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How to date faults, fractures and fluids with U-Pb calcite geochronology

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Calcite U-Pb geochronology is fast becoming a go-to method for dating brittle deformation. Utilisation of a LA-ICP-MS (Laser Ablation Inductively Coupled Plasma Mass Spectrometry) approach offers several advantages over traditional bulk-dissolution techniques, opening up the method to new applications. The speed of acquisition means that many samples can be screened to find suitable material, i.e. favourable 238U/204Pb (μ) and both U and Pb concentrations. The high spatial resolution that LA-ICP-MS offers is essential for sampling of small (<1 mm) crystals, individual growth domains of calcite, and for avoiding alteration domains. It also allows micro-domains with variable μ to be targeted, thereby increasing the precision of the resulting isochron through an increased spread of U-Pb ratios.

Calcite vein mineralisation takes many different forms but always represents precipitation of calcite from a fluid, as such, robust calcite dates have the potential to be linked to a fluid-flow event. Calcite dates can be linked to displacement and/or opening of a fracture (i.e. brittle deformation), only when the dated calcite can be demonstrated to have formed via crack-seal-slip mechanisms, and even then, it should be noted that calcite mineralisation brackets individual slip events. Secondary mineralisation and isotopic resetting present further hurdles to accurate linking of dates to events. Thus, as with any chronometer, calcite U-Pb geochronology requires a careful and considered approach. We present: 1) a broad framework for linking vein textures to dated events; 2) a methodological workflow that utilises various imaging and mapping techniques; and 3) selected examples to show application to faults, fractures and fluid-flow.