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Titanium-in-quartz geothermometry (TitaniQ) in mylonites of the Simplon Fault Zone, Switzerland

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The Simplon Fault zone (SFZ) is a major detachment fault between the Upper and Lower Penninic Units in the Central Alps and comprises mylonitic quartz microstructures deformed under the presence of water (Mancktelow & Pennacchioni 2004 and references therein) at metamorphic conditions ranging from lower greenschist facies (N) to upper amphibolite facies conditions (S). In order to study strain localization history in this large-scale structure, different sample series were collected in profiles across the Simplon fault to investigate the changes in dynamic recrystallization mechanisms and recrystallized grain size of quartz.

In the case of pure quartz mylonites (former qtz veins and qtz lenses), fine-grained recrystallized and large ribbon quartz grains occur within a ca. 500 meter wide high strain zone. The recrystallized grain size in this fault zone generally is reduced compared to the undeformed veins, but the degree of grain size reduction varies strongly. The mechanisms of dynamic recrystallization are not only a function of the distance to the SZ, but also of strain localization, depending on the particular strain rate and temperature conditions (Hirth and Tullis, 1992 and Stipp et al. 2002, 2010). In order to track down the effect of temperature, titanium-in-quartz geothermometry (TitaniQ, Wark & Watson 2006) was applied using LA-ICP-MS on thick slices of quartz, displaying both, host grains (also ribbons) as well as dynamically recrystallized grains. In this way, sample series covering a range of distances to the fault from 3 m up to 4000 m were investigated. Temperatures were calculated using the equation of Wark & Watson 2006 and Ti activities of 0.6, 0.8 and 1.0:

$$T(^{\circ}C) = \frac{-3765}{\log(X\frac{qtz}{Ti}) - 5.69} - 273$$

In the studied quartz microstructures we obtain a temperature variation from 375 up to 530°C. Interestingly, the foot wall samples at the farthest locations to the shear zone center display +/- the highest temperatures, whereas samples near the SZ center yield temperatures of around 440 °C. Despite this general temperature trend, local deviations enable interesting insights into the timing and the processes involved into chemical equilibration of Ti in quartz. For example, in the case of strongly elongated quartz ribbons, which were deformed under low temperature plasticity under absence of dynamic recrystallization, still the high temperature event is preserved. This observation suggests that the quartz grains survived a first stage of large-scale strain localization and were only deformed during a late deformation event during which dynamic recrystallization was disabled in quartz. On the other hand, host quartz grains embedded in a fine-grained recrystallized quartz mylonite display similar low temperatures as found in the surrounding recrystallized aggregates. In this case, we assume a synkinematic formation of the quartz veins under low temperature conditions, where the host quartz was only partly recrystallized. We therefore conclude that most of the host grains show inherited temperatures reflecting either high or low temperature deformation, depending on their age of formation. Only the combination with measurement of the recrystallized matrix allows a further discrimination with this respect. In this sense, TitaniQ can indeed be a powerful geothermometer in quartz mylonites, provided that the measurements are accompanied by careful microstructural analyses and the careful selection of the samples with respect to the kinematic framework of the large-scale shear zone.|