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Ti distribution in quartz across a heterogeneous shear zone within a granodiorite: the effect of deformation mechanism and strain on Ti resetting

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The study of a heterogeneous ductile shear zone developed at ca. 500 °C and 0.2 GPa during post-magmatic cooling of a granodiorite allows the effect of strain and recrystallization on Ti re-equilibration of quartz to be assessed. Understanding this effect is critical for applying Ti-in-quartz (TitaniQ) thermobarometry to mylonites.

Differently strained quartz across the shear zone shows a heterogeneous distribution of Ti (measured by SIMS) with overall Ti range between 2 and 45 ppm. Quartz cathodoluminescence (CL) is proved by spectral analysis to be univocally correlated to Ti content and CL images were calibrated as Ti maps using SIMS measurements. Coarse grained weakly deformed domains consist of magmatic quartz extensively recrystallized by grain boundary migration (GBM) and mostly (65-75% area) contain 20-38 ppm Ti. Ti resetting to lower amounts occurred locally: (i) in haloes surrounding titanite and biotite inclusions (Ti as low as 6 ppm); (ii) along grain boundaries and healed microfractures; and (iii) towards the quartz domain boundary. With increasing strain quartz underwent progressive grainsize reduction and developed a bimodal microstructure with elongate grains (>100's μm long) surrounded by mantles of new grains (10-30 μm in size) recrystallized by subgrain rotation (SR). Dynamic recrystallization by SGR, associated with prism <a> slip, became increasingly important over GBM as strain increased towards the shear zone core. Relevant resetting of Ti in quartz only occurred in high strain domains (shear strain gamma $\geq$ 10) in the shear zone core where fine recrystallization amounts at 50-60% area and coarser cores are strongly substructured. These domains are not compositionally homogeneous and still show a range of Ti content between 2 and 10 ppm. In all strain facies of the shear zone quartz-filled pressure shadows associated with feldspar show an almost constant Ti of $\sim$ 2ppm. Therefore the pristine Ti content of the magmatic quartz mylonitized in the shear zone core is significantly reset and "asymptotically" converges towards the "equilibrium" 2ppm values shown by new quartz precipitated in pressure shadows. It is inferred that extensive recrystallization by SGR and iterated cycles of dislocation creep and rearrangement provided fluid access to quartz interior promoting chemical buffering and leading to partial re-equilibration.

The study indicates that TitaniQ has not a simple application in these mylonites, especially because of incomplete resetting of the pristine Ti content of quartz and this represents a warning for use of this thermobarometer in mylonites. However, Ti in quartz in combination with SEM-CL imaging appears a very powerful tool for investigation of grain scale deformation mechanism in mylonites.