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Effects of strain rate on boudinage processes

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Deformation of rocks produces structures that are in many cases periodic (folding or boudinage), with variable amplitude and wavelength. Boudinage is the process of fragmentation of layers, bodies or foliation planