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## SECOND OCCURRENCE OF FERSMITE


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### Abstract

Fersmite, (Ca, Ce, Na)(Cb, Ti, Fe, Al)$_2$ (O, OH, F)$_6$, occurs as small anhedral inclusions and intergrowths with a tantalum-free columbite occurring in Ravalli County, Montana. Chemical and crystallographic data, along with the physical and optical properties, agree in general with those given in the original description of fersmite from the Ural Mountains of Russia. *X*-ray diffraction data, not given in the original description, and more specific optical data have been determined.


### Introduction

Fersmite is a rare calcium columbate of the $AB_2O_6$ group, (Ca, Ce, Na) (Cb, Ti, Fe, Al)$_2$ (O, OH, F)$_6$, first described from the pegmatites of the Vishnevye Mountains, Central Urals, Russia, by Bohnstedt-Kupletskaya and Burova (1946).

The new locality for fersmite, representing the first recorded occurrence in North America and apparently only the second reported occurrence in the world, is the Dark Star claim in sections 3 and 4, T4S, R22W, Bitterroot Base Line, Ravalli County, Montana. The prospect is in the ruggedly dissected east slope of the Bitterroot Mountains approximately five miles south of Alta, Montana, and is easily accessible by highway and Forest Service access roads. The region is composed chiefly of schists and gneisses believed to have been originally Belt-series argillaceous and calcareous sediments of Precambrian age that were metamorphosed during the introduction of the Idaho batholith (Ross 1950). Intermittent amphibolite, quartzite, and thin-bedded marble also are present. Rhyolite and pegmatite dikes crosscut and intrude the metamorphic complex in a number of areas.

The fersmite described herein occurs as small anhedral inclusions and intergrowths with a tantalum-free columbite associated with monazite, ancylite, barite, quartz, and apatite in a fine-grained buff-colored marble. The bed ranges in thickness from approximately 1 to 6 feet, and reportedly can be traced for approximately 700 feet along the surface. According to Sahinen (1957), the strike of the marble is N. 67½° W, and the dip is 77° NE at the surface but straightens to vertical near the bottom of a 12-foot cut.

As shown in Fig. 1, the columbite, along with intergrown fersmite, occurs as well-defined blebs and irregular masses ranging up to 2 inches across. The microcrystalline structure of these black masses, and particularly the close relationship of the fersmite to columbite, is illus-

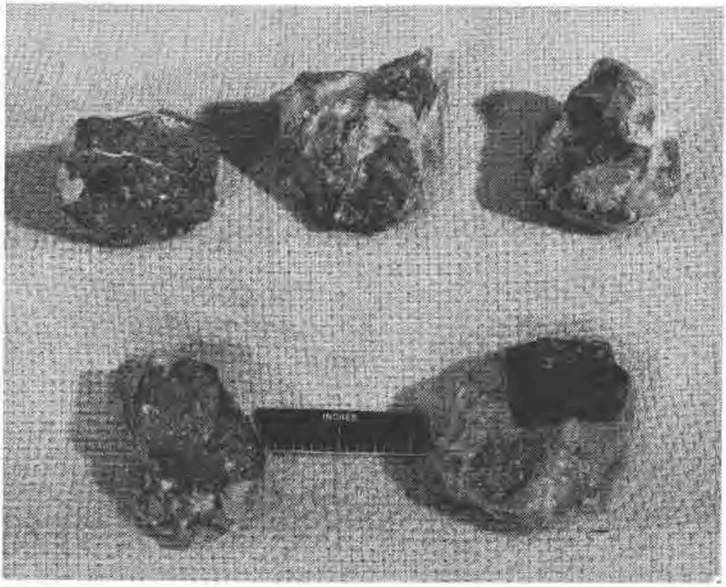

FIG. 1. Photograph of selected specimens illustrating the occurrence of the black columbite masses which contain the fersmite.

trated in Fig. 2. Monazite is observed only as small sparsely disseminated anhedral inclusions in the columbite masses, and can be recognized with the unaided eye in contrast to the black host mineral. Conversely, the the ancylite is not directly associated with the columbite, but rather occurs as a fine-grained pinkish material associated with the carbonate host rock.

