Texasite, a new mineral: the first example of a differentiated rare-earth species

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Abstract

Texasite, PrO₂SO₄, occurs as a supergene alteration product of primary rare-earth minerals at the Clear Creek pegmatite, Burnet County, Texas, and at the Rode Ranch pegmatite, Llano County, Texas. Associated minerals include gadolinite, allanite, yttrofluorite, bastnaesite, behoite, rowlandite, tengerite, and chlorine-bearing jarosite. Crystals are small (0.1 mm), translucent, and apple-green in color. It is orthorhombic, space group Imm2 or I222. The unit-cell constants are \( a = 4.139(5), b = 4.243(5), c = 13.431(15) \) \( \text{Å} \), \( Z = 2 \). The strongest lines in the X-ray powder pattern are 6.72(3)(002), 4.051(7)(011), 3.960(6)(101), 3.358(6)(004), 3.082(10)(013), 2.238(2)(006), and 1.980(2)(202). These are essentially identical with those of synthetic PrO₂SO₄. Texasite is biaxial (-), \( 2V = 26-31^° \), with refractive indices \( \alpha = 1.862(2), \beta = 1.917(2), \gamma = 1.921(2) \). Density (calc) is 5.769. The name is in honor of the state of Texas, the location of the Barringer Hill rare-earth pegmatite district.

Introduction

In 1975 the writer discovered a 5 cm \( \times \) 5 cm specimen of a supergene alteration crust between large crystals of allanite, yttrofluorite, and gadolinite at the Clear Creek pegmatite, Burnet County, Texas. Associated minerals in the alteration assemblage include bastnaesite, behoite, rowlandite, tengerite, and chlorine-bearing jarosite. In the alteration several small green crystals of an unknown species were found intimately associated with tengerite and jarosite. Further investigation of this mineral indicated that it was a new rare-earth oxysulfate.

The name, texasite, is in honor of the state of Texas, the location of the famous Barringer Hill rare-earth pegmatite district. The mineral and the name have been approved by the Commission on New Minerals and Mineral Names, IMA. Single specimens of type material have been deposited in the collections of this department and in the Smithsonian Institution.

Occurrence

Texasite occurs on one specimen collected at the Clear Creek pegmatite, 7 miles northwest of Burnet, Burnet County, Texas (38°48'N, 98°20'W). Additional specimens were also found at the Rode Ranch pegmatite, Llano County, Texas, some 26 miles west of the type locality. The Clear Creek and Rode Ranch pegmatites are two of the rare-earth pegmatites for which the region is noted. Rare-earth minerals from this province have been described by Hidden and Mackintosh (1889), Hidden (1905), Hess (1908), Landes (1932), Ehmann et al. (1964), Ewing and Ehmann (1973), and Crook (1976, 1977). Large crystals up to 300 pounds (Hess, 1908) of gadolinite, fergusonite, uraninite, yttrialite, yttrcosite, zircon (cyrtolite), samarskite, polycrase, and allanite have been reported. Alteration by both late pegmatic solutions and by oxidizing surface waters is common. Secondary minerals include thorogummite, behoite, bastnaesite, doverite, synchysite, cordylite, tengerite, and rowlandite.

Texasite occurs at the Clear Creek pegmatite on an alteration rind between crystals of allanite, yttrofluorite, and gadolinite. Many of the small cavities in the alteration material are lined with 0.1-0.4 mm crystals of texasite, intergrown with tengerite, fluorine-bearing jarosite, and chlorine-bearing jarosite. Jarosite shows distinctive selective replacement of hydroxyl by both fluorine (as much as 0.92%) and chlorine (from 0.08 to 5.3%) and apparently repre-
CROOK: TEXASITE

sents a new solid-solution series in the alunite-
jarosite family.

Physical properties

Texasite occurs as radial stellate groups and as
individual bladed crystals up to 0.4 mm long and
elongate along the c axis. Crystals of texasite have
two equally abundant morphologies, both tabular to
{010} but one type is terminated by a {011} prism and
the other by {101}. Indices were obtained by goniomet-
ic measurements. Mohs hardness is approxi-
mately 2½, and the crystals are brittle with a well-
developed {010} cleavage. Crystals have a vitreous
luster, perfectly translucent and apple-green in color.
The streak is pale green.

Optically it is biaxial negative, refractive indices for
NaD are α = 1.826(2), β = 1.917(2), γ = 1.921(2), V =
26–31°. It is pleochroic: α: colorless to pale gray-
green, β: pale green to greenish-gray, γ: pale
green. The optic plane is parallel to {010} with the
optic orientation α: Z, β: Y, c: X.

