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NOTES ON THE MINERALOGY OF AN YTTRIUM-BEARING PEGMATITE BODY NEAR LAKE GEORGE, PARK COUNTY, COLORADO*

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INTRODUCTION

During a visit by Edwin Over to the Lake George pegmatite area in 1928 he discovered gadolinite, an yttrium-rich beryllium iron silicate, and collected some good crystals from a small outcrop. Inspired by a new demand for gadolinite, Over returned to the same locality in 1956. He found, as a result of road building and feldspar mining, the exposed face and waste dumps of a large vertical pegmatite body. Lumps of massive fluorite—some that weighed 600 pounds—were common in the mine dumps. Examination of these fluorite bodies revealed inclusions of several minerals found to be yttrium bearing.

The description of the fluorite masses and their associated feldspar pegmatite is based on the observations of Edwin Over, who provided the material for this study. The optical data and the mineral identifications are by Jewell J. Glass, and the spectrographic analyses were made by Harry J. Rose, Jr.

LOCALITY

The yttrium-bearing pegmatite body is called the Teller pegmatite Lode Claim. It is in the Lake George mining district, Park County, Colorado; NE $\frac{1}{4}$, sec. 31, T. 12 S., R. 71 W. The mine workings are 0.5 mile south of Lake George on the Eleven Mile Canyon Road, and only a few hundred feet east from the South Platte river. The original workings in this pegmatite were for feldspar in 1940.

OCCURRENCE

The yttrium-bearing deposits, apparently hydrothermal replacement of feldspar, occur as lenses of fluorite mostly in the north portion of the Teller pegmatite body which consists of a large mass of pink microcline feldspar. This pegmatite body is in an area of massive Pikes Peak granite that rises to an altitude of 8,350 feet and lies about 20 miles air line west northwest of Pikes Peak and about 4 miles nearly due west of Crystal Peak. The age of the pegmatite body is not known to the writers, but the host rock is Pikes Peak granite, whose determined age (Precambrian) is a billion years (Holmes, 1931).

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Mineralogy

The most abundant yttrium-bearing minerals that occur in the fluorite (some of which is itself rich in yttrium) are allanite, gadolinite, monazite, and xenotime. An unidentified, high-yttrium, cerium-earth carbonate occurs in small amounts and is being studied in detail.

Spectrographic analyses show all the lanthanides (atomic nos. 57–71) and yttrium (atomic no. 39) to be present in these minerals with the exception of promethium (atomic no. 61). The lanthanides of even atomic number (Ce, Nd, Sm, Gd, Dy, Er, Yb) are more abundant than their neighbors of odd atomic number (La, Pr, Eu, Tb, Ho, Tm, Lu) as shown in Table 1. This observation has been noted by previous investigators and is known as the rule of Oddo and Harkins (Rankama and Sahama, (1950).

Allanite (Orthite).—Allanite in hand specimen is glossy black, massive, in irregular lumps as large as a walnut. The allanite is brittle and has no distinct cleavage. Under the microscope the mineral is metamict. The color is smoky grayish-green. The index of refraction is $n=1.70$. Along the contact of the allanite with microcline, the allanite border is yellowish red and is partly anisotropic. The spectrographic analysis of allanite is given in Table 1.

Fluorite.—The fluorite is massive and varies from pink, pale green, and cream to deep purple. The pink and cream colored fluorite is heavy with inclusions of yttrium-bearing minerals, especially xenotime and gadolinite. The index of refraction for the fluorite ranges from 1.437 to 1.450—that is, most of this material is yttrian fluorite or yttrofluorite.

Gadolinite.—Gadolinite, an iron-beryllium-yttrium silicate, occurs as crystals as much as $1\frac{1}{2}$ inches long embedded in the fluorite. The gadolinite is greenish black; it is brittle and breaks with a conchoidal fracture. The mineral is optically positive; 2V is near 90°. The indices of refraction are: $\alpha=1.800$, $\beta=1.808$, $\gamma=1.818$. Some grains are metamict, and have lower, variable indices.

Molybdenite.—Molybdenite, a sulfide of molybdenum, occurs rarely as small foliated masses about 1 cm. across in vugs in some of the purple fluorite.

Monazite.—A reddish brown variety of monazite, cerium phosphate, that contains yttrium, is commonly associated with brick-red, earthy inclusions in the fluorite. It is assumed that these red inclusions are iron-stained residue from the alteration of gadolinite. The monazite grains are small, none of them is more than 1 mm. across. The mineral is optically biaxial positive, $2V=10°$. The indices of refraction are: $\alpha=1.786$, $\beta=1.787$, $\gamma=1.840$.

Xenotime.—Xenotime, yttrium phosphate, is disseminated unevenly but consistently through most of the fluorite, and also occurs as aggregates in allanite. No crystals have been noted but some of the grains are elongated. A few grains in one sample are 1 mm. long and about one third as wide. Most of the grains are colorless, but some are pale pink. Xenotime is uniaxial positive, $\omega=1.717$ and $\epsilon=1.816$. The spectrographic analysis of xenotime is given in Table 1.

The fine-grained, high-index carbonate in some samples may well be bastnaesite.

Association of fluorite and rare earth minerals in pegmatite bodies has been discussed by Heinrich (1948). The Teller pegmatite illustrates a reverse condition of the association common in pegmatites: the fluorite here is host to a suite of rare earth minerals.

A complex problem in geochemistry is presented here. Data are not yet sufficient for a

Table 1. Semiquantitative Spectrographic Analyses for Minor Elements in 16 Samples of Minerals from Yttrium-Bearing Pegmatite Body near Lake George, Park County, Colorado

Analyst: Harry J. Rose, Jr.

Sample	Description	0 in unit column means element not detected									
		Si	*Al*	*Be*	*P*	*F**	*Ca*	*Fe*	*Y*	*Lu*	*Yb*
SpC 1	Gadolinite, massive, impure	x.	.0x	x.	0	—	.x	x.	x0.	.x	x.
SpC 2	Total ore-bearing rock	.x	.x	.0x	0	x0.	x0.	.x	x0.	.x	x.
SpC 3	Pink fluorite with xenotime	.0x	.0x	.00x	.x	x0.	x0.	.0x	x0.	.x	x.
SpC 4	Pale green fluorite	.0x	.0x	.00x	0	x0.	x0.	.0x	x.	.0x	.x
SpC 5	Purple fluorite partly pure	.0x	.x	.000x	0	x0.	x0.	.0x	.x	.00x	.0x
SpC 6	Purple fluorite ore	.x	x.	.00x	0	x0.	x0.	x.	x0.	.0x	x.
ReC 1	Gadolinite crystal	x.	.x	x.	0	—	.x	x.	x0.	.x	x.
ReC 2	Glossy black allanite	x.	x.	.00x	0	—	.x	x.	.x	0	.0x
ReC 3	Xenotime inclusions from allanite	.x	.x	.00x	x0	—	.x	.x	x0.	.x	x.
ReC 4	Cream fluorite partly pure	.0x	.0x	.00x	0	x0.	x0.	.x	x0.	.x	x.
ReC 5	Inclusions from ReC 4	.x	.x	.00x	0	—	x0.	x.	x0.	.x	x.
ReC 6	Fluorite host of molybdenite	.x	x.	.00x	0	x0.	x0.	x.	x0.	.x	x.
ReC 7	Altered gadolinite	.x	x.	x.	0	—	.x	x.	x0.	.0x	x.
ReC 8	Red alteration products	.x	x.	x.	0	—	.x	x.	x.	.x	x.
ReC 9	Brick-red powder, alteration	.x	.x	.00x	x.	x0.	x.	x.	x.	.x	x.
ReC 10	Fluorite with rare earth carbonate	.x	.x	.00x	0	x0.	x.	x.	x0.	.x	x.