The presence of these columbium and rare-earth minerals—ordinarily regarded as being of granitic or pegmatitic origin, but here occurring in a metamorphosed limestone of probably sedimentary origin—represents a unique occurrence. It also is of interest to note that high-purity columbite concentrates analyzed by optical and $x$-ray spectrographic methods at the Albany, Oregon, laboratory of the Federal Bureau of Mines were found to contain no tantalum. The tantalum-free nature of columbite from the Dark Star claim originally was reported by Sahinen (1957) on the basis of analyses made by the Montana Bureau of Mines and the U. S. Geological Survey. However, the black homogeneous-appearing columbium-bearing masses were described by Sahinen as being "stubby prismatic crystals of columbite as much as two inches across," and no mention was made of the intimately intergrown fersmite.

FIG. 2. Plane light, ×45. Photomicrograph of columbite masses showing the relationship of anhedral fersmite (gray, high relief) to subhedral columbite (black) and interstitial calcite (white).

The Montana fersmite first was noticed in January 1954 during a routine mineralogical examination of a prospector's sample submitted by Louis Erickson, Corvallis, Montana, to the U. S. Bureau of Mines Petrographic Laboratory at Albany. At that time, R. E. Lubker, the laboratory geologist examining the sample, called the authors' attention to a small quantity of a dark brown, translucent mineral which he observed in the nonmagnetic fraction of crushed material passed through the Frantz isodynamic magnetic separator at 1.5 amperes.

When the mineral could not be classified by *x*-ray diffraction analysis, a more thorough study and literature search was made to determine the possibility of a new mineral species. It was through this detailed study, and subsequent tests made on a suite of selected samples supplied by

Louis Erickson, that the unidentified mineral was found to have the properties of fersmite as described by Bohnstedt-Kupletskaya and Burova (1946). Unfortunately, the original description of fersmite lacked *x*-ray diffraction data, and attempts to obtain identified samples for comparison purposes were unsuccessful. However, the chemical, physical and optical properties and limited crystallographic data listed correspond so closely with the material from Ravalli County that the relationship seems unquestionable.

## Crystallography

The Montana fersmite occurs as small anhedral inclusions and intergrowths with columbite. This, plus its extreme brittleness, made it impossible to obtain individual crystals suitable for detailed study with the optical goniometer. However, through considerable search and effort, several imperfect crystals and crystal fragments were isolated permitting limited single-crystal study.

Study of these fersmite grains indicates that the mineral is orthorhombic in crystallization and belongs to the bipyramidal class. The few distinct crystals observed measure from 0.5 to 1 millimeter across, while the predominant anhedral forms are somewhat larger. The habit is prismatic, with the unit prism (110) predominating, and less commonly tabular parallel to (100). Macrodome and macropinacoid modifications also are observed on some of the crystalline grains. The prism faces are striated, and several crystal fragments showed parting parallel to (100).

The axial ratio, as derived from *x*-ray study, is $a:b:c=0.381:1:0.346$ which compares with the "approximate ratio" $a:b:c=0.377:1:0.356$ reported by Bohnstedt-Kupletskaya and Burova (1946) on the Russian fersmite.

## Unit Cell and Space Group

The unit cell dimensions of the Montana fersmite were obtained with MoK$\alpha$ radiation using a cylindrical camera. Following the same technique, the cell dimensions of the associated columbite also were determined to illustrate the rather close similarity of these two intimately associated minerals.

The space group of fersmite was found to be the same as for columbite and tantalite, $D_{2h}^{14}$—*Pbcn*. The cell dimensions obtained for the fersmite and associated columbite are as follows, with the order of listing in conformance with the International Tables for X-ray Crystallography:

| Fersmite | Columbite |
|---|---|
| $a_o = 5.764$ Å | $a_o = 5.730$ Å |
| $b_o = 15.09$ Å | $b_o = 14.238$ Å |
| $c_o = 5.232$ Å | $c_o = 5.082$ Å |

## X-Ray Powder Diffraction Data

The original description of fersmite reported by Bohnstedt-Kupletskaya and Burova did not include powder diffraction data, and therefore a comparison could not be made. The powder diffraction data obtained for the Montana fersmite, using a Norelco Geiger Counter Spectrometer and CuK$\alpha$ radiation, are listed in Table 1.

