PLASTIC DEFORMATION OF ZIRCON: A HIGH-T DEFORMATION DATING TOOL?

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Most differential or incremental material motion during tectonic processes is taken up by shear zones. These work at different size scales, temperatures, pressures, fluid compositions and time scales and inevitably involve the deformation of minerals. The unambiguous exact quantification of these parameters is vital for the geologically meaningful reconstruction of tectonic processes. In this respect especially the age and duration of tectonic processes is important.

Traditionally, "ages" of shear zone activity are determined by Rb/Sr and Ar/Ar mica dating. But due to the low closing temperatures in micas temperatures higher than ca. 500 °C cannot be dated by mica chronometry. Thus any shear zone activity above 500 °C is undetectable by these methods. Other possibilities can be Sm/Nd and Lu/Hf dating of garnet or Ar/Ar dating of amphiboles. Garnet dating is problematic because single mineral dating is not possible. Thus internal isochrons or whole rock - mineral isochrons have to be sought. This approach is often hampered by an open system behaviour of rocks undergoing deformation.

The in-situ U/Th/Pb dating of zircon has the potential to overcome the above mentioned drawbacks:

Zircon is plastically deformed by recovery and/or subgrain rotation recrystallisation that indicates formation and migration of dislocations under high-T conditions in a stress field. Plastic deformation in zircon occurs during deformation events due to stresses associated with the collision of zircon crystals with surrounding mineral phases. Different crystals domain showing different amounts of deformation are linked by so called low angle boundaries. These potentially act as a fast diffusion pathways facilitating Pb, Ti, U, Th and trace element mobility in the crystals. Crystal-plastic deformation in zircon can thus cause rapid redistribution (outwards diffusion) of radiogenic Pb which leads to a partial or complete rejuvenation of the U/Th/Pb ages. Due to the high closing temperature of the U/Th/Pb system in zircon (> 800 °C) the detection of such ages potentially allows the dating of the high-T deformation events at T > 500 °C. And due to the robustness of zircon low angle boundaries and associated U/Th/Pb age disturbances can be preserved at crustal temperatures for billions of years.