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Directly dating deformation with calcite U-Pb; the good, the bad and the ugly!

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Deformation in the upper crust is commonly accommodated by brittle fracturing, faulting and dissolution-precipitation creep. These short-lived, low temperature deformation processes are notoriously difficult to date as minerals commonly used to record geological time (such as zircon and monazite) typically do not crystallise or recrystallize in response to deformation under these conditions. Brittle fractures provide pathways for fluids, resulting in abundant calcite/quartz veins in the earth's upper crust. Analytical techniques have recently been developed for direct dating of brittle structures using U-Pb in calcite slickenfibres and syn-tectonic veins (e.g. Roberts and Walker, 2016; Nuriel et al., 2017). This has opened up a whole new realm of possible tectonic investigations in the upper crust.

This talk will explore the effectiveness of the U-Pb calcite dating technique for providing timing constraints for upper crustal deformation, fluid flow and mineralisation events. Like other unconventional geochronometers that have low U content and incorporate common Pb into their structures (e.g. titanite), calcite is not always suitable for U-Pb analysis and results can therefore be ambiguous to interpret. We present examples spanning the range of the 'good, bad and ugly' in the world of calcite U-Pb dating. Despite these challenges, we use case studies from continental-scale thrust and strike-slip faults including the Main Boundary Thrust in the Himalaya, the North Anatolian Fault, and the Big Creek Fault in the Yukon, Canadian Cordillera to demonstrate how U-Pb calcite dating can be successfully used to reconstruct the displacement history of these various first-order structures.

Roberts and Walker, 2016, Geology, 44, p. 531; Nuriel et al., 2017, Geology, 45, p.587