Dingdaohengite-(Ce) from the Bayan Obo REE-Nb-Fe Mine, China: Both a true polymorph of perrierite-(Ce) and a titanite analog at the C1 site of chevkinite subgroup

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ABSTRACT

Dingdaohengite-(Ce), ideally CeFe2+Ti4+Ti3+(SiO3)O, is a new member of the chevkinite group minerals from the world-famous Bayan Obo REE-Nb-Fe Mine near Baotou city, Inner Mongolian Autonomous Region, North China. It occurs in the magnesian skarn in the excontact of granite within dolomitic marble. Most individual crystals vary from 0.2 to 1.0 cm in length. Associated minerals are diopside, tremolite, richterite, allanite-(Ce), magnetite, ilmenite, spinel, titanite, pyrochlore, F-rich phlogopite, fluorapatite, quartz, and fluorite, etc. Dingdaohengite-(Ce) is probably of bimetasomatic origin among Ca-Mg-carbonate rock and/or carbonatite, and REE-, F-rich postmagmatic hydrothermal solutions. The mineral is black and becoming brown black in thin fragments. It is translucent to opaque with a submetallic-metallic luster, and a brown streak. It is brittle with conchoidal fracture. No cleavage or parting is observed. Its hardness is VHN 25.6, 606–717.4 kg/mm² (Mohs hardness near 5.9). The measured density is 4.83(7) g/cm³ and the calculated density is 4.88(0) g/cm³. Its reflectance values (for ʎ = 589 nm) are 11.4–12.5%. It is biaxial negative. The strongest six X-ray diffraction lines in the powder pattern [d in Å (l)] are 2.7524(10) (212), 2.7263(98) (313), 3.1978(68) (212), 2.5460(54) (304), 2.8702(52) (020), and 3.1622(46) (212).

An electron-microprobe analysis on the crystal used to collect X-ray intensity data for crystal-structure refinement gives SiO2 19.29, TiO2 18.26, Al2O3 8.49, Fe2O3 1.67, ThO2 0.16, MgO 1.32, CaO 2.17, Nb2O5 0.47, Ta2O5 0.00, La2O3 19.53, Ce2O3 28.08, Nd2O3 n.d., Y2O3 0.00, Na2O 0.00, sum 99.48 wt%; the Fe2+ /Fe3+ ratio was converted by Mössbauer spectroscopy. The empirical formula is (Ce2+1.1La0.6Ca0.4Th0.0)2+Fe3+(Ti4+1.9Fe2+1.1Mg0.4Fe2+0.0)Σ2+Fe2+0.0(Ti1.98Nb0.02)Σ2+O, based on 22 O atoms with prevalence of Ti in the C1 site of the structure. Dingdaohengite-(Ce) is monoclinic, a = 13.4656(15) Å, b = 5.7356(6) Å, c = 11.0977(12) Å, β = 100.636(2)°, V = 842.39(46) Å³, and Z = 2.

The crystal structure of dingdaohengite-(Ce) was refined with space groups P2₁/a and C2/m. Pseudo-extinction was found, i.e., reflections with h + k = 2n are systematically strong, while those with h + k = 2n + 1 are weak, which show that the true space group of dingdaohengite-(Ce) is P2₁/a (pseudo-C2/m).

Keywords: Dingdaohengite-(Ce), P2₁/a (pseudo-C2/m) space group, chevkinite subgroup, new mineral, Bayan Obo, China

INTRODUCTION

Chevkinite is not only a name given to a mineral species; it is also a group and subgroup name for the REE (or Sr)-Fe (or Zr)-Ti silicate minerals. As a mineral species from Urals, Russia, it was named after General-Major Konstatin Vladimirovich Tschevkin (Chevkin) (1802–1875), Chief of Staff of the Russian Mining Engineers Corps., by a German mineralogist Rose as early as 1839 (Vlasov et al. 1964). About 150 years later, it had been redefined as chevkinite-(Ce) by Nickel and Mandarino (1987). The chevkinite group can be divided into two subgroups according to the β angle: the chevkinite subgroup with β ≈ 100° and the perrierite subgroup with β ≈ 113°. Chevkinite-(Ce), polyakovite-(Ce) (Popov et al. 2001), and maoniupingite-(Ce) (Shen et al. 2005) should fit into the chevkinite subgroup. Strontiochevkinite, which has been described by Haggerty and Mariano (1983), is isostructural with perrierite-(Ce) but not with chevkinite-(Ce) (Toraya 1993; Miyawaki et al. 2002). It is noteworthy that the actual space groups of chevkinite group minerals and its synthetic materials are under discussion in the past 50 years, and a natural member with space group P2₁/a in this mineral subgroup has not been found.

Fortunately, we found such a mineral, which is isostructural with chevkinite-(Ce), space group P2₁/a with Ti dominant at the