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Recrystallization rims in zircon (Valle d'Arbedo, Switzerland): An integrated cathodoluminescence, LA-ICP-MS, SHRIMP, and TEM study

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Abstract

Recrystallization rims are a common feature of zircon crystals that underwent metamorphism. We present a microstructural and microchemical study of partially recrystallized zircon grains collected in polymetamorphic migmatites (Valle d'Arbedo, Ticino, Switzerland). The rims are bright in cathodoluminescence (CL), with sharp and convex contacts characterized by inward-penetrating embayments transgressing igneous zircon cores. Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) data and transmission electron microscopy (TEM) imaging indicate that the rims are chemically and microstructurally different from the cores. The rims are strongly depleted in REE, with concentrations up to two orders of magnitude lower than in the cores, indicating a significant loss of REE during zircon recrystallization. Enrichment in non-formula elements, such as Ca, has not been observed in the rims. The microstructure of zircon cores shows a dappled intensity at and below the 100 nm scale, possibly due to radiation damage. Other defects such as pores and dislocations are absent in the core except at healed cracks. Zircon rims are mostly dapple-free, but contain nanoscale pores and strain centers, interpreted as fluid inclusions and chemical residues, respectively. Sensitive high-resolution ion microprobe (SHRIMP) U-Pb ages show that the recrystallization of the rims took place >200 Ma ago when the parent igneous zircon was not metamict. The chemical composition and the low-Ti content of the rims indicate that they form at sub-solidus temperatures (550–650 °C). Recrystallization rims in Valle d'Arbedo zircon are interpreted as the result of the migration of chemical reaction fronts in which fluid triggered in situ and contemporaneous interface-coupled dissolution-reprecipitation mechanisms. This study indicates that strong lattice strain resulting from the incorporation of a large amount of impurities and structural defects is not a necessary condition for zircon to recrystallize. Our observations suggest that the early formation of recrystallization rims played a major role in preserving zircon from the more recent Alpine metamorphic overprint.

Keywords: Alps, microstructure, recrystallization, trace elements, U-Pb geochronology, zircon