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## Planar deformation bands in zircon: a new evidence of seismicity

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Our discovery of planar microstructures in zircon from paleo-seismic zones demonstrates that they are not exclusively attributed to impactites, but can also form as a result of seismic activity in the upper crust.

Deformed zircons were found in the high-grade metapelitic rocks of the Ivrea-Verbano Zone, Southern Alps (Northern Italy). Sampled granulitic mylonites contain pseudotachylytic veins resulting from frictional melts and are associated with ultramylonites. Planar microstructures formed in zircon at ~10 km depth due to unusually high differential stresses and strain rates generated by earthquakes and/or due to shearing at elevated temperatures in the vicinity of frictional melts.

The interior of polished zircon grains ranging from 30 to 150 mμ in length were investigated with optical microscope and scanning electron microscope (SEM) techniques, including secondary electron (SE), backscattered electron (BSE), forescatter electron (FSE), cathodoluminescence (CL) imaging, crystallographic orientation mapping by electron backscatter diffraction (EBSD) analysis, and secondary ion mass spectroscopy (NanoSIMS). Among different cataclastic and crystal-plastic deformation microstructures in zircon we identified characteristic planar deformation bands (PDBs), planar fractures (PFs), and curviplanar fractures (CFs). Planar features form in specifically oriented grains with <c> axis parallel to the stretching lineation. Planar deformation bands in zircon appear as contrast lamellae in orientation contrast images and in EBSD maps, and in rare cases can be observed with an optical microscope. They are crystallographically controlled planar lattice volumes with misorientation from the host grain, which can reach up to 3°. PDBs are strictly parallel to {100} crystallographic planes, are 0.3-1 μm wide with an average spacing of 5 μm. Discovered structures represent a result of crystal-plastic deformation of zircon lattice with operating dislocations having <100>{010} glide system and <001> misorientation axis. PDBs are different from well-known impact-related planar deformation features (PDFs), because they occupy other crystallographic planes and are not amorphous [2,3]. Furthermore, we have demonstrated that formation of PFs in zircon takes place not only during impacts, but also in seismically active zones. We observe at least two cases of PFs formation with {100} orientation: (1) as a result of evolution of PDBs and (2) as micro-cleavage [1].

Portions of zircon grains that contain PDBs were investigated with NanoSIMS, with the goal to study the effect of PDBs on trace elements isotope distribution. We have found that PDBs cause re-distribution and loss of radiogenic lead isotopes which result in systematic rejuvenation of the affected domains. Moreover, PDBs may facilitate enhanced pipe diffusion of REE, Hf, and possibly P and Ti. These effects can be very important for zircon microchemistry and geochronology, and may be used in the future as a tool for dating of seismic events.

According to the new findings, planar deformation bands and planar fractures in zircon derived from the deep tectonic settings represent newly recognized evidence of seismicity, and help to understand how seismic energy is released at depth and interacts with metamorphic processes [1].

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