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NOTES ON WESTERN MINERAL OCCURRENCES¹E. WM. HEINRICH, *The University of Michigan,
Ann Arbor, Michigan*5. *Euxenite from Sappington, Montana*

The Sappington pegmatites, described by Jovik (1942), Cooke and Perry (1945) and Heinrich (1948, 1949), are about 3 miles south-southeast of the Sappington railroad station and one mile east of Montana Highway No. 1, in the northeastern corner of Madison County, Montana. They have been intruded into Prebeltian metamorphic rocks (possibly part of the Cherry Creek Group) near their contact with the unconformably overlying Cambrian Flathead Formation. The three largest of the swarm of five major pegmatites (plus five other very small pods) were prospected for muscovite during World War II. About 10 tons of scrap-quality mica was produced from the westernmost and largest of the northeast-trending group, which extends over an area of 1000 × 350 feet. From the main pegmatite there also has been obtained a total of several pounds of a highly radioactive, metamict mineral previously identified as fergusonite (Cooke and Perry, 1945) but now known to be a highly altered and chemically variable euxenite.

The pegmatite, a bulbous dike, intrudes hornblende gneiss whose foliation strikes east-west and dips 45–75° N. The dike itself, which trends N. 75° E. and dips 30–50° NW., is 100 feet long and as much as 110 feet thick. It is a classic example of the development of markedly asymmetric zonal structure in a pegmatite of moderate to low dip:

Hanging-wall hornblende gneiss

1. (Wall zone) Feldspathic pegmatite, poorly exposed, not more than 6–8 inches thick.
2. (Core) Massive white quartz regularly fractured, as much as 70 feet thick.
3. (Core-margin replacement pod) Muscovite-albite rock with accessory euxenite and relict microcline and quartz.
4. (Wall zone) Microcline-quartz with accessory sodic plagioclase, muscovite, magnetite and schorl, as much as 35 feet thick.
5. (Contact replacement unit) Fine-grained highly vuggy muscovite-quartz-albite pegmatite with remnants of microcline.

Footwall hornblende gneiss

Euxenite occurs as irregular pods as much as 3 inches long, replacing albite and microcline which have been stained dark red. In many places the replacement has been controlled by the feldspar cleavages. Mega-

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scopically the euxenite is olive to dark brown with a resinous luster. Its optical properties are:

Isotropic, $n=1.83-1.84$, red brown to resin brown. In reflected light, medium gray with irregular patches of steel gray. Numerous veinlets of lower reflectivity crisscross the aggregate (Fig. 1).

Chemical analyses of the mineral are presented in Table 1. X-ray data are listed in Table 2; $G=3.95-3.96$.

Autoradiographic studies demonstrate the extreme variation in radioactivity (Fig. 1). It is clear that analysis 1 (Table 1) was made on quartz-contaminated material, but analyses 4 and 5 were made on carefully selected material. Despite this difference and the major difference in analytical techniques between 4 and 5, some unresolved discrepancies

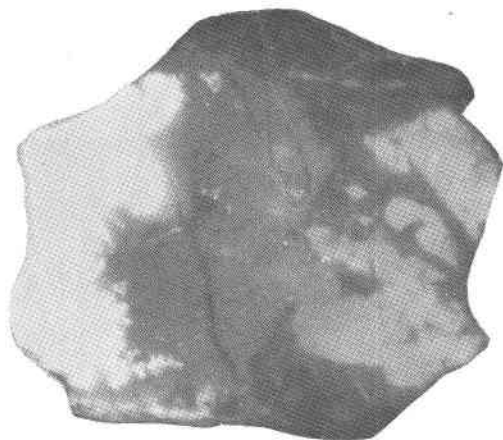


FIG. 1. Autoradiograph of polished section of euxenite, Sappington, Montana. 2X.

remain. These can only be ascribed to the marked internal variation of the mineral as demonstrated in polished sections and in autoradiographs. In part this variation appears to have accompanied partial or complete metamictization,¹ but some of it may have originated during crystallization, since the variation in radioactivity is extreme (Fig. 1).

Strongly developed inhomogeneity in various metamict species (*e.g.* euxenite, samarskite, fergusonite, allanite) is much more common than is apparently realized. The variability of some allanites is seen readily in thin section, but polished section studies are necessary to perceive the variations in euxenite and samarskite.

¹ George (1949, p. 187) even reports uranophane as an alteration product.

TABLE 1. ANALYSES OF EUXENITE, SAPPINGTON, MONTANA

	1	2	3	4	5
CaO	1.85	2.61		3.08	
BaO				0.55	
RE ₂ O ₃	8.55	12.06		9.27	7.1
U ₃ O ₈	7.20	10.14	10.04 UO ₃	14.42	12.7
ThO ₂				1.77	1.4
Fe ₂ O ₃	11.15	16.27		6.00	8.0
Al ₂ O ₃	2.40			2.54	
SiO ₂	25.00% (est.)			4.05	
TiO ₂	1.17	1.65			
WO ₃				4.39	3.2
ZrO ₂	0.42	0.59			
Nb ₂ O ₅	36.03	50.74		39.76	
Ta ₂ O ₅	4.25	5.94		2.69	4.9
Total H ₂ O (Penfield)				12.25	
As ₂ O ₃					0.3
Total	98.02	100.00		100.00	

1. Analysis by Union Carbon and Carbide Lab., Niagara Falls, N. Y. (George, 1949).
2. Recalculation of 1 after subtraction of SiO₂ and Al₂O₃ as impurities (George, 1949).
3. George, 1949.
4. Analysis by Harry Levine, U. S. Geol. Survey, by wet chemical methods. No UO₂ present.
5. Analysis by R. A. Borup, by x-ray fluorescence methods.

