American Mineralogist, Volume 97, pages 1544–1563, 2012

Brittle-ductile microfabrics in naturally deformed zircon: Deformation mechanisms and consequences for U-Pb dating

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Abstract

We present an electron backscatter diffraction, cathodoluminescence, and radiogenic U-Pb dating study of large zircon grains (0.8–1.5 mm) that show evidence of intracrystalline deformation, fracturing, grain size reduction and a large spread in U-Pb ages. The samples are from an amphibolite facies deformation zone within granulite facies anorthositic rocks (Bergen Arc, Norway). Large zircon grains show three main lattice distortion types: (I) distortions with rotations around <001> and an orientation change of ~0.3 °/μm subparallel to (100); (II) highly distorted, half circular shaped zones located at grain edges with at least 0.8–1°/μm distortions; and (III) low-angle boundary networks forming deformation zones up to 100 μm wide. Types II and III distortions exhibit significant disturbances of the otherwise homogeneous CL signature.

Crystal plastic deformation with the slip system [010](100) resulted in type I distortions. Stress concentrations at grain contacts between rheologically hard grains caused localized crystal plastic deformation with minor amount of microfracturing forming type II distortions. Type III distortions formed by crystal plastic deformation often associated with inclusions using several slip systems. Distortions of types I and II show minor and moderate resetting of the original ca. 900 Ma zircon grains, respectively, due to enhanced pipe diffusion along dislocation walls. In type II distortions, accelerated lattice diffusion through the highly distorted crystal lattice, combined with exceptionally high boundary to volume ratio, caused significant chemical disturbance and age resetting to 410 Ma. Fine-grained aggregates contain grains with low internal deformation and an oscillatory zoned CL signature (Z-grains) or high internal deformation and a disturbed CL signature (D-grains). Z- and D-grains are interpreted to have formed by heterogeneous nucleation and growth, and fracturing along strain-hardened low-angle boundaries present within types I and II, respectively. Z-grains show a clustered chemical signature with a 437 ± 11 Ma age interpreted to directly date the Caledonian amphibolite facies reworking.

Keywords: Zircon, electron backscatter diffraction (EBSD), lattice distortion, stress concentrations, recrystallization, U-Pb dating