

Yttrialite and Uraninite, Additional Minerals from the Rode Ranch Pegmatite, Central Mineral Region, Texas

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Abstract

Yttrialite occurs in the Rode Ranch pegmatite as irregular, totally metamict, vitreous masses, dark olive green to brown in color, with thin laminations of tenerite. The specific gravity is 3.86, and n varies from 1.760 to 1.660. The calculated formula based on $RE_2Si_2O_7$ is $(Y_{1.110}RE_{0.182}Th_{0.190}Mn_{0.101}Ca_{0.095}U_{0.034}Fe^{+2}_{0.004}Mg_{0.004})(Si_{1.921}Fe^{+3}_{0.114})O_{7.087}$. Heating at 1000°C for one hour in air results in the crystallization of low temperature gamma-phase yttrialite.

Uraninite occurs as small, dull black, opaque inclusions in columnar, metamict crystals of fergusonite. In weathered specimens, the uraninite inclusions are replaced by bright yellow thorogummite.

Introduction

In the original study of the Rode Ranch pegmatite, Ehlmann *et al* (1964) described allanite, gadolinite, fergusonite and cyrtolite as the prominent, primary rare-earth minerals present. Attention was called to the great similarity in rare-earth mineral composition, general zoning and geologic setting between the Rode Ranch and the famous, but now-inundated, Baringer Hill Pegmatite. Additional study has resulted in the identification of yttrialite and uraninite as primary minerals and has further emphasized the similarity between the two pegmatites.

Yttrialite

The yttrialite of Rode Ranch is similar in appearance to the Baringer Hill yttrialite described by Hidden and Mackintosh (1889). Irregular nodules of yttrialite show no crystal form and in some masses are associated with allanite. A central core of blackish, vitreous, brittle yttrialite is commonly surrounded by a rind of tan alteration which grades from waxy near the vitreous core to powdery along the outer edges.

The blackish vitreous yttrialite core is semi-opaque to translucent, varying in color from dark olive green to brownish black. The variable coloring tends to show a network design indicating that microfracturing has controlled the color pattern. Some of the more pronounced fractures contain thin laminations

of pearly white, flakey tenerite, identified by X-ray diffraction.

Microscopic fragments are colorless to dark brown and isotropic. The index of refraction varies from 1.760 for the colorless to about 1.660 for the brown fragments. This range is considered to be the result of variable hydration and oxidation commonly noted in the alteration of metamict minerals.

Specific gravity determinations (Berman balance) on seven carefully selected apparently unaltered chips gave an average value of 3.86 (standard deviation = 0.10). Previously published values (Hidden and Mackintosh, 1889; Hillebrand, 1905; Ueda and Nishimura, 1954; Nilssen, 1971) and additional values determined by the authors (U.S.N.M. #R-3780, #85070, #R-9961) range from 3.71 to 4.65. This range appears to result from variable hydration, alteration, and varying chemical composition. The value of 2.95 for the waxy tan alteration product may indicate the lower limit for the metamict range.

Differential thermal analysis from ambient temperature to 1000°C showed two peaks, a large endotherm peaking at 195°C and a smaller exotherm peaking at 920°C. The endotherm represents dehydration of the metamict material; the exotherm, crystallization from its previous amorphous state. To determine the recrystallized phase, a sample was heated at 1000°C for one hour in air and was examined using X-ray diffraction. The X-ray diffraction lines are in good agreement with those given by Lima-de-Faria (1964) for gamma-phase annealed "Llano" yttrialite heated at 1000° for 1 hour in air and

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with JCPDS² Card #18-1469 for Llano County, Texas, yttrilite heated at 770°C for 25 hours in air. Both standard specimens are undoubtedly from the Baringer Hill pegmatite because, although ambiguous statements of localities are given, no other yttrilite localities in this area have been reported prior to the present work.

The tan alteration product was also amorphous. After heating at 1000°C for an hour in air, the material gave a diffuse X-ray pattern containing most of the yttrilite lines shown by the vitreous core material after similar heating.

