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# How good is the glue? An experimental and numerical investigation of the mechanics of crack seal processes in vein networks.

Janos L. Urai (1,2), Werner Kraus (2), Steffen Abe (2), Max Arndt (1,2), Simon Virgo (1,2), Marc Holland (3), Rainer Telle (4), and Thorsten Tonnesen (4)

(1) FRACs Research Consortium, (2) Structural Geology Tectonics Geomechanics, RWTH Aachen University, Lochnerstrasse 4-20, D-52066 Aachen, Germany, www.ged.rwth-aachen.de, j.urai@ged.rwth-aachen.de, (3) now at Baker Hughes | Reservoir Development Services (GMI) Emmerich-Josef-Str. 5, 55116 Mainz/Germany, (4) RWTH Aachen University, Institut für Gesteinshüttenkunde, Lehrstuhl für Keramik und Feuerfeste Werkstoffe, Mauerstr.5, D-52064 Aachen

An exhumed high-pressure cell in outcrops of Cretaceous carbonates on the southern flank of Jabal Shams in the Oman Mountains shows a complex and rapidly changing mechanical structure during the evolution of multiple generations of fault and fracture sets. Burial extension within a high fluid-pressure environment led to the formation of four fracture generations by an anticlockwise rotating stress field. This was followed by bedding parallel shear under lithostatic fluid pressure conditions at a minimum temperature of 134-191°C deduced from primary and pseudosecondary fluid inclusions in quartz. The high pressure cell was drained along dilatant normal faults that were also repeatedly cemented and reactivated. Calcite cement healed faults and fractures both mechanically and hydraulically before the next sets were formed. Cementation produced mechanically strong veins so that new fractures were localized along the vein/rock interface or within the matrix itself. The rapidly changing mechanical anisotropy in combination with a chemically reactive system form a complex feedback system in which the mechanical strength, strain and the permeability undergo major changes in this coupled thermal, hydraulic, and mechanical (THM) system. Simple conceptional models relating the mechanical strength of the vein and the morphology of the resulting vein network were tested in a series of experiments where pressed blocks of $Al_2O_3$ powder were fired to strengths equivalent to soft to very strong rocks. The blocks were broken in three-point bending, healed with a brittle cement of intermediate strength, broken again and healed with a cement of the same mechanical properties but different color. Results show systematic changes and the development of syntaxial or antitaxial vein sets with different degrees of localization, depending on the relative strengths of the host rock, vein cement and adhesive contact. The experiments were compared with results of a newly developed algorithm using DEM simulations, where the fracture generated in the first step was filled with discrete elements, followed by a cementation step, creating different strength values for the vein. This new structure is then re-fractured and filled+ sealed. Results of these numerical simulations agree well with the experiments, and form the basis for mechanical models for the evolution of vein networks.