Synfaulting calcite U-Pb ages constrain the evolution of the Dead Sea Fault

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Time constraints on the early phases of brittle fault activity (>1 Ma) are seldom determined or involve very high uncertainties, thereby limiting our understanding of the long-term deformational history of faults and fault systems in the brittle environment. The use of U-Pb calcite dating allows us to see beyond 500 ka, and approach important tectonic questions for the first time. Traditional U-Pb bulk analyses for carbonate samples are time intensive and require large sample sizes. In this study, we utilize the latest advances in Laser Ablation techniques (LA) combined with multi-collector inductively coupled plasma mass spectrometry MC-ICPMS to analyze calcite material without chemical separation (in situ). The in situ approach offers several advantages over traditional bulk analyses, including, but not limited to, the preservation of samples for further analysis, considerable time savings, and better petrographic control.

We combine U-Pb chronology with calcite strain analyses, measured on twinned calcite, to demonstrate temporal and spacial changes in brittle fault activity. The method is applied to fault-related calcite samples such as breccia cement, fault-coating, and vein-fillings taken from different sites along the active Dead Sea Fault system (DSF). The results indicate possible propagation and localization of fault activity. The southern part of the DSF was active by 19 Ma while the northern part of the DSF in Israel was active by 15 Ma. In addition, the western fault in the southern part of the DSF was active before the more eastern fault (19 and 14 Ma, respectively). Four ages from the same site in northern Israel gave similar ages of 14.2 ±1.2 2σ, suggesting a well-developed plate boundary for a >500 km long sector by this time. Calcite strain analyses indicate a DSF-related strain field with a NNW-SSE direction of maximum horizontal shortening and a secondary N-S direction. The two directions may represent the far DSF-related strain field (NNW) and the local 'weak' subparallel direction (N-S), prevailing during the early stage of DSF evolution between 19 and 12 Ma.