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Influence of deformation and fluids on the Ti exchange in quartz

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In the last 10 years, many attempts have been mad to use the titanium-in-quartz geothermobarometer (TitaniQ) to constrain the ambient conditions during mylonitization of quartz in metamorphic rocks. However, most of the studies have shown that the TitaniQ is not readily applicable. First, the application of the TitaniQ calibrations[1-2] is possible if two of the relevant variables (temperature, pressure and Ti activity) can be fixed. But the results of both calibrations can deviate by >100°C. Secondly, several studies have shown that deformation/recrystallization processes, the availability of aqueous fluids, the amount of strain and the duration of deformation result in microstructures with a heterogeneous distribution of Ti concentrations [Ti]. Therefore, in most cases, homogenous and complete equilibration of the [Ti] at the ambient conditions of deformation does not occur. In quartz mylonites, the microstructure is commonly complex as result of strain partitioning and total accumulated strain. For such a complex rock the challenge for applying TitaniQ is to identify those domains where Ti re-equilibration to the syn-kinematic ambient conditions, did possibly occur. Identifying such domains requires the strict integration of correlated high-resolution analysis by optical microscopy, SEM-CL, EBSD and Ti-in-qtz analysis using secondary ion mass spectrometry (SIMS). This integrated information especially provides a robust interpretative tool for the interplay between grain-scale deformation, fluid-rock interaction, geochemical exchange and the evolution of the crystallographic preferred orientation during progressive strain.

We present the study of the deformation microstructures of quartz veins (Schober Group, Eastern Alps) as key example of such an integrated data collection to unravel characteristic deformation processes responsible for the partial or complete resetting of the Ti-in-quartz system under retrograde conditions. The Schober quartz veins developed at amphibolite facies conditions (510-590 °C, 0.5-0.6 GPa) and were overprinted by deformation at lower greenschist facies. Subgrain rotation (SGR) recrystallization was the dominant recrystallization mechanism during mylonitization. During deformation complete resetting of the initial [Ti] of 3-4 ppm down to 0.2-0.6 ppm occurred in domains (e.g. pressure shadows) where sufficient fluids were available and could percolate through the microstructures. High strain and pervasive quartz dynamic recrystallization did not necessarily result in homogeneous and complete re-equilibration of the [Ti]. Our study reveals that subgrain boundaries were locally pathways for partial [Ti] reset.

Using the example of mylonitized quartz veins from the Schober Group in the Austroalpine domain of the Eastern Alps, we aim at showing that the initial Ti-in-qtz and corresponding CL signature of the quartz vein is reset to different degrees even at high strains and pervasive dynamic recrystallization, depending on the availability of fluids and its repartitioning.

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