COLUMBIUM AND CERIUM MINERALS IN MONTANA

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Abstract

Rare minerals of the fergusonite and allanite groups, containing yttrium, scandium, columbium and cerium, occur in many places of southwestern Montana. They are found in granite pegmatite, in part pre-Cambrian, in part late Cretaceous or early Tertiary age. Some material is radioactive. As yet the occurrences have not been proven to be of commercial importance.

Geologic and Geographic Occurrence

Widely scattered occurrence of rare minerals containing yttrium, scandium, columbium and cerium in southwestern Montana has recently been recognized, and three new varieties have been identified. Some of the material is radioactive. Little or no attention has been paid to these columbium- and cerium-bearing minerals during the long mining history of Montana, mainly because they occur in coarse-grained granite pegmatite dikes not mined for ores, and also possibly because they superficially resemble black tourmaline which is rather plentiful in pegmatites in this region. Although no commercial significance is attached to these discoveries at present, they do open up a large field for investigation, since the mineral content of these pegmatites has not been studied critically.

Hundreds of massive pegmatite dikes are known to be present in this region, which is from one to two hundred miles across. They show as large bold outcrops, called "quartz blowouts" by prospectors, and from the highways they appear as conspicuous white blotches on an otherwise gray somber landscape. These bodies are typically lenticular, commonly 10 to 20 feet in width, and 50 to 300 feet in length. Two or three lens-like outcrops may be linearly arranged along a distance of 1000 yards or more, suggesting a hidden continuity.

Some of the dikes appear to be of pre-Cambrian age, because of their intimate association with a series of Archean or Huronian schists and gneisses, their lack of association with Cambrian strata, and because of the presence of boulders and fragments of pegmatitic material similar to that of the dikes in a late Proterozoic (Belt series) conglomerate which lies unconformably above the metamorphic complex. Other dikes of this type are definitely associated with the late Cretaceous granitic intrusives prevalent in southwestern Montana. Geologic age of the dikes is particularly significant since it is noted that the two observed occur-

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rences of the columbium mineral are in areas of pre-Cambrian rocks, and that those of the cerium minerals are in areas of late granites.

The material examined comes from five widely separated localities near Sappington, Laurin, Boulder, Homestake and Janney; the first two in pre-Cambrian areas, the last three in areas of late granitic rocks. The occurrences are somewhat complicated in that the Laurin, Boulder and Homestake materials were found in placers and not in place, although the presence of nearby pegmatites is suggestive of their ultimate origin. The widespread distribution of these occurrences leads the writers to believe that careful search would lead to numerous localities where these minerals might be found in pegmatite dikes.

The so-called "Sappington Mica Mine," about eight miles south of the small station by that name, is in a typical granite-pegmatite which lies parallel to the gneissic structure in a complex mass of hornblende and biotite gneiss. Perhaps 95 per cent of the pegmatite is feldspar and quartz. Orthoclase is dominant, but some oligoclase may be present. Black tourmaline occurs sparingly. The quartz is generally milky, or snow-white, but transparent and rose quartz is present, and it commonly shows a rudimentary cleavage. The dike is about 25 feet wide at its thickest place. Through the central part of the dike is a zone 5 to 10 feet thick in which "books" of muscovite mica are plentiful, and the columbium-bearing mineral occurs in scattered grains and in lumps up to two inches in diameter in the muscovite zone. The muscovite amounts to less than 1 per cent of the pegmatite.

The material from near Laurin appears to be fairly plentiful and was discovered in gravel of a bench-placer being worked for gold. The placer is about four miles east of Laurin on California gulch not far from its head. The entire area is underlain by the basal complex of schist and gneiss, locally cut by quartzitic pegmatite dikes.

The material from near Boulder also comes from gold placers about ten miles south of the townsite. Only two pieces about one inch in diameter were obtained, but it is reported that more is present. The placer lies on the eastern edge of the Boulder batholith (late Cretaceous quartz monzonite) which is locally cut by numerous aplite dikes and occasional pegmatite bodies.

The material from near Homestake comes from placers in a creek draining into Lake Delmoe which is six miles northeast of the railroad station. There is reported to be about one pound of the mineral per cubic yard of gravel.

The fifth sample comes from a pegmatite body near Janney, a small station on the Milwaukee railroad about ten miles south of Butte. The pegmatite is essentially quartz with some feldspar, and the cerium-bearing mineral occurs as isolated lumps in the rock mass.

Only where the pegmatite has been opened by pits were the two occurrences in situ of these rare minerals observed. They are not recognizable in the weathered outcrops, which show only quartz and feldspar; apparently they decompose by weathering to a rusty mass of limonite. It is probably this condition which has resulted in their oversight through the long years of prospecting in Montana, because pegmatite dikes in Montana are commonly considered barren of minerals of ready commercial value. If Montana pegmatites were worked on a large scale for their content of orthoclase or muscovite, it is probable that much more of this type of material would come to attention.

Mineral Characteristics

The mineral from near Sappington is massive with a conchoidal fracture, dark brown in color, and resinous. Carefully concentrated material has a specific gravity of 3.95. The hardness is slightly over 5, and it is infusible in the blow-pipe flame. The mineral is radioactive.

The Laurin mineral is massive, jet black, and has a conchoidal fracture. The specific gravity is 5.6, the hardness is 6, and it is infusible in the blowpipe flame. This mineral is also radioactive, but less so than the Sappington mineral.

The material from south of Boulder is massive, jet black, with uneven fracture; specific gravity is 3.9, or slightly over, and hardness is slightly over 5. This mineral fuses easily in the blowpipe flame with intumescence yielding a black slag. The mineral is not radioactive.

