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NanoSIMS study of seismically deformed zircon: Evidence of Y, Yb, Ce, and P redistribution and resetting of radiogenic Pb

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Abstract

Lattice defects in zircon can cause trace elements redistribution and disturbance of isotopic systems. This study investigates in detail how seismically induced deformation microstructures in zircon correlate with trace element and isotope re-equilibration.

Felsic mylonites with pseudotachylyte veins from the Ivrea-Verbano Zone in Northern Italy were studied with special focus on deformed zircon. We have revealed the following post-growth deformation microstructures: planar deformation bands (PDBs), planar fractures (PFs), non-planar fractures (both healed and open), and finite strain patterns. PDBs are planar portions of crystal lattice that are strictly parallel to {100} crystallographic planes, and are rotated to up to 3° with respect to the host grain. They are from 0.5 to 1 μm wide and have average spacing of 5 μm. PDBs originate in seismically active environment at elevated differential stress, strain rate and temperature.

Several grains, in which PDBs are observed, were analyzed with ion microprobe. Ion maps indicate redistribution of radiogenic Pb isotopes associated with PDB formation. Isotopic redistribution preferably occurs in PDBs with larger crystallographic misorientation. Profiling demonstrated clear spatial correlation of PDBs with variations of REE abundances (both gain and loss), and possible correlations with increased and decreased Hf, Ti, and P abundances. Trace elements can be depleted or enriched (compared to the abundance in surrounding matrix) in deformed domains, depending on the spacing of PDBs and the proximity of the analyzed volume to grain boundary or to detrital core. $^{207}Pb/^{206}Pb$ ratio demonstrates systematic Pb-loss in the PDB-bearing lattice domains with respect to PDB-free domains; in some cases Pb-gain is observed, where the PDBs source radiogenic Pb from older detrital cores.

Our study has important implications for geochronology and microchemistry of zircon from seismically deformed sections of Ivrea-Verbano Zone and from other paleo-seismic zones of the world. Zircon found in seismically deformed rocks near pseudotachylyte veins may demonstrate distorted and even reset isotopic ages, and altered trace element abundances. Enhanced trace element exchange between deformed zircon and host mylonite can influence mass-balance calculations for the bulk rock.

Keywords: Paleo-seismic zones, zircon, planar deformation bands, trace elements, isotopes, geochronology, ion microprobe