

Texasite, a new mineral: the first example of a differentiated rare-earth species¹

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Abstract

Texasite, $\text{Pr}_2\text{O}_2(\text{SO}_4)$, 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, yttrifluorite, 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 $a = 4.139(5)$, $b = 4.243(5)$, $c = 13.431(15)$ 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 $\text{Pr}_2\text{O}_2(\text{SO}_4)$. Texasite is biaxial (-), $2V = 26-31^\circ$, 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 × 5 cm specimen of a supergene alteration crust between large crystals of allanite, yttrifluorite, 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), Ehlmann *et al.* (1964), Ewing and Ehlmann (1973), and Crook (1976, 1977). Large crystals up to 300 pounds (Hess, 1908) of gadolinite, fergusonite, uraninite, yttrialite, yttracrasite, zircon (cyrtolite), samarskite, polycrase, and allanite have been reported. Alteration by both late pegmatitic solutions and by oxidizing surface waters is common. Secondary minerals include thorigummite, behoite, bastnaesite, doverite, synchysite, cordylite, tengerite, lanthanite, and rowlandite.

Texasite occurs at the Clear Creek pegmatite on an alteration rind between crystals of allanite, yttrifluorite, 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-

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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 goniometric measurements. Mohs hardness is approximately 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 $\alpha = 1.826(2)$, $\beta = 1.917(2)$, $\gamma = 1.921(2)$, $2V = 26-31^\circ$. It is pleochroic: $\alpha =$ colorless to pale gray-green, $\beta =$ pale green to greenish-gray, $\gamma =$ pale green. The optic plane is parallel to {010} with the optic orientation $a = Z$, $b = Y$, $c = X$.

Due to the combination of small crystal size and the high specific gravity, direct determination of the specific gravity on both natural and synthetic $\text{Pr}_2\text{O}_2(\text{SO}_4)$ was not possible. Density (calc) is 5.769 for texasite and 5.762 (calc) for synthetic $\text{Pr}_2\text{O}_2(\text{SO}_4)$. The specific gravity was calculated using a value of $Z = 2$ as determined from partial crystal-structure analysis. Neither natural nor synthetic material fluoresces under ultraviolet radiation.

X-ray crystallography

Unit-cell parameters from Weissenberg photographs using $\text{CuK}\alpha$ (1.54051 Å) radiation with estimated standard deviations in parentheses are $a = 4.139(5)$, $b = 4.243(5)$, $c = 13.431(15)$ Å, $Z = 2$, $V = 235.87$ Å³. Lattice parameters were obtained by extrapolation as a function of $\cos^2\theta$ (0–90°) for $h00$, $0k0$, and $00l$ reflections from zero-level Weissenberg photographs. The lattice parameters for texasite are in good agreement with data obtained from Weissenberg photographs of synthetic $\text{Pr}_2\text{O}_2(\text{SO}_4)$ ($a = 4.141$, $b = 4.247$, $c = 13.429$ Å) (Haschke, personal communication, 1976). The space group is either *Imm2* or *I222* (see below). The only extinctions observed were those corresponding to the body-centered lattice, $h + k + l = 2n + 1$. Indexed X-ray powder data are listed in Table 1. Indices were obtained using lattice parameters from the single crystal study. The powder data are essentially identical to those of synthetic $\text{Pr}_2\text{O}_2(\text{SO}_4)$.

Table 1. Powder X-ray diffraction data for texasite

| Synthetic $\text{Pr}_2\text{O}_2(\text{SO}_4)$ * | | | | Texasite** | | | |
|--|------------------|-------------------|------------------|------------|------------------|-------------------|------------------|
| hkl | d_{obs} | d_{calc} | I/I ₀ | hkl | d_{obs} | d_{calc} | I/I ₀ |
| 002 | 6.72 | 6.715 | 30 | 002 | 6.72 | 6.72 | 30 |
| 011 | 4.053 | 4.049 | 70 | 011 | 4.051 | 4.045 | 70 |
| 101 | 3.960 | 3.957 | 60 | 101 | 3.960 | 3.955 | 60 |
| 004 | 3.360 | 3.357 | 60 | 004 | 3.358 | 3.358 | 60 |
| 013 | 3.081 | 3.081 | 100 | 013 | 3.080 | 3.082 | 100 |
| 103 | 3.043 | 3.040 | 5 | 103 | 3.040 | 3.039 | 5 |
| 110 | 2.966 | 2.965 | 5 | 110 | 2.966 | 2.963 | 5 |
| 112 | 2.714 | 2.712 | 10 | 112 | 2.708 | 2.711 | 10 |
| 015 | 2.269 | 2.268 | 10 | 015 | 2.271 | 2.270 | 10 |
| 105 | 2.255 | 2.253 | 5 | --- | --- | --- | --- |
| 006 | 2.239 | 2.238 | 20 | 006 | 2.238 | 2.238 | 20 |
| 020 | 2.124 | 2.123 | 10 | 020 | 2.124 | 2.122 | 10 |
| 022 | 2.025 | 2.025 | 5 | 022 | 2.030 | 2.023 | 5 |
| 202 | 1.979 | 1.979 | 20 | 022 | 1.980 | 1.978 | 20 |
| 211 | 1.843 | 1.843 | 5 | 211 | 1.843 | 1.843 | 5 |
| 116 | 1.787 | 1.786 | 5 | --- | --- | --- | --- |
| 123 | 1.742 | 1.741 | 5 | --- | --- | --- | --- |
| 107 | --- | --- | --- | --- | --- | --- | --- |
| 213 | 1.719 | 1.718 | 10 | 213 | 1.719 | 1.718 | 10 |

* Guinier camera data (J. Haschke, pers. comm., 1976).

** $\text{CuK}\alpha$ radiation; 114.6 mm Gandolfi camera. Intensities visually estimated.

Chemical analysis

Electron microprobe analysis (Table 2) was used in the identification of texasite, due in part to the lack of sufficient material for a standard chemical analysis. The analysis was conducted with 150 nA specimen current and 15 kV excitation voltage. Microprobe standards used for the following elements are: Pr [Pr_2O_3 and synthetic $\text{Pr}_2\text{O}_2(\text{SO}_4)$], La (La_2O_3 and synthetic $\text{La}_7\text{OH}_{18}\text{NO}_3$), Ce (Ce_2O_3), Nd (Nd_2O_3), and S (galena). Corrections were made using the EMPADR

Table 2. Chemical analyses of texasite

| | 1 | 2 | 3 | 4 |
|-------------------------|--------|--------|--------|--------|
| Pr_2O_3 | 80.87 | 80.60 | 80.36 | 80.47 |
| La_2O_3 | 0.08 | 0.06 | 0.11 | ----- |
| Ce_2O_3 | 0.03 | ----- | 0.03 | ----- |
| Nd_2O_3 | 0.01 | 0.03 | 0.02 | ----- |
| SO_3 | 19.16 | 19.50 | 19.89 | 19.53 |
| TOTAL | 100.15 | 100.19 | 100.41 | 100.00 |

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

3) Rode Ranch pegmatite, Llano County, Texas.

4) Ideal $\text{Pr}_2\text{O}_2(\text{SO}_4)$.

VII program (J. Rucklidge and E. L. Gasparri, 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 thalenite (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*, *I2₁2₁*, or *Immm*. The number and symmetry of available equipoints in *I2₁2₁* and *Immm* 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 La₂O₂(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 Pr₂O₂(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.

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