Composition of the RE (R. A. Borup)

Y ₂ O ₃	3.6
La ₂ O ₃	n d, <0.5% total
Ce ₂ O ₃	n d, <0.5% total
Nd ₂ O ₃	0.3
Sm ₂ O ₃	0.6
Gd ₂ O ₃	0.9
Dy ₂ O ₃	1.1
Er ₂ O ₃	0.6
	7.1

Minor and trace elements (Helen W. Worthing)

0.1x%	Dy, Gd, Er, Nb, Ba, Pb
0.01x%	Ce, Sm, Yb, Lu, Ho, La, Tb, Tm, Se, Ti, Zr, Mn, B, Sn, Sr
0.001x%	Ni, V, Mg, Ca, Be, Cr

TABLE 2. X-RAY POWDER DIFFRACTION DATA FOR EUXENITE FROM MONTANA NORELCO 11.46 CM POWDER CAMERA. $\text{Cu K}\alpha$ RADIATION, Ni FILTER. $\lambda = 1.54 \text{ \AA}$

Euxenite; (Sappington, Mont.) Heated in air at 1050° C. for 1 hr. in electric muffle furnace.		Euxenite; Micanite, Colo. Sample heated in air at 1050° C. for 1 hr.		Euxenite; Harvard No. 84648 Tangen, Norway. Heated in air at 1050° C. for 1 hr.	
d(Å)	I _o	d(Å)	I _o	d(Å)	I _o
4.17	vvw				
3.98	w				
3.57	vw	3.63	w	3.63	w
		3.34	vvw	3.34	vvw
		3.25	vw		
3.16	m				
3.10	w-m				
2.98	str	2.96	str	2.98	str
2.90	m	2.93	m	2.94	m
2.74	vw	2.76	w	2.77	w
		2.61	vw		
2.58	m	2.58	vw	2.58	w
		2.54	vw	2.54	w
		2.51	vvw		
2.48	w	2.44	vvw	2.44	vw
		2.41	vvw	2.42	vw
		2.30	vvw	2.30	vw
		2.20	vvw	2.20	vw
		2.18	vvw	2.18	vvw
		2.10	vw	2.11	w
		1.96	vvw	1.96(br)	m
		1.93	vw	1.93	vw
1.905	w(br)	1.89	m	1.89	w
1.86	vw	1.85	w		
1.83	str	1.82(br)	m	1.81	m
		1.80	m	1.80	m
				1.77	m
1.73	vvw	1.72(br)	m	1.72(br)	m
1.70	vvw				
1.69	vvw				
1.66	vw	1.65	m-w	1.64	m
1.625	vvw	1.62(br)	m-w	1.61	vvw
		1.60	vvw	1.58	vvw
1.56	str	1.54(br)	m-w	1.56	w
		1.53	w	1.54	m-w
1.51	w	1.51	w		
1.49	w	1.495	vw	1.49(br)	m-w
1.47	vw	1.47(br)	m-w	1.47	vvw

TABLE 2—(continued)

Euxenite; (Sappington, Mont.) Heated in air at 1050° C. for 1 hr. in electric muffle furnace. Euxenite; Micanite, Colo. Sample heated in air at 1050° C. for 1 hr. Euxenite; Harvard No. 84648 Tangen, Norway. Heated in air at 1050° C. for 1 hr.

d(Å)	Io	d(Å)	Io	d(Å)	Io
1.455	vvw	1.45	m	1.46	vw
1.43	w-m	1.44	vvw	1.435	w
1.38	vvw	plus others		plus others	
1.35	w				
1.29	w				
1.24	vvw				
1.23	vvw				
1.20	w				
1.19	m str				
1.16	m				
1.11	vvw				
1.08	vvw				
1.06	m(br)				
1.00	m				
0.917	w-m(br)				
0.893	vvw				
0.887	m				
0.865	w-m				
0.835	vvw				
0.820	w				
0.806	w				
0.792	w(br)				
0.783	w(br)				

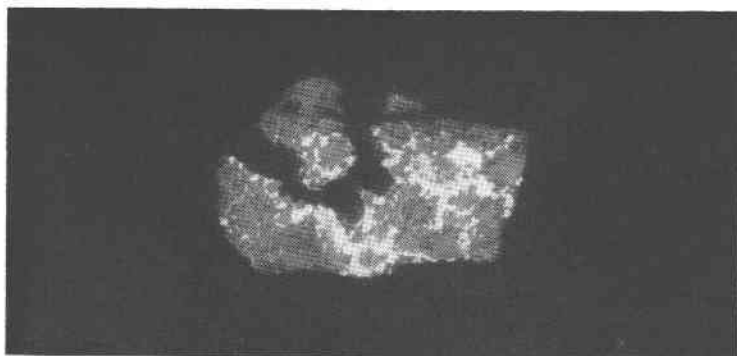


FIG. 2. Autoradiograph of polished section of euxenite, Cotopaxi, Colorado. 2X.



FIG. 3. Autoradiograph of polished section of euxenite, Cotopaxi, Colorado. 2X. Figs. 2 and 3 are of specimens from the same pegmatite. Note extreme variation in radioactivity of specimen of Fig. 2 and moderate variation in that of Fig. 3 but with a totally different distribution pattern.

Examples of some highly variable euxenites and samarskites are shown in Figs. 2 and 3. The different radioactively variable parts all can be identified as samarskites or euxenites by means of *x*-ray diffraction methods, following recrystallization by ignition. Clearly such heterogeneous material requires unusually careful selection before chemical analysis. It is very doubtful that any such specimens would give worthy radioactive age determination results.

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