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Fluid flow and permeabilities in basement fault zones

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Fault zones are important sites for crustal fluid flow, specifically where they cross-cut low permeability host rocks such as granites and gneisses. Fluids migrating through fault zones can cause rheology changes, mineral precipitation and pore space closure, and may alter the physical and chemical properties of the host rock and deformation products. It is therefore essential to consider the evolution of permeability in fault zones at a range of pressure-temperature conditions to understand fluid migration throughout a fault's history, and how fluid-rock interaction modifies permeability and rheological characteristics.

Field localities in the Rwenzori Mountains, western Uganda and the Outer Hebrides, north-west Scotland, have been selected for field work and sample collection. Here Archaean-age TTG gneisses have been faulted within the upper 15km of the crust and have experienced fluid ingress.

The Rwenzori Mountains are an anomalously uplifted horst-block located in a transfer zone in the western rift of the East African Rift System. The north-western ridge is characterised by a tectonically simple western flank, where the partially mineralised Bwamba Fault has detached from the Congo craton. Mineralisation is associated with hydrothermal fluids heated by a thermal body beneath the Semliki rift, and has resulted in substantial iron oxide precipitation within porous cataclasites. Non-mineralised faults further north contain foliated gouges and show evidence of leaking fluids. These faults serve as an analogue for faults associated with the Lake Albert oil and gas prospects.

The Outer Hebrides Fault Zone (OHFZ) was largely active during the Caledonian Orogeny (ca. 430-400 Ma) at a deeper crustal level than the Ugandan rift faults. Initial dry conditions were followed by fluid ingress during deformation that controlled its rheological behaviour. The transition also altered the existing permeability. The OHFZ is a natural laboratory in which to study brittle fault rocks, and younger Mesozoic age faults may provide analogues for the West Shetland basin.

Samples have been collected from both of these localities, and will be examined by optical and scanning electron microscopy. X-Ray micro-tomography will also be used to analyse the permeability characteristics of the fault rocks. Our understanding of fault zone permeability is crucial for a number of research areas, including earthquake geoscience, economic mineral formation, and hydrocarbon systems. As a result, this research has relevance to a variety of industry sectors, including oil and gas (and ccs), nuclear waste disposal, geothermal and mining.