Pb nano-spheres in seismically deformed zircon from the Ivrea-Verbano Zone

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Zircon, the most common U-Pb geochronometer, may exhibit a great complexity of it internal structures, including growth zoning, lattice distortion and inhomogeneous distribution of trace elements and radiogenic isotopes on micro- and nano-scales. Zircon grains from the granulitic metapelites of the Ivrea-Verbano Zone in the Southern Alps are hosted by (ultra)mylonites and are associated with seismically-produced pseudotachylitic veins. In these tectonic settings, zircon grains were subject to crystal-plastic and brittle deformation regimes. The goal of our study was to investigate possible inhomogeneities of trace elements distribution at different scales, and, if present, to evaluate their effects on measured isotopic ages.

To reveal the zircon U-Pb age, zircon was studied by sensitive high-resolution ion microprobe (SHRIMP). To characterize deformation patterns in zircon we employed electron backscatter diffraction (EBSD) mapping. To study the effect on trace elements distribution in the selected deformed grains we used secondary ion mass spectroscopy (NanoSIMS), and to decipher nano-textural features – transmitted electron microscopy (TEM).

The U-Pb age of analysed zircon is 280 Ma with inherited cores yielding 574 Ma. The age of 280 Ma indicates the time of peak granulite metamorphic conditions in the unit.

EBSD mapping indicated planar deformation bands (PDBs) and other crystal-plastic deformation patterns, such as chess-board patterns, bending of the lattice, marginal grain size reduction; as well as planar, curviplanar and non-planar fractures. NanoSIMS mapping documented clusters of radiogenic Pb associated with the PDBs with higher degree of misorientation. PDBs also facilitate diffusion of Y, Yb, Ce and P in the affected grains.

The TEM study revealed arrays of straight dislocations in glide configuration, indicating crystal-plastic deformation without annealing. Crystalline Pb nanospheres of 5-7 nanometer diameter, not associated with the dislocations, were also documented with TEM. Nanospheres usually contain other elements such as Si, Al, Na and Ca. In contrast to Pb spheres documented in UHT Enderby Land (Antarctica) and Kerala Khondolite Belt (India), which are built of metallic Pb, the spheres in Ivrea-Verbano Zone are composed of Pb oxide. Oxidation might be caused by the presence of fluid, as the nanospheres are frequently associated with porosity, which, in turn, could be a product of fluid-induced dissolution-reprecipitation.

This is the youngest documented population of zircon with Pb spheres in deformed crystal lattice. Our observations shed a new light on the Pb behaviour in zircon, and, following this discovery, the existing model of nanosphere formation mechanism should be revised. We did not find any noticeable effect of Pb nanospheres on measured U-Pb ages.