Due to the combination of small crystal size and
the high specific gravity, direct determination of the
specific gravity on both natural and synthetic
Pr$_2$O$_5$(SO$_4$) was not possible. Density (calc) is 5.769
for texasite and 5.762 (calc) for synthetic Pr$_2$O$_5$(SO$_4$).
The specific gravity was calculated using a value of Z
as determined from partial crystal-structure anal-
lysis. Neither natural nor synthetic material fluoresces
under ultraviolet radiation.

X-ray crystallography

Unit-cell parameters from Weissenberg photo-
graphs using CuKα (1.54051 Å) radiation with esti-
mated standard deviations in parentheses are $a =$
4.139(5), $b =$ 4.243(5), $c =$ 13.431(15) Å, $Z =$ 2, $V =$
235.87 Å$^3$. Lattice parameters were obtained by ex-
trapolation as a function of $\cos^2\theta$ (0–90°) for $hk0$,
$0k0$, and $00l$ reflections from zero-level Weissenberg
photographs. The lattice parameters for texasite are
in good agreement with data obtained from Weissen-
berg photographs of synthetic Pr$_2$O$_5$(SO$_4$) ($a =$ 4.141,
$b =$ 4.247, $c =$ 13.429 Å) (Haschke, personal com-
munication, 1976). The space group is either Imm2 or
I222 (see below). The only extinctions observed were
those corresponding to the body-centered lattice, $h + k + l =$ 2$n$ + 1. Indexed X-ray powder data are listed
in Table 1. Indices were obtained using lattice para-
eters from the single crystal study. The powder
data are essentially identical to those of synthetic
Pr$_2$O$_5$(SO$_4$).

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### Table 1. Powder X-ray diffraction data for texasite

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<th>$d_{calc}$</th>
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### Table 2. Chemical analyses of texasite

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1,2) Clear Creek pegmatite, Burnet County, Texas.

3) Rode Ranch pegmatite, Llano County, Texas.

4) Ideal Pr$_2$O$_5$(SO$_4$).
VII program (J. Rucklidge and E. L. Gasparrini, University of Toronto, written communication, 1969). Tests for chlorine, fluorine, additional rare-earth elements, and water were negative. Texasite is insoluble in mineral acids.

Discussion

Rare-earth minerals are typically differentiated to some extent, expressing a preference for either the lighter or heavier lanthanides. However, even strongly selective minerals such as bastnaesite (Ce) and thalinite (Y) commonly contain traces of all the rare-earth elements and only approximate their idealized chemical formulae. In this regard, texasite is a notable exception. Not only are the rare-earths strongly partitioned to the cerium-group elements, but in all analyzed materials, praseodymium accounts for 99.9 percent of the total rare-earths present. Haschke (personal communication, 1976) suggests that a unique crystal-chemical situation relative to the coordination geometry of the praseodymium ion is responsible for the partitioning of the rare-earths. Haschke has synthesized all of the rare-earth oxysulfates, and has found that the praseodymium oxysulfate is by far the most stable and easiest to synthesize. The presence of abundant rare-earths in the weathering environment, combined with the sulfate-rich waters precipitating jarosite, provided the unique elemental conditions responsible for the crystallization of texasite.

Diffraction symmetry shows the space group of texasite to be either Imm2, I222, I2221, or Immn. The number and symmetry of available equipoints in I2221 and Immn appear inconsistent with the number of sulfur atoms per cell and the symmetry of a tetrahedrally-coordinated sulfur. The remaining two space groups have equipoints which are consistent with SO4 tetrahedron geometry and two sulfur atoms per cell. Fahey (1976) erroneously dismissed Imm2 in his proposed structure model of La2O4(SO4), based on his belief that this space group was inconsistent with available equipoints for a sulfate tetrahedron. Structure analysis of texasite currently in progress has shown, however, that both Imm2 and I222 are consistent with the positioning of sulfur tetrahedra.

Texasite is related to synthetic Pr2O3(SO4) by an order-disorder relationship involving a different orientation of the anionic group along the c direction. This superstructure, which occurs in the synthetic phase, indicates a reduction in ideal symmetry, although the substructures are identical. The superstructure reflections are limited in number and quite weak (Haschke, personal communication, 1976). Many rare-earth oxy- and hydroxysulfates and nitrates have similar types of superstructures (Peacor, personal communication 1976). In each case, the rare-earth polyhedra are translationally periodic, whereas the sulfate or nitrate groups have a periodicity which is some multiple of that of the rare-earth polyhedra.

Acknowledgments

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References


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