Table 1. X-Ray Powder Spacing Data for Fersmite from Ravalli County, Montana

CuK$\alpha$ radiation

| *d* (meas.) | *d* (calc.) | $I/I_0$ | hkl |
|---|---|---|---|
| 7.449 | 7.54 | 6 | 020 |
| 5.345 | 5.38 | 9 | 110 |
| 3.762 | 3.77 | 21 | 111, 040 |
| 3.427 | 3.44 | 9 | 121 |
| 3.049 | 3.07 | 100 | 131 |
| 2.864 | 2.88 | 8 | 200 |
| 2.684 | 2.69 | 4 | 220 |
| 2.606 | 2.62 | 7 | 002 |
| 2.514 | 2.52 | 8 | 060 |
| 2.493 | 2.47 | 14 | 022 |
| 2.385 | 2.38 | 1 | 102 |
| 2.367 | 2.38 | 1 | 151 |
| 2.279 | 2.27 | 1 | 061 |
| 2.247 | 2.26 | 5 | 231 |
| 2.145 | 2.15 | 4 | 132 |
| 2.117 | 2.11 | 1 | 161 |
| 2.087 | 2.10 | 5 | 241 |
| 2.004 | 2.01 | 3 | 142 |
| 1.967 | 1.94 | 10 | 251 |
| 1.929 | 1.93 | 3 | 202 |
| 1.916 | 1.91 | 1 | 310 |
| 1.899 | 1.89 | 1 | 080 |
| 1.882 | 1.88 | 9 | 171, 222 |
| 1.862 | 1.87 | 1 | 152 |
| 1.804 | 1.81 | 9 | 232 |
| 1.789 | 1.80 | 7 | 330 |
| 1.786 | 1.79 | 8 | 311 |
| 1.771 | 1.77 | 8 | 081 |
| 1.691 | 1.70 | 6 | 023, 331, 181 |
| 1.629 | 1.63 | 4 | 252, 341 |
| 1.626 | 1.62 | 6 | 350 |
| 1.580 | 1.58 | 4 | 043 |
| 1.537 | 1.54 | 2 | 312, 262, 191 |
| 1.527 | 1.53 | 15 | 082 |
| 1.512 | 1.52 | 3 | 322 |
| 1.502 | 1.51 | 1 | 0.10.0, 281 |
| 1.489 | 1.49 | 2 | 213 |
| 1.482 | 1.48 | 2 | 332 |
| 1.476 | 1.46 | 5 | 361, 223 |
| 1.427 | 1.43 | 1 | 370 |
| 1.387 | 1.38 | 4 | 411 |
| 1.380 | 1.38 | 2 | 352 |
| 1.363 | 1.37 | 1 | 421 |
| 1.334 | 1.33 | 1 | 1.11.0 |
| 1.229 | 1.30 | 1 | 441 |
| 1.256 | 1.26 | 6 | 402, 451 |
| 1.248 | 1.25 | 1 | 333 |
| 1.245 | 1.25 | 1 | 183 |
| 1.222 | 1.22 | 3 | 343 |
| 1.211 | 1.21 | 11 | 144 |
| 1.192 | 1.19 | 1 | 204 |
| 1.183 | 1.18 | 13 | 154 |
| 1.158 | 1.16 | 1 | 064 |
| 1.145 | 1.15 | 1 | 480 |
| 1.133 | 1.14 | 1 | 392 |
| 1.126 | 1.13 | <1 | 462 |
| 1.121 | 1.12 | 3 | 511 |
| 1.107 | 1.11 | 1 | 521 |

## Physical Properties

The specific gravity of the Ravalli County fersmite was determined by two methods: (1) with a Berman density balance, in which fragments were first weighed in air and then in toluene; and (2) with a pycnometer, using xylene as the displacement liquid. These procedures were necessitated by the small size of the fragments because grinding through 48-mesh or finer was required to insure liberation from any contaminating columbite. The results of the two methods show close agreement, with specific gravity values of 4.79 and 4.80 obtained by using the Berman balance and the pycnometer, respectively. Even though the values were redetermined several times with complete agreement, there is a noted variation with the 4.69 value reported by Bohnstedt-Kupletskaya and Burova (1946) for the Ural Mountains fersmite.

A further comparison of the physical properties of fersmite from the two localities is listed in Table 2.

