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Timing and duration of brittle deformational events. Laser U-Pb SSI ages on calcite (Al Hajar Mountains, Oman)

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Ductile and brittle deformation reshapes our planet as a consequence of plate tectonics. While the relative age of these processes can be inferred with field and petrographic relationships, absolute timing of these multiphase processes is usually unclear. Most attempts to directly date these events have failed because mineral closure temperatures are too low for classical thermochronology.

This work aims to directly date timing and duration of brittle deformational processes recorded by calcite fibres from carbonate rocks. The study area is the Al Hajar Mountains in Oman and the method used is the U-Pb small scale isochrone (SSI) method recently developed at GUF. This area is known to be affected by multiple deformation events from the Cretaceous and therefore is a perfect target to apply this methodology.

The samples are cross-cutting calcite veins and fibres (orientated thin/thick sections) where in situ analyses were performed, using an Excimer laser coupled to an Element2 SF-ICPMS. This method is based on the fact that carbonates, that (re-)crystallised and equilibrated during an event, contain low but variable amounts of U and μ (238U/204Pb). Therefore, several analyses ($\sim$10 to 50) will yield variable U/Pb ratios and thus form an isochrone in the 207Pb/206Pb vs 238U/206Pb space. The age is interpreted to be lower intercept with the Concordia curve and the intercept with the y-axis to be the initial Pb isotope composition.

The geological background frame the deformational events from a late Cretaceous ophiolite obduction, followed by extension, to a Neogene shortening, where the timing of the uplift of the Al Hajar Mountains is a matter of debate. The results of this work show that top-south, layer-parallel shearing due to ophiolite obduction occurred in the Coniacian to early Campanian. Afterwards, top-NE early Paleocene layer-parallel veins developed during post-obduction exhumation. Eocene to early Miocene horizontal shortening formed strike-slip structures that cross-cut and reactivate older faults, mainly causing the current high topography of the Al Hajar Mountains. The youngest structures are crack-seal fibres in hairline veins dated as late Miocene to middle Pleistocene [1].

The results show that the SSI technique successfully constrains complicated successions of brittle deformational structures.

[1] Hansman, R. J. et al. (Geology, 2018). Absolute Age of Multiple Generations of Brittle Structures by U-Pb Dating of Calcite.