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New data on cerian vesuvianite from San Benito County, California

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Abstract

A previously-reported cerium-rich vesuvianite from San Benito County, California, was reinvestigated using powder diffraction, single-crystal X-ray, and electron microprobe techniques. The material was shown to be a variety of vesuvianite with space group $P4/nnc$, a = 15.631–15.932, c = 11.858–11.896A, Z = 4. Uniaxial negative, ϵ = 1.723–1.756, ω = 1.741–1.763. Gmeas = 3.564–4.074. Chemical analyses show the mineral to correspond to a generalized vesuvianite formula, $(Ca,RE)_{19-x}(Mg,Fe^{3+},Mn,Ti,Al)_{13-y}Si_{18}(O,OH)_{76}$, with slight site deficiencies due to the presence of abundant rare-earths.

Introduction

Cerian vesuvianite was originally reported from San Benito County, California by Murdoch and Ingram in 1966. Due to the lack of quantitative chemical data on the individual rare-earth elements, it was suggested to the authors by Delbert L. Oswald, head of the mineralogy department at the Carnegie Museum of Natural History, that the mineral be reinvestigated using electron microprobe analysis. Subsequent chemical, physical, X-ray single-crystal, and powder data confirm the general conclusions reached by Murdoch and Ingram.

The mineral occurs on fractures in extremely altered greenstones of Franciscan age. Associated minerals include melanite garnet, chlorite, diopside, clinozoisite, perovskite, and apatite. Cerian vesuvianite is easily distinguished by its characteristic prismatic habit and gold to brown-black color.

Physical properties

Cerian vesuvianite occurs as slender prismatic (0.2–3.0 mm) crystals with observed forms {010}, {001}, {110}, {101}, {111}, and {121}. Fracture is subconchoidal, and there is no observable cleavage. The color is variable from translucent gold to deep red to an opaque brown-black, the intensity of the color increasing with increasing RE content. The streak is white, and the hardness is 5½–6½. The specific gravity (21°C) was determined on a Berman balance by repeated measurements on single crystals weighing 12–18 mg to be 4.074(5) on opaque RE-rich material, and 3.564(5)–3.829(5) on gold to red specimens.

The mineral is uniaxial (−) with ϵ = 1.732(2), ω = 1.741(2) (red to gold color, RE-poor); ϵ = 1.756(2), ω = 1.762(2) (black color, RE-rich) (Na light). All grains examined are non-pleochroic.

X-ray crystallography

Single crystals were studied using oscillating crystal, Weissenberg, and precession methods. Unit-cell parameters from a least-squares refinement are a = 15.631(2), c = 11.858(1) (RE-poor); a = 15.932(3), c = 11.896(1) (RE-rich), V = 2897.2-3019.5A^3, Z = 4. Extinctions observed were: $\{0kl\}$, $k + l = 2n + 1$; $\{h0l\}$, $h + l = 2n + 1$; $\{hk0\}$, $k = 2n + 1$. The space group is $P4/nnc$.

Chemical analysis

An electron microprobe analysis (Table 1), conducted with 150 nA specimen current and 15 kV excitation voltage, was used in the characterization of cerian vesuvianite. Water was measured by weight loss on ignition. The iron is assumed to be present as Fe^{3+}, because this is the valence of iron reported in the originally described material (Murdoch and Ingram, 1966). Corrections were made using the EMPADR VII program of Rucklidge and Gasparrini (1969).

Electron microprobe analyses were normalized to 76 total O + OH, consistent with the generalized vesuvianite formula, $A_{19}B_{13}C_{18}(O,OH,F)_{76}$. There is a great deal of substitution in the A and B sites such that the chemical formula for the RE-rich material (analysis 1) is $(Ca_{12.805}Na_{0.128}K_{0.128}Y_{0.448}La_{0.683}Ce_{1.195}$

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Table 1. Chemical analysis of cerian vesuvianite

	1	2	RE_2O_3	1	2
CaO	22.46	31.06	La_2O_3	3.47	0.43
Na_2O	0.15	0.26	Ce_2O_3	6.09	1.18
K_2O	0.19	0.19	Pr_2O_3	1.39	0.29
RE_2O_3	20.57	4.87	Nd_2O_3	2.04	0.61
MgO	3.91	3.37	Sm_2O_3	2.98	0.88
Fe_2O_3	3.05	5.61	Gd_2O_3	1.04	0.14
MnO	0.29	0.62	Tb_2O_3	0.26	0.03
TiO_2	2.47	4.08	Dy_2O_3	0.94	0.25
Al_2O_3	10.87	11.58	Ho_2O_3	0.23	0.15
SiO_2	33.56	35.77	Er_2O_3	0.29	0.12
H_2O	2.17	1.86	Tm_2O_3	0.06	0.04
			Yb_2O_3	0.11	0.22
			Lu_2O_3	0.12	0.18
			Y_2O_3	1.55	0.35
TOTAL	99.69	99.27	SUM	20.57	4.87

1. Rare-earth-rich vesuvianite, San Benito Co.
2. Rare-earth-poor vesuvianite, San Benito Co.

$Pr_{0.277}Nd_{0.384}Sm_{0.576}Gd_{0.192}Tb_{0.043}Dy_{0.171}Ho_{0.043}Er_{0.043}Tm_{0.021}Yb_{0.021}Lu_{0.021})(Mg_{3.105}Fe^{3+}_{1.217}Mn_{0.128}Ti_{0.992}Al_{6.710})(Si_{17.880}Al_{0.120})(O_{68.316}OH_{7.683})$. Thus the idealized formula is $(Ca,RE)_{19-x}(Mg,Fe^{3+},Mn,Ti,Al)_{13-y}Si_{18}(O,OH)_{76}$. The presence of abundant rare earths (20.57 weight percent) accounts for the slight site deficiencies seen in both the *A* and *B* sites.

Discussion

These data suggest that the mineral is a rare-earth, notably cerium-rich variety of vesuvianite. Optical and physical data are slightly different from reported values for vesuvianite, but are not unreasonable considering the substitution of the rare-earths for calcium. X-ray data show the mineral to have space group *P4/nnc*, consistent with known vesuvianites, with an expanded lattice due to the increasing RE content. Chemical analyses of all color types show a range in total RE content from 0.64 to 20.57 weight percent. Previously-reported RE vesuvianites (Orlov and Mart'yanov, 1961; Murdoch and Ingram, 1966) list values which fit into this range but do not exceed it.

References

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