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The transition of boudinage into brittle low-angle faults – chemical and mechanical feedback mechanisms

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Slip on mid to upper crustal low-angle normal faults with maximum compressive sub-vertical stress trajectories represents a considerable mechanical problem. Their initiation and subsequent growth is commonly explained by unusual low fault friction caused by either high fluid pressure, weak fault-zone materials and/or aseismic deformation mechanisms. Recently, a reduction of the friction coefficient value of fault rocks has been suggested by fluid triggered phyllosilicate growth, which may lead to a significant fault weakening.

On Serifos (Greece) dolomite/calcite mylonites are interlayered with some centimeter-thick quartz mylonites in the footwall of a ductile to brittle low-angle normal fault. Both mylonites have a strong shape and lattice preferred orientation of the mineral grains. Several tens of meters below the fault a reaction front developed between the dolomite/calcite and the quartzite mylonite consisting of fluid assisted stress-induced breakdown of dolomite and nucleation of talc and calcite. Locally also tremolite formed. The source of the fluid was most likely related to the intrusion of a nearby granodiorite pluton, which occurred during movement along the low-angle fault. Importantly, with the formation of this reaction zone the quartz layers started to develop layer perpendicular calcite-filled fractures which develop by antithetic slip co-rotating domino boudins. Where the rotated quartzite boudin necks were juxtaposed against the dolomite/calcite mylonite host, the talc-forming reaction continues. During ongoing co-rotation the boudins reoriented into a position, where the talc-coated top and bottom of two neighbouring boudins connected resulting into synthetic localization of deformation along these planes forming a shearband boudinage. This switch of domino to shearband boudinage leads to the isolation of the boudins and the formation of a continuous talc-rich layer, which developed into low-angle sc and scc'-type shear zones. Slip along numerous of these talc-rich zones continued during decreasing temperatures in the upper crust with cataclastic deformation of the dolomite.

Based on these structural and petrological investigations we present a numerical mechanical finite element model, which tests the boudinage of a weaker layer (quartzite) in a stronger host rock (dolomite) by introducing a much weaker reaction zone (talc).