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Interactions between fracturing and pressure solution creep in the upper crust: evidence from natural observations and experiments

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Fracturing and pressure solution creep processes are very often associated in the upper crust deformation. One can see for example that mineral grains and pebbles are both fractured and dissolved under stress, that stylolites are bounded by fractures or that pressure solution spaced cleavage is associated with veins. The question is thus how pressure solution creep and fracturing processes interact in the upper crust to make it behave in both a brittle and viscous manner?
Dynamic indenting experiments allow understanding how fracturing and pressure solution creep processes interact. Such experimental technique includes the static loading of a sample by an indenter and its dynamic loading by episodic shocks. The experimental results show that fracturing and comminuting processes induced by the shock accelerate the pressure solution creep rate by reducing the distance of mass transfer. However, it is also observed that after each shock the creep rate progressively decreases due to healing and sealing processes. The main healing processes, in non-porous material such as halite crystal, are crack healing and grain compaction. In porous aggregates such as plaster, the main healing processes are grain sliding, grain dissolution indenting and redeposition. In both cases, when pressure solution is the creep mechanism, fracturing and comminuting weaken the rock whereas compaction, healing and sealing strengthen it. This leads to a non-steady state creep process. This also leads to a chemical segregation of the rocks which is amplified by lithological effect: all the conditions of the deformation being the same, pressure solution creep rate is faster for a mixture of soluble and insoluble minerals than for monomineralic soluble material. Consequently in natural deformation, starting from the common mixture of soluble (quartz, calcite, feldspars…) and insoluble (oxides, phyllosilicates) minerals, successive fracturing and creep-healing events develop a segregation of the rock with the development of rock heterogeneity that is seen for example in faulted rocks with two end members: (i) weak active creep zones, which are the zones of progressive depletion in soluble species and (ii) damage zones, which are progressively strengthen by the redeposited minerals and which are the zones of potential (micro)seismicity. Actually, the microseismicity in the damage zone could even activate the pressure solution creep rate as long as deposition does not occur in the creeping zone.
So fracturing and pressure solution creep are associated processes that interact in the upper crust in order to accommodate its deformation in a ductile or brittle manner depending on the geological conditions and such interactions amplify the segregation between brittle (seismic) and ductile (creep) deformation.