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High-Resolution Transmission Electron Microscopy Study of Polytypic Faults in Bixbyite

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The mineral Bixbyite, $(Mn,Fe)_2O_3$, characterized in this study was found at Thomas Range (Utah) where it occurs in the cavities of a rhyolite host rock in association with topaz, pseudobrookite, braunite, hematite, hausmannite and quartz [1]. Bixbyite crystallizes in the Ia3 space group, forming black cubic crystals with metallic lustre that are commonly truncated by small icositetrahedral faces at corners. Most of the bixbyite crystals from Thomas Range show distinct reentrant facets at halfway of every edge of the cube, linked by a band of parallel notches, crossing at the center of each cube face. According to the morphological features these crystals appear as {100} twins; however, any twinning operation on {100} planes of the centrosymmetric bixbyite structure would produce an identical crystal, suggesting that these features are in fact a novel type of polytypic faults.

In order to disclose the nature of the defects, scanning electron microscopy (SEM) in conjunction with energy dispersive X-ray spectroscopy (EDS) was used to determine the chemical composition of bulk bixbyite versus the intrinsic fault regions. High-resolution transmission electron microscopy (HRTEM) was used to study the atomic structure of the polytypic faults. HRTEM images showed polytypic faults running along {100} planes of the bixbyite structure. The interfaces are atomically sharp and planar over large areas of the crystal. TEM/EDS analyses revealed the presence of Si in the fault regions with a simultaneous increase of the Mn content. The composition of the polytypic faults closely corresponds to a manganese silicate braunite, $Mn^{2+}Mn_6^{3+}SiO_{12}$ [2]. Small precipitates in close proximity to the planar faults suggest an increased diffusion rate along those defects.

References

[1] Christiansen E.H. *et al*., Am. Mineralogist **69** (1984) 223-236.

[2] Johan P. R. de Villiers and Peter R. Buseck, Am. Mineralogist **74** [11-12] (1989) 1325-36.