Sample No.	0 in unit column means element not detected												
	Tm	*Er*	*Ho*	*Dy*	*Tb*	*Gd*	*Eu*	*Sm*	*Nd*	*Pr*	*Ce*	*La*	*Th*
SpC 1	.x	x.	.x	x.	.x	x.	.0x	.x	.x	.0x	x.	.x	.0x
SpC 2	.0x	.x	.x	.x	.0x	.x	0	.x	.x	0	x.	.x	0
SpC 3	.0x	.x	.x	.x	.0x	.x	0	.x	.x	0	x.	.x	0
SpC 4	.00x	.0x	.0x	.x	0	.0x	0	.0x	0	0	.x	.0x	0
SpC 5	.00x	.0x	.0x	.0x	0	.0x	0	.0x	0	0	.x	.0x	0
SpC 6	.0x	.x	.x	.x	.0x	.x	0	.x	.x	0	x.	.x	.0x
ReC 1	.x	x.	.0x	x.	.x	.x	.0x	.x	.x	.0x	x.	.x	.0x
ReC 2	.00x	0	.0x	.0x	0	.x	0	.x	.x	.0x	x.	.x	.x
ReC 3	.0x	x.	.x	.x	.x	.x	.0x	.x	.x	0	.x	.x	.x
ReC 4	.0x	.x	.x	.x	.0x	.x	0	.x	.x	0	.x	.x	0
ReC 5	.0x	.x	.x	.x	.0x	.x	0	.x	.x	0	x.	.x	.0x
ReC 6	.0x	.x	.x	.x	.0x	.x	.0x	.x	0	0	x.	.x	0
ReC 7	.x	.x	.x	x.	.0x	x.	0	.x	.x	0	x.	.x	.0x
ReC 8	.x	.x	.x	x.	.0x	.x	.0x	.x	.x	.0x	x.	.x	.x
ReC 9	.0x	.x	.x	.x	.0x	.x	.0x	.x	.x	.0x	x.	.x	.x
ReC 10	.0x	.x	.x	.x	.0x	.x	0	.x	.x	0	x.	.x	0

* The presence of F was determined by observing the intense yellow color of CaF in the arc during excitation. Dashes indicate the absence of the yellow color during arcing.

discussion of the geochemistry of the rare earths, nor the paragenesis of the minerals. These subjects remain for further study.

DESCRIPTION OF SAMPLES USED FOR SPECTROGRAPHIC ANALYSIS IN TABLE 1

SpC 1.—Gadolinite is massive, dark grayish green, fractured, and somewhat altered. Under the microscope the mineral is partly metamict with n = 1.78. Some areas have low birefringence with variable mean index, n = 1.80 to 1.81.

SpC 2.—Total ore-bearing fluorite rock is a mixture of fragments of pink microcline, purple, pinkish cream, gray, and pale green fluorite. The fluorite is host to several rare earth minerals.

SpC 3.—Pinkish cream fluorite, n = 1.440, contains numerous inclusions of small, high-index grains of minerals, mostly xenotime.

SpC 4.—Pale green fluorite, n = 1.440, contains few inclusions.

SpC 5.—Purple fluorite from which part of the inclusions have been removed with the Frantz separator, has the index of refraction, n = 1.437.

SpC 6.—Purple fluorite, n = 1.450, commercial ore, contains inclusions of xenotime, monazite, allanite, gadolinite, and alteration products of these minerals.

ReC 1.—Gadolinite crystal is described under mineralogy.

ReC 2.—Glossy black allanite is described under mineralogy.

ReC 3.—Xenotime, inclusions from allanite, are described under mineralogy.

ReC 4.—Cream-colored fluorite, n = 1.450, has had some inclusions removed with the Frantz separator.

ReC 5.—Inclusions from cream-colored fluorite, contain an abundance of xenotime, and some monazite.

ReC 6.—Purple fluorite, n = 1.440, contains gadolinite, monazite, and xenotime.

ReC 7.—Altered dark brown gadolinite is partly replaced by fluorite and abundant xenotime.

ReC 8.—Red dense alteration product represents a more advanced stage of alteration of gadolinite. Xenotime inclusions are less conspicuous; iron oxide, and monazite are present.

ReC 9.—Brick red powder appears to be the last stage of the alteration of gadolinite. It consists of iron oxide and monazite.

ReC 10.—Lavender colored fluorite crystals one to two centimeters in diameter contain small inclusions of an unidentified rare-earth carbonate.

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