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Effects of recrystallization and strain on Ti re-equilibration in quartz in a cooling pluton

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Since a couple of years the trace amount of Ti in quartz (Ti-in-quartz or TitaniQ) has been used to constrain the deformation temperature in quartzitic rocks. Independently of how precise the estimate of deformation temperature could be, a basic question still remains controversial of how effective is dynamic recrystallization to reset the Ti in quartz in mylonites. The study of a heterogeneous ductile shear zone developed during post-magmatic cooling of a titanite-bearing granodiorite allows the effect of strain and recrystallization on Ti re-equilibration in quartz to be assessed.

The different strain facies show a heterogeneous distribution of Ti content (measured by SIMS) which correlates well with cathodoluminescence (CL) intensity. In the granodiorite protolith CL-bright Ti-rich (20-38 ppm) quartz shows CL-dark Ti-poor haloes (Ti as low as 6-8 ppm) surrounding euhedral titanite. Grain-scale heterogeneities include Ti depleted (CL-darker) grain boundaries (Ti 4-6 ppm). In the protomylonite quartz shows a variable degree of recrystallization associated with strain gradients along S-C foliations anastomosing around feldspar porphyroclasts. Original CL-dark haloes surrounding titanite were passively stretched into the foliation; away from these haloes recrystallized quartz appears mainly bright in CL and retained high Ti contents as in the protolith. Quartz-filled pressure shadows, appended to disrupted feldspar porphyroclasts, show dark CL indicative of very low Ti content (1-3 ppm). In the mylonites and ultramylonites quartz forms totally recrystallized layers that are dominantly dark in CL but show internally a “subtle” CL layering subparallel to foliation reflecting variations of Ti in the range of 3 to 12 ppm. EBSD analysis of quartz indicates that prism <a> was the dominant crystallographic slip system, associated with subgrain formation and subgrain rotation recrystallization, at all stages of deformation. This indicates together with dynamic recrystallization of K-feldspar and plagioclase (Oligoclase: An 16-20%) deformation conditions at $\sim$500 °C.

We conclude that under, the dominant conditions of deformation at $\sim$500 °C: (i) Ti content is strongly dependent on microstructure; (ii) high strain and complete recrystallization by subgrain rotation produced only incomplete homogenization of Ti, (iii) water-assisted synkinematic precipitation of new quartz in pressure shadows dramatically changed the Ti content of quartz to very low values. These observations pose serious limitations to the use of the Ti-in-quartz thermo-barometer to constrain ambient conditions of ductile deformation.