Dating faults with U-Pb calcite petrochronology

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Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) offers several advantages over traditional bulk-dissolution techniques for U-Pb calcite geochronology, opening up the method to new applications[1]. These advantages include speed of acquisition; this is beneficial in that many samples can be screened to find suitable material, i.e. favourable $^{238}U/^{204}Pb$ (μ) and U+Pb concentrations. More importantly, 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. Additionally, micro-domains with variable μ can be targeted, thereby increasing the precision of the isochron through increased spread of U-Pb ratios. U-Pb dates are linked to calcite growth and/or recrystallisation through imaging, using conventional techniques (back-scattered electron, cathodoluminescence) and elemental mapping with LA-ICP-MS.

To date faults, primary calcite growth within mineralised fault planes that exhibit crack-seal textures is targeted. Calcite with crack-seal growth is assumed to form at the same time as fault displacement, within the analytical uncertainty. We present examples from three types of calcite mineralisation with crack-seal texture: 1) repeated crack-seal-slip textures in localised pull-apart structures, 2) repeated crack-seal-slip textures as slicken-fibres, and 3) crack-seal growth within implosion breccia structures. Examples will be drawn from areas of applied geoscience: both conventional and unconventional hydrocarbon basins, and from nuclear waste repository sites. Additionally, we present contrasting results where calcite mineralisation dates fluid-flow through fractures, but does not constrain the timing of fault displacement.

[1]Roberts, N.M. and Walker, R.J., 2016. U-Pb geochronology of calcite-mineralized faults: Absolute timing of rift-related fault events on the northeast Atlantic margin. *Geology*, *44*, 531-534.