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Temperature record of quartz mylonite during exhumation

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We present a study in which quartz microstructure, texture, geothermometry (Ti-in-quartz) and conventional thermobarometry are used to constrain the temperature of deformation in a granulite grade shear zone during exhumation and cooling.

The samples are from a major crustal detachment in central-south Madagascar. The 1 to 25 km thick Betsileo shear zone separates two contrasting major geological units: (1) the Antananarivo Block in the footwall and (2) in the hanging wall the Southwest Madagascar Block comprising several lithotectonic domains. Due to the complex deformation history of both blocks and of the shear zone there is no consensus on its kinematics and age but the shear zone was most likely playing major role in both crustal thickening and crustal thinning during the Late Neo-Proterozoic to Ordovician.

Quartz optical microstructure is characterized by the grain boundary migration recrystallisation as the dominant dynamic deformation mechanism, which together with chessboard extinction suggests peak deformation temperatures in excess of 650 °C. This microstructure is overprinted to different degree by the subgrain rotation recrystallisation. Because of the large grain size any standard crystallographic preferred orientation measurement would show single-grain texture and thus be statistically irrelevant. For this reason we performed texture measurements on a neutron texture goniometer which analyses rock cylinders 28 mm in diameter and 28 mm high. The obtained texture is consistent with high temperature of deformation inferred from the microstructure and thermobarometry. The kinematics of the shear zone is consistent with a dominant flattening rather than a plane-strain simple shear, which may be an additional reason why researchers disagree on the kinematics of the shear zone.

The analyses for the Ti-in-quartz thermometry were all done on the SHRIMP RG (Sensitive High Resolution Ion MicroProbe, Reverse Geometry), which allows for a high spatial resolution and high sensitivity of measurements. To link the temperature measurements to the microstructure and texture the samples were imaged by cathodoluminescence and electron backscatter diffraction before and after the SHRIMP measurements respectively. The range of within-sample temperature variation is consistent with the relative degree of the retrograde overprint. However there temperature distribution is more consistent with the CL pattern than with the microstructure and texture. Together with relatively low temperatures (500-550 °C) this suggest that the cooling and related volume diffusion of trace elements (i.e. Ti) in quartz outlasted the deformation.