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Development of fluid veins during deformation of fluid-rich rocks close to the brittle-ductile transition: comparison between experimental and physical models.

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Laboratory experiments generally show that high temperature shear deformation of rocks rich in interstitial fluid leads to the development of long fluid veins parallel to R1 and R2 Riedel directions. This contradicts results of numerous mathematical models suggesting that deformation of a rock with a purely viscous solid rheology triggers fluid banding on planes orthogonal to the direction of maximal extension . High-temperature shear laboratory experiments on a sub-micron flint conducted in an internally heated Paterson apparatus with torsion capabilities (Schmocker et al. 2003; Schmocker 2002) reveal that: (i) flint deforms by grain boundary sliding and dissolution precipitation processes, leading to the development of fluid banding orthogonal to up to a strain of about 0.1-0.2; (ii) R1 and R2 fluid veins form beyond these strains, crossing the first generation of bands formed at low , (iii) during the whole deformation process, the strain rate remains perfectly uniform through the entire sample. In order to understand and rationalize these observations, one dimensional numerical modelling of fluid-rock separation during shear has been performed. The model assumes a constant strain rate and uses the interstitial fluid dependence of pressure-solution viscosity of quartz. When shearing is initiated, fluid and solid pressures are equal (pf = ps). Thereafter in zones of compaction, i.e. zones from which fluid is expelled, pf drops and the solid viscosity rises sharply. Although strain rate is uniform across the bulk sample, local stress sharply rises in the compaction bands but remains low in zones of fluid segregation. Indeed, the model shows that, in the zones of compaction, both the deviatoric stress and the excess pressure (pf - ps) have the same amplitude. Their value exceeds the bulk shear stress necessary to maintain the strain rate constant through the entire sample by a factor of about 5. To maintain a high strain rate during shear, laboratory experiments are generally run with a bulk shear stress close to but lower than the fracturation threshold of the rock. It is thus inferred that the development of R1 and R2 bands simply results from embrittlement of the rock in the zones of compaction in response to the steep increase in local stress and the steep drop in fluid pressure during shearing, while the bulk stress applied to deform the experimental sample remains below the brittle threshold of the rock. Implications of this process for melt segregation in the mantle and fluid percolation in gouges are discussed