The chemical analysis³ of the Rode Ranch yttrilite is: 27.35 SiO₂, 2.64 Fe₂O₃, 0.10 FeO, 1.68 MnO, 0.05 MgO, 0.89 CaO, 2.09 U₂O₃, 11.98 ThO₂, 0.30 La₂O₃, 1.33 CeO₂, 0.27 Pr₂O₃, 2.30 Nd₂O₃, 1.79 Sm₂O₃, 3.11 Gd₂O₃, 0.56 Tb₂O₃, 3.78 Dy₂O₃, 0.68 Ho₂O₃, 2.30 Er₂O₃, 0.43 Tm₂O₃, 2.54 Yb₂O₃, 1.13 Lu₂O₃, 29.14 Y₂O₃, 3.84 H₂O. The atomic ratio of $\Sigma X : \Sigma Z : O$ is 2.00 : 2.07 : 7.09, where X represents Y, RE, Th, Mn, Ca, U, Fe⁺², Mg; Z represents Si and Fe⁺³. This ratio is in general agreement with the theoretical formula for yttrilite, RE₂Si₂O₇, with cationic substitution for the rare earth elements. With the exception of slight cationic variations, the composition of the yttrilite from Rode Ranch is essentially the same as that from Baringer Hill given by Hidden and Mackintosh (1889) and Hillebrand (1905). Comparison of the lanthanide distribution is not possible because, at the time of these early analyses, all of the individual lanthanides had not been identified and were not reported. The depletion of the lanthanides near the lanthanum end of the series with a marked enrichment of those lanthanides with the smaller ionic radii is in agreement with the distribution in the Iveland yttrilite (Nilssen, 1971). It should be noted, however, that in the Iveland yttrilite the lanthanide distribution peaks at Yb whereas in the Rode Ranch yttrilite the distribution peaks at Dy.

Autoradiographs of the Rode Ranch yttrilite showed a strong but variable blackening, indicating the uranium and thorium content is not homogeneous. This is probably the result of alteration along previously noted microfracturing.

² Joint Committee on Powder Diffraction Standards, formerly under the American Society for the Testing of Materials (ASTM).

³ Analysis by B. Bruun and B. Jensen, Mineralogisk Museum, Oslo.

Infrared absorption spectra of both the Rode Ranch yttrilite and Baringer Hill yttrilite (U.S.N.M. #3780) showed broad absorption peaks at 3 μ , 10 μ , and 22 μ . The first two absorption peaks probably represent the OH stretch and silicon-oxygen stretch vibrations respectively. The broadening of the peaks is the result of variable bond lengths characteristic of the disordered state of metamict minerals.

Uraninite

Uraninite occurs within columnar, vitreous, liver-brown, metamict fergusonite crystals as dull, black, opaque inclusions. The inclusions are generally irregular in cross section although a few show the characteristic cubic habit of uraninite. The inclusions are visible in hand specimen and range in size from 1 mm cubes to 10 mm long irregular patches. A similar occurrence of uraninite inclusions in fergusonite was reported by Vormea *et al* (1966). Examination of more weathered specimens of fergusonite showed inclusions of bright yellow thorogummite whose relationship indicates replacement of the original uraninite. On autoradiographs, the uraninite inclusions show intense blackening relative to the matrix fergusonite.

The identification of uraninite was confirmed by X-ray powder diffraction of carefully selected fragments from crushed fergusonite crystals. Debye-Scherrer films showed the uraninite inclusions to have identical lines with uraninite inclusions in fergusonite (U.S.N.M. #88445) from Baringer Hill. The d -spacings are generally intermediate between JCPDS card #13-225 and #5-0550; however, the powder pattern matched perfectly with uraninite patterns from specimens #94709 (Katanga, Belgium Congo) and #R-9014 (Wheat Owless, England) in the U.S. National Museum.

To date, large masses of uraninite, called nivenite by Hidden and Mackintosh (1889) at the Baringer Hill locality, have not been identified at the Rode Ranch pegmatite.

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