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Qingsongite, natural cubic boron nitride: The first boron mineral from the Earth's mantle

Larissa F. Dobrzhinetskaya[1,*], Richard Wirth[2], Jingsui Yang[3], Harry W. Green[1], Ian D. Hutcheon[4], Peter K. Weber[4] and Edward S. Grew[5]

[1]Department of Earth Sciences, University of California at Riverside, 900 University Avenue, Riverside, California 92521, U.S.A.
[2]Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Section 3.3, Chemistry and Physics of Earth Materials, Telegrafenberg, C 120, D-14473 Potsdam, Germany
[3]Key Laboratory for Continental Dynamics, Institute of Geology, Chinese Academy of Geological Sciences, 26 Baiwanzhuang Road, Beijing, 100037, PR China
[4]Glenn T. Seaborg Institute, Lawrence Livermore National Laboratory, 7000 East Avenue, Livermore, California 94550, U.S.A.
[5]School of Earth and Climate Sciences, 5790 Bryand Global Sciences Center, University of Maine, Orono, Maine 04469-5790, U.S.A.

Abstract

Qingsongite (IMA 2013-30) is the natural analog of cubic boron nitride (c-BN), which is widely used as an abrasive under the name "Borazon." The mineral is named for Qingsong Fang (1939–2010), who found the first diamond in the Luobusa chromitite. Qingsongite occurs in a rock fragment less than 1 mm across extracted from chromitite in deposit 31, Luobusa ophiolite, Yarlung Zangbu suture, southern Tibet at 29°13.86N and 92°11.41E. Five electron microprobe analyses gave B 48.54 ± 0.65 wt% (range 47.90–49.2 wt%); N 51.46 ± 0.65 wt% (range 52.10–50.8 wt%), corresponding to $B_{1.113}N_{0.887}$ and $B_{1.087}N_{0.913}$, for maximum and minimum B contents, respectively (based on 2 atoms per formula unit); no other elements that could substitute for B or N were detected. Crystallographic data on qingsongite obtained using fast Fourier transforms gave cubic symmetry, $a = 3.61 \pm 0.045$ Å. The density calculated for the mean composition $B_{1.100}N_{0.900}$ is 3.46 g/cm^3, i.e., qingsongite is nearly identical to synthetic c-BN. The synthetic analog has the sphalerite structure, space group $F\bar{4}3m$. Mohs hardness of the synthetic analog is between 9 and 10; its cleavage is {011}. Qingsongite forms isolated anhedral single crystals up to 1 μm in size in the marginal zone of the fragment; this zone consists of ~45 modal% coesite, ~15% kyanite, and ~40% amorphous material. Qingsongite is enclosed in kyanite, coesite, or in osbornite; other associated phases include native Fe; TiO_2 II, a high-pressure polymorph of rutile with the αPbO_2 structure; boron carbide of unknown stoichiometry; and amorphous carbon. Coesite forms prisms several tens of micrometers long, but is polycrystalline, and thus interpreted to be pseudomorphic after stishovite. Associated minerals constrain the estimated pressure to 10–15 GPa assuming temperature was about 1300 °C. Our proposed scenario for formation of qingsongite begins with a pelitic rock fragment that was subducted to mid-mantle depths where crustal B originally present in mica or clay combined with mantle N ($\delta^{15}N = -10.4 \pm 3$‰ in osbornite) and subsequently exhumed by entrainment in chromitite. The presence of qingsongite has implications for understanding the recycling of crustal material back to the Earth's mantle since boron, an essential constituent of qingsongite, is potentially an ideal tracer of material from Earth's surface.

Keywords: Cubic boron nitride, deep mantle, crustal boron, mantle nitrogen