STUDIES OF URANIUM MINERALS (XIV): RENARDITE*†

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ABSTRACT

A new chemical analysis of renardite from Katanga has confirmed the formula $Pb(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O$. *X*-ray single-crystal study established the unit cell as orthorhombic, with the dimensions *a* 16.01 Å, *b* 17.5, *c* 13.7. Renardite is isostructural with both dewindtite (*a* 16.07 Å, *b* 17.50, *c* 13.62) and phosphuranylite. The chemical composition of dwindtite, however, cannot be reconciled with that of renardite on this basis. Phosphuranylite probably is the calcium analogue of renardite, with the formula $Ca(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O$.

RENARDITE

Renardite was originally described from Katanga, Belgian Congo, by Schoep (1928, 1930) and it has since been identified at several localities in France by Branche *et al.* (1951). A new analysis of Katanga material cited in line 2 of Table 1, confirms the composition

$$Pb(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O$$

earlier derived by Schoep and by Branche *et al.*

Several minute crystals were examined by *x*-ray rotation and Weissenberg methods in copper radiation. The orthorhombic unit cell dimensions obtained are cited in Table 2. The specific gravity, given as slightly more than 4 by Schoep and as 4.35 by Branche *et al.*, indicates that the unit cell contents are $6[Pb(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O]$. The calculated specific gravity then is 4.34. Crystals of renardite are tablets or laths flattened on {100} with {010} and {001} or {010} and {101} as the only other forms. The orientation and partial morphological unit of Schoep corresponds to the *x*-ray unit. The average measured ρ value of {101} is 39° 47′ ±2° (Schoep), 40° 07′ ±1° (present study), and the ρ value calculated from the *x*-ray cell is ~40½°. The *x*-ray powder spacing data are given in Table 3.

Optically the material described here has slightly higher indices of refraction than that described in earlier reports (Table 4). Some of our crystals had lower indices (as low as $nX = 1.704$) and a few crystals varied in index along the elongation or showed concentric zones with the outer parts having the highest indices. The differences perhaps are due

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TABLE 1. CHEMICAL ANALYSES OF RENARDITE

	BaO	PbO	UO_3	P_2O_5	H_2O+	H_2O-	Rem.	Total
1.		13.16	68.92	8.37	9.55			100.00
2.	0.91	12.95	69.08	9.17	3.11	4.78		100.00
3.		12.26	64.82	8.15	3.77	4.97	6.53	100.50
4.		12.3	67.6	8.0	8.7		3.2	99.8

1. Theoretical weight percentages of $Pb(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O$.

2. Renardite from Katanga, Belgian Congo. Microanalysis by F. Cuttitta. Recalculated to 100 after deducting Al_2O_3 0.31, Fe_2O_3 0.62, SiO_2 1.54 from original sum of 100.21. Spectrographic analysis also showed the presence of Ca, Mg, Cu, Mn, Ni, Y, and V.

3. Renardite from Katanga, Belgian Congo (Schoep, 1928). Rem. includes $(Fe, Al)_2O_3$ 3.68, MoO_3 0.74, and quartz 2.11.

4. Renardite from Grury, France (Branche, *et al.*, 1951). Rem. is CaO 0.9, Al_2O_3 0.7, Fe_2O_3 0.9, SiO_2 0.7.

TABLE 2. UNIT CELL DIMENSIONS OF RENARDITE, DEWINDTITE, AND PHOSPHURANYLITE

	(Present Study)		(Hogarth & Nuffield, 1953)	
	Renardite	Dewindtite	Dewindtite	Phosphuranylite
a_0	16.01 Å	16.07 Å	16.00 Å	15.85 Å
b_0	17.5	17.50	17.62	17.42
c_0	13.7	13.62	13.66	13.76
Space group				Bmmb

