American Mineralogist, Volume 91, pages 1739–1746, 2006

Effects of natural radiation damage on back-scattered electron images of single crystals of minerals

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ABSTRACT

Generally, it has been assumed that signal intensity variations in back-scattered electron (BSE) images of minerals are mainly controlled by chemical heterogeneity. This is especially true for images of single crystals, where effects of different crystal orientations with respect to the incident beam on the observed BSE are excluded. In contrast, we show that local variations of the structural state within single-crystals (i.e., degree of lattice order or lattice imperfectness) may also have dramatic effects on the back-scattering of electrons. As an example, we present BSE images of single-crystals of natural zircon, $ZrSiO_4$, whose intensity patterns are predominantly controlled by structural heterogeneity, whereas effects of chemical variations are mostly negligible. In the case of natural zircon, structural heterogeneity affecting the BSE patterns is predominantly due to heterogeneous accumulation of radiation damage. We attempt to explain our observations with lowered penetration and channeling and, thus, enhanced back-scattering of electrons in more radiation-damaged internal zones and micro-areas. Back-scattered electron contrast of natural zircon is, therefore, considered as a special case of electron channeling contrast. This phenomenon seems to have been generally underappreciated in the discussion of BSE images of radiation-damaged minerals thus far.

Keywords: Electron microscopy, BSE imaging, Raman spectroscopy, zircon