The mineral from Homestake and Janney is very similar to that last mentioned, although the hardness and specific gravity are slightly different.

Optical Properties

All five minerals were examined by the immersion method without the benefit of a universal stage. The refractive index of the Laurin mineral was measured in a sulfur-selenium melt. Indices of the other minerals were obtained in media prepared by mixing phosphorus, sulfur and methylene iodide.[1] Indices of these last mentioned mixtures were measured directly with a Fisher refractometer,[2] reading to $n = 1.900$.

[1] West, C. D., Immersion liquids of high refractive index: *Am. Mineral.*, **21,** 245–249 (1936).

[2] Fisher Scientific Company, Pittsburgh, Penna.

The optical properties of all four minerals are tabulated below.

Sappington	*Laurin*	*Boulder*	*Janney*
Lemon-yellow	Dark brown	Light brown	Light brown
Isotropic	Isotropic	Biaxial (−)	Biaxial (−)
$n=1.830$ to 1.840	$n=2.120^{\pm}.005$	$\alpha=1.769$	$\alpha=1.781$
		$\beta=1.795$	$\beta=1.802$
		$\gamma=1.805$	$\gamma=1.810$
		$\gamma-\alpha=0.036$	$\gamma-\alpha=0.029$
		$2V=60°$	$2V=60°$
		Dispersion weak	$r>v$, strong
		X, light brown	X, light straw-brown
		Y, brown	Y, brown
		Z, very dark brown, almost opaque	Z, very dark red-brown

The optical properties of the mineral from near Homestake are practically the same as those of the Janney mineral.

X-ray Analysis

The Sappington material has been studied at Harvard University where Dr. Clifford Frondel has made *x*-ray powder photographs of the ignited mineral. He decided that it showed similarity in pattern and line intensity to material from Petaca, New Mexico, and Ytterby, Sweden; and that all three specimens are fergusonite. Differences in pattern and line intensity are attributed to differences in chemical composition, possibly to different tantalum-columbium ratios which have not been determined for all of the material. It is not definitely known how this ratio affects properties in this mineral.

Chemical Composition

Quantitative chemical analyses of these minerals are at present difficult to obtain because of the rare elements present. Comparative spectrographic analyses show that columbium is the major element in the Sappington and Laurin minerals. The other three minerals are more complex, at least with respect to the major elements.

Spectrographic analyses of the five samples were made on a five foot Wadsworth grating spectrograph. By comparison of individual spectra, and of these with the spectra of standard samples, the following semiquantitative results were obtained. The nomenclature corresponds approximately to that of Merriam and Kennard.[3]

Elements listed under "Trace" are in the order of their atomic num-

[3] Merriam, R., and Kennard, T. G., An unidentified mineral in the quartz basalt of Lassen Volcanic National Park, California: *Am. Mineral.*, **28**, 602–604 (1943).

bers. The other entries contain the elements in the approximate order of their abundance. Other elements having sensitive arc lines were searched for, but were not found.

Qualitative chemical tests show that considerable amounts of phosphorus are present in the Boulder, Homestake and Janney minerals, but absent from the other two.

	Sappington	*Laurin*	*Boulder*	*Janney and Homestake*
Large amount	Cb	Cb	Ce	Ce
	Y	Sc	Ca	Ca
	Sc	Sm	Al	Al
	Fe	Y	Ti	Ti
			Si	Si
Small amount	Ti	Fe	Fe	Fe
	Ba	Ca	Mn	Mn
	Si	Ti	Nd	Nd
	Ca	Sn		
	Ta	Gd		
	U	Dy		
	Sm			
	Yb			
Very small amount	Al	Ba	Mg	Mg
	Pb	Pb		
	Dy	Mn		
	Nd	U		
	Eu	Nd		
	Gd	Er		
	Er	Yb		
	Th	Lu		
Trace	Mg	Mg	V	V
	V	Al	Sr	Cu
	Cr	Si	Y	Sr
	Mn	V	Cb	Y
	Co	Cu	Ag	Cb
	Cu	Sr	Ba	Ag
	Sr	Ag	Sm	Ba
	Ag	La	Gd	Sm
	Ce	Ce	Dy	Gd
	Ho	Ho	Ho	Dy
	Lu	Ta	Er	Ho
		Th	Yb	Er
			Lu	Yb
			Pb	Lu
				Pb

Conclusions

The rare earth minerals herein described are members of two different isomorphous groups, and are variants within each group not identical with described species. The columbium-bearing mineral belongs to the fergusonite group, and the cerium-bearing mineral belongs to the allanite group.

The specific gravity of the Sappington mineral (3.95) is markedly less than that of commonly described fergusonite (5.38 for fergusonite containing 54.07 Cb_2O_5 and no tantalum.[4] This reference states that specific gravity decreases "markedly with hydration"). The index of refraction (1.84) is also notably less than those given by Larsen[5] (2.115 to 2.19). It is possible that part of this discrepancy is due to the relatively high scandium content as indicated by the spectrographic analyses. Scandium is not reported in the 13 analyses given by Dana (seventh edition), and necessarily must have been very low, because each of the analyses totals to close to 100 per cent, or else this element was included with other elements. The Laurin mineral conforms to the fergusonite group in all determined properties except for its scandium content.

The minerals from near Boulder, Homestake, and Janney are similar in physical properties and almost identical in composition. All are believed to be members of the allanite group.

[4] Palache, C., Berman, H., and Frondel, C.: *Dana's System of Mineralogy*, seventh ed., vol. **1**, p. 760 (1944).

[5] Larsen, E. S., and Berman, H., The Microscopic Determination of the Non-opaque Minerals: *U.S.G.S. Bull.* **848**, Sec. Ed., pp. 62–64 (1934).