TABLE 3. *X*-RAY POWDER SPACING DATA FOR RENARDITE

(*Copper radiation, nickel filter, d in* Å)

d	*I*	*d*	*I*	*d*	*I*
10.25	5	3.40	4	2.00	1
8.86	1	3.11	9	1.896	3
7.95	10	2.88	8	1.851	1
6.38	1	2.72	1	1.780	1
5.86	6	2.59	1	1.718	2
5.53	1	2.44	1	1.669	1
4.97	1	2.22	2	1.594	1
4.75	1	2.16	2	1.540	2
4.43	6	2.09	2	1.512	1
3.96	7	2.05	2	1.438	1

TABLE 4. OPTICAL PROPERTIES OF RENARDITE

	Orientation		n	Pleochroism
Renardite from Katanga (Schoep, 1928)	X	a	1.715	colorless
	Y	c	1.736	yellow
	Z	b	1.739	yellow
	$r>v$			
Renardite from Katanga (present study)	X	a	1.721	colorless
	Y	c	1.741	yellow
	Z	b	1.745	yellow
	$r>v$			
	$2V\sim45°$			
Renardite from France (Branche *et al.*, 1951)	X	a	1.716	colorless
	Y	c	1.736	yellow
	Z	b	1.740	yellow

to a varying substitution of Ba or Ca for Pb. Phosphuranylite, presumably the Ca analogue of renardite, shows a similar variation in the indices of refraction due to the substitution of Pb for Ca.

RELATION OF RENARDITE TO DEWINDTITE AND PHOSPHURANYLITE

The x-ray powder pattern of renardite is virtually identical with those of dewindtite and phosphuranylite, as are the unit cell dimensions (Table 2), and these three minerals must be presumed to be isostructural. The isostructural relation of dewindtite and phosphuranylite was earlier indicated by Frondel (1950) and by Hogarth & Nuffield (1953). The unit cell dimensions reported by the latter authors for dewindtite were here confirmed (Table 2) on an unanalyzed specimen that answered the description of Schoep (1930).

Renardite, dewindtite, and phosphuranylite should have analogous chemical formulas if they are isostructural, but the formulas reported for these minerals cannot be reconciled on this basis. The principal difficulty is with dewindtite. Dewindtite and renardite are both hydrated lead uranyl phosphates, and as their x-ray powder and single-crystal photographs are the same, they may be presumed to be identical. The four chemical analyses reported of dewindtite, however, are reasonably consistent and are near to the formulas $Pb_2(UO_2)_5(PO_4)_4(OH)_4 \cdot 10H_2O$ (Schoep) or $Pb_3(UO_2)_6(PO_4)_4(OH)_6 \cdot 9H_2O$ (Hogarth & Nuffield)—quite different from the formula of renardite, $Pb(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O$. Further, the specific gravity of dewindtite is 5.03 as compared to 4.35 for renardite; and the indices of refraction of the two minerals are dif-

ferent. Possibly the x-ray and other measurements reported for dewindtite were not all made on the same mineral.

Our knowledge of phosphuranylite is scant and contributes little to the general problem. The three partial analyses reported of this mineral show that it is a hydrated calcium uranyl phosphate, but the ratios of the analyses are widely divergent. One of the analyses (No. 2 in Table 4 of Frondel, 1950), however, has virtually the same ratios as renardite, with $CaO:UO_3:P_2O_5 = 1:4.1:1.2$. The formula of phosphuranylite probably is $Ca(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O$ analogous to renardite, rather than $Ca_3(UO_2)_6(PO_4)_4(OH)_6 \cdot 9H_2O$ analogous to dewindtite. New analyses of type dewindtite and of phosphuranylite are desirable.

Study of authentic specimens of dumontite, $Pb_2(UO_2)_3(PO_4)_2(OH)_4 \cdot 3H_2O$, and of parsonsite, $Pb_2(UO_2)(PO_4)_2 \cdot 2H_2O$, has shown that these minerals are not related to the minerals at hand.

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