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CRYSTAL-PLASTIC DEFORMATION OF ZIRCON AND ITS EFFECT ON MICROCHEMISTRY AND GEOCHRONOLOGY

Kovaleva, E.[1, 2], Klötzli, U.[1] & Habler, G.[1]

[1]Department of Lithospheric Research, University of Vienna, Althanstrasse 14, UZA II, 1090, Vienna, Austria
[2]Department of Geology, University of the Free State, Nelson Mandela Drive 205, 9300, Bloemfontein, South Africa

The research is focused on zircon grains derived from high-temperature ductile shear zones from the western Tauern Window (Eastern Alps), the Ivrea-Verbano zone (Southern Alps) and the Ötztal-Stubai crystalline complex (Eastern Alps). Zircon from the shear zones has been affected by crystal-plastic deformation. We have investigated plastically deformed zircon grains in-situ with secondary electron (SE) imaging, forward-scatter electron (FSE) imaging, electron backscatter diffraction (EBSD), field emission gun electron microprobe analyzer (FEG-EMPA) and nano-scale secondary ion mass spectrometry (NanoSIMS).
We demonstrate that trace elements in zircon are being re-distributed in most of the crystals showing deformation microstructures. Low angle boundaries and distorted lattice domains are usually depleted in Y, Yb (HREE), U, Pb and enriched in Ce and Nd (LREE). Thus we conclude that the behaviour of trace elements in crystal-plastically strained crystal lattice is mainly controlled by the respective atomic radii. For Ti, Hf and P the re-distribution seemingly is more erratic and may primarily depend on the availability of these elements in the host matrix.
Measured age of zircons may be greatly affected by crystal-plastic deformation. Lattice distortion can cause lead isotope re-distribution and, therefore, relative rejuvenation or ageing of zircon domains:
a) Relative ageing of the zircon U-Pb system was observed in highly deformed rim domains, where a dense network of low- and high-angle boundaries is developed. The aging effect can be explained by contamination of the crystal lattice by common lead from grain exterior sources.
b) Relative rejuvenation of the U-Pb system is attributed to weakly deformed zircon domains in the grain interior. Invoked processes can either be an internal re-distribution of U and Pb or the simple loss of radiogenic Pb from the crystal lattice.
In both cases the degree of age shift is proportional to the dislocation density. The knowledge of the deformation state of a zircon crystal lattice and the understanding of the underlying deformation processes is thus essential to interpret measured U-Pb systematics from strained zircon. This on the other hand allows linking U-Pb ages in crystal-plastically deformed zircon to high-temperature ductile shear zone activity and thus may provide a potential to directly date high-temperature deformation events.