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Fracture Sealing in Sedimentary Rocks: Micro- to Basin Scale Processes

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Fractures significantly enhance the bulk permeability of rock following the cubic law. Sealed fractures originally acted as fluid conduit, its microstructure giving constraints on the fracture aperture. In this contribution, we will summarize our numerical and experimental approaches, which explore the fundamental principles of fracture sealing on a microscale. Numerical modelling shows the variation in microstructure, leaving almost no fracture aperture to form fibrous veins. Lateral along-fracture transport seals the inlet, as shown by analogue and hydrothermal experiments. Results are used for case studies of reservoir rocks (limestones/Oman, sandstones/Germany) covering micro-to regional scale aspects. We present the temporal evolution of fluid systems in these two different settings and estimate the fluid overpressures causing vein formation. Seven different sets of calcite veins were observed in Mesozoic limestones, which are consistent across a 2500 km2 anticline. Stable isotopes of calcite veins show an early rock buffered system, which opens to meteoric waters with the onset of normal faulting. Triassic sandstones sealed with bedding-normal calcite veins, overprinted with anhydrite veins. Locally, the latest phase displaced by halite veins. Calcite veins formed in a compacting sediment. Anhydrite veins were derived from Zechstein evaporites, as indicated by sulphur isotopy. Fluid inclusion and basin subsidence data were used to derive the timing and p-T conditions of the externally derived fluid. Anhydrite may have precipitated due to a pressure drop caused by hydro-fracturing and ongoing basin subsidence.