Andrew Whitham CASP Fieldwork Awards 2025 – Winner

Applicant: Kathryn Page
Project title: Coupled chemical-hydro-mechanical sealing processes in evaporitic mudrock-hosted fracture networks
Award: £2,200

Scientific question and rationale: Scientific question: How does fracture cement distribution change across fault zones in MMG? Rationale: The Mercia Mudrock Group (MMG) is a laterally extensive regional caprock being assessed as a prospective host rock for subsurface radioactive waste disposal and gas storage. The relatively low primary permeability is potentially compromised by fault-fracture networks through the group, but many of these have been sealed by carbonate or sulphate cements which have not been previously reviewed in detail. These cement-filled fractures contain significant information about the conditions of fracturing and sealing, and have implications for the future sealing capacity of the MMG.

Changes in cement chemistry can indicate different phases of fluid flow through a fracture network, for example a calcite cement in a more evaporitic member could suggest greater distance in fluid movement than a gypsum cement in the same member. Changing cement width and texture has implications for the hydro-mechanical state at point of cementation; coarser crystal texture and wider cement would imply a highly dilatant fracture, vs a fracture with very narrow width and slickensides, would indicate a higher slip tendency as in Ferril et al. (2020) and Cawood et al. (2024). In prior fieldwork, we saw fractures with multiple cement phases, suggesting reactivation. We anticipate that this has significant implications for fluid leakage associated with the migration of fluids and solutes (including radionuclides) in the subsurface, as the timeline of fracture sealing and correlation of types of sealing to formations within the MMG, are mostly unknown at present. This would assist in de-risking storage.

Specific objectives and deliverables:

- To measure changes in fracture width, cement chemistry and texture through fault-fracture networks. Displacement, dip, and fracture lengths will be measured as independent variables.
- To quantify distributions in cemented vs barren fractures.
- To generate a digitised map of cemented fracture networks in the study areas using drone imaging
- To report into the implications for conventional and dynamic fracture opening in mudrocks.

Proposed work plan: In the first year of the PhD study (Sept 2023 to Aug 2024), the characterisation of field sites around the Bristol Channel and the English South coast, as well as the description of major faults of interest have been completed. The focus for the Q1/2025 fieldwork will be on the collection of drone images which will allow me to mechanically model and map fracture intensities using the software FracPaQ. The main fieldwork is planned for Q2 to Q3 2025, focussing on 2-3 coastal sites in SW England where outcrops of MMG-hosted faults are more common. This will involve identification and analysis of:

- Useable fault-fracture networks in the cliff face, ideally those traceable in 3D.
- Wavecut platforms below high tide mark. We anticipate that these will be unlikely to provide us with undamaged gypsum textures. Therefore, they will only be used for carbonate (e.g. calcite, dolomite) cement fills.

Once a fault is located, the "primary" transect will be conducted along the fault zone, parallel to the fault plane, collecting dip, dip direction, fracture aperture, fracture fill chemistry and texture, of fracture in that fault zone. The "secondary" transect will be completed across the fault zone, perpendicular to the fault plane, collecting the same data for numerous fractures, with the additional calculation of "damage zone" fracture occurrence.

These important measures, with the exception of dip and dip direction, are not possible to quantify from the drone imagery so require the extra time allotted. The transect data is also important to ground truth the drone measures of dip and dip direction.

5 to 10 samples will be collected from fault core and clay gouge material for uranium series dating and stable isotope (oxygen, hydrogen, sulphur) analysis. This will facilitate relative dating of different phases of fracture cementation.

Equipment required: tape measure/meter rule, compass-clino, fieldnote book, drone camera (all in possession)

Proposed expenditure, including details of any other sources of funding: Travel to Bristol by train £250, followed by travel between sites by hire car - £500 (10 days, incl. petrol). Accommodation for 10 days fieldwork: is £100/night=£1000 with subsistence: £45/day=£450 - Total: £2200