Table 2. A Comparison of the Physical Properties of Fersmite

| | Ravalli County Montana | Vischnevye Mts. Central Urals |
|---|---|---|
| Specific gravity | 4.79 | 4.69 |
| Color | Dark brown to black | Black |
| Streak | Grayish-brown | Grayish brown |
| Luster | Resinous | Subvitreous to resinous |
| Hardness | $4–4\frac{1}{2}$ | $4\frac{1}{2}$ |
| Cleavage | None | None |
| Fracture | Subconchoidal | Uneven to subconchoidal |
| Tenacity | Brittle | Brittle |

## Optical Properties

The fersmite from Ravalli County is translucent and dark honey yellow in thin section and fragment mounts, and exhibits moderate pleochroism. Information on the optical properties of the Russian fersmite is incomplete, and only the roughest comparison can be made. However, the optical properties listed in the initial description of fersmite, together with the optical constants of the Ravalli County material as measured by the writers, are given in Table 3.

The minimum and maximum indices of refraction were measured in lithium light using the procedures outlined by Merwin and Larsen (1912) in which mixtures of selenium and amorphous sulfur are used for immersion media. The 2V was established by use of a universal stage.

TABLE 3. A COMPARISON OF OPTICAL DATA FOR FERSMITE

| | Ravalli County, Montana | Vischnevye Mts. Central Urals |
|---|---|---|
| Indices of refraction | $\alpha=2.07$ (Li)<br>$\beta=2.08$ (Calc.)<br>$\gamma=2.19$ (Li) | About 2 |
| Pleochroism | $x$ and $y$=pale greenish yellow to colorless<br>$z$ =dark greenish yellow to olive yellow | Not listed |
| 2V | 20°–25° | Large |
| Sign | + | Probably + |
| Birefringence | 0.12 | Medium |

TABLE 4. A COMPARISON OF CHEMICAL ANALYSES OF FERSMITE

| | Ravalli County, Montana | Vishnevye Mts. Central Urals | |
|---|---|---|---|
| | | Pegmatite 1 (complete anal.) | Pegmatite 2 (partial anal.) |
| CaO | 15.02 | 14.49 | 15.53 |
| $Cb_2O_5$ | 74.44 | 70.12 | 71.51 |
| $Ta_2O_5$ | n.d. | Trace | |
| REO | 6.36[a] | 4.79[b] | 3.98 |
| $TiO_2$ | 2.01 | 3.21 | 2.94 |
| $SiO_2$ | 0.32 | 0.72 | |
| MnO | 0.11 | 0.48 | |
| $Fe_2O_3$ | 0.34 | 1.71 | 1.25 |
| $ThO_2$ | 0.10 | | |
| $Al_2O_3$ | 0.10 | 1.28 | |
| MgO | n.d. | 0.98 | 0.97 |
| $Na_2O$ | n.d.[c] | 0.46 | |
| F | n.d.[d] | 1.87 | |
| $U_3O_8$ | 0.08 | | |
| $H_2O$ | 0.18 | 0.72 | |
| Total | 99.04 | 100.83 | 96.18 |

n.d.—not detected.
[a] Shown to be essentially $La_2O_3$ by $x$-ray spectrographic analysis with only minor $CeO_2$.
[b] Reported as 80% Ce group, 10% Y group, and 10% $ThO_2$.
[c] Confirmed by flame photometry.
[d] Confirmed by molecular spectroscopy.

## Chemical Composition

A chemical analysis of the Ravalli County fersmite conforms closely to the $AB_2O_6$ formula, (Ca, Ce, Na) $(Cb, Ti, Fe, Al)_2$ $(O, OH, F)_6$, originally reported by Bohnstedt-Kupletskaya and Burova (1946). However, as shown in Table 4, sodium and fluorine are absent in the Ravalli County fersmite, and lanthanum rather than cerium represents the major rare-earth constitutent.

## Acknowledgments

The *x*-ray data included in this report required special effort by P. A. Romans and M. P. Krug of the Albany Bureau of Mines laboratory. The authors also thank Louis Erickson, owner of the Dark Star claim, for supplying the test samples and providing helpful information concerning the deposit. Thanks are extended to Dr. Michael Fleischer of the U. S. Geological Survey who, during a visit by the senior author in March 1956, reviewed the basic data and offered advice concerning proper classification of the mineral.

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