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Dingdaohengite-(Ce) from the Bayan Obo REE-Nb-Fe Mine, China: Both a true polymorph of perrierite-(Ce) and a titanic analog at the *C*1 site of chevkinite subgroup

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ABSTRACT

Dingdaohengite-(Ce), ideally $Ce_4Fe^{2+}Ti_2Ti_2(Si_2O_7)_2O_8$, 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_{25g} 606.0–717.4 kg/mm^2 (Mohs hardness near 5.9). The measured density is 4.83(7) g/cm^3 and the calculated density is 4.88(0) g/cm^3. Its reflectance values (for λ = 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 (*I*) (*hkl*)] are 2.7524(100)($\bar{1}$21), 2.7263(98)(313), 3.1978(68)(212), 2.5460(54)($\bar{3}$04), 2.8702(52)(020), and 3.1622(46)($\bar{3}$12).

An electron-microprobe analysis on the crystal used to collect X-ray intensity data for crystal-structure refinement gives SiO_2 19.29, TiO_2 18.26, Al_2O_3 0.04, FeO 8.49, Fe_2O_3 1.67, ThO_2 0.16, MgO 1.32, CaO 2.17, Nb_2O_5 0.47, Ta_2O_5 0.00, La_2O_3 19.53, Ce_2O_3 28.08, Nd_2O_3 n.d., Y_2O_3 0.00, Na_2O 0.00, sum 99.48 wt%; the Fe^{3+}/Fe^{2+} ratio was converted by Mössbauer spectroscopy. The empirical formula is $(Ce_{2.13}La_{1.49}Ca_{0.48}Th_{0.01})_{\Sigma 4.11}Fe^{2+}(Ti_{0.88}Fe^{2+}_{0.47}Mg_{0.41}Fe^{3+}_{0.26}Al_{0.01})_{\Sigma 2.03}(Ti_{1.96}Nb_{0.04})_{\Sigma 2.00}(Si_2O_7)_2O_8$, based on 22 O atoms with prevalence of Ti in the *C*1 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) Å^3, and Z = 2.

The crystal structure of dingdaohengite-(Ce) was refined with space groups $P2_1/a$ 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 $P2_1/a$ (pseudo-$C2/m$).

Keywords: Dingdaohengite-(Ce), $P2_1$/a (pseudo-$C2/m$) space group, chevkinite subgroup, new mineral, Bayan Obo, China