral alone are not uncommon. Greenish-black blades and plates are common in association with mitridatite and iron and manganese oxides.

A colorimetric manganese determination on the reddish-brown material indicates  $\text{MnO} > 7\%$ . The material is ferroan frondelite.

Several altered nodules were collected displaying spongy friable material associated with siderite and black frondelite-rockbridgeite. Two such specimens of yellow spongy material upon closer examination showed coatings of a bright yellow mineral not unlike xanthoxenite the writer has seen from the Palermo Quarry, N. Groton, N. H. The cavities are lined with striated laueite of a nut-brown color up to 1 mm across associated with golden sprays and spheroidal clusters of needles of strunzite. These minerals are probably more widespread than previously considered; they will probably be found wherever triphylite is hydrothermally altered.

Clusters of colorless to white tabular crystals commonly making up a major portion of the fillings of cavities in siderite were encountered. Powder and single crystal data established them as ludlamite and of morphology very similar to type material.

Triphylite, manganapatite, amblygonite, heterosite-purpurite and ferri-sicklerite have been reported previously from the Etta pegmatite (Page *et al.*, 1953; Landes, 1928). Mitridatite occurs as dull olive-green stains, coatings and cavity fillings. The strongest  $x$ -ray powder lines are: 8.67(10), 2.74(5), 2.18(5).

I wish to thank Dr. D. J. Fisher for the use of his  $x$ -ray powder file, Dr. Mary Mrose for identifying the dull olive green material as mitridatite, and Dr. Arthur Montgomery for supplying a fine type montgomeryite.

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## INVESTIGATIONS OF LANDESITE

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Landesite, a rare hydrated manganous-ferric phosphate, is an alteration product of reddingite which, in turn, is derived from the hydration and alkali-leaching of lithiophilite-triphylite at the Berry Quarry, Poland, Maine. The lithiophilite-triphylite material from this locality has a Mn:Fe ratio of approximately 3:1, and the alteration products represent the manganese side of the Mn-Fe series. Thus, reddingite and landesite also have Mn:Fe about 3:1.

The chemical analysis of landesite by Gonyer (1930) yielded the formula  $\text{Fe}^{3+}_6\text{Mn}^{2+}_2(\text{PO}_4)_{16}\cdot 27\text{H}_2\text{O}$ . There is a serious charge imbalance of 10 electrons, and somehow this remained unnoticed all these years. A quick glance suggests a very close relationship to reddingite,  $(\text{Mn}, \text{Fe})_3(\text{PO}_4)_2\cdot 3\text{H}_2\text{O}$  or even huréaulite,  $\text{H}_2\text{Mn}_5(\text{PO}_4)_4\cdot 4\text{H}_2\text{O}$ , except for the presence of ferric iron in landesite.

The writer, who is presently developing a general structural classification scheme for hydrated Fe-Mn phosphates, undertook single crystal studies of landesite in order to clarify its relationship to reddingite. A small ( $0.1\times 0.1\times 0.2$  mm) fragment, dirty yellowish-brown in color, kindly supplied by Dr. D. J. Fisher, was selected for this study. The single crystal data (Table I) as well as powder data (Table II) agree very well with reddingite but show that subtle differences exist.

The powder film data were obtained from the same type materials using Fe/Mn radiation, 114.6 mm camera diameter, and NaF as internal standard. Relative intensities are visual estimates.

The optical data of Berman and Gonyer (1930) clearly show that  $\text{Fe}^{3+}$  is an integral part of the landesite formula. The best cleavage in landesite is {010} and was indexed to conform with space group *Pbcn*. The vibration normal to {010} has the index 1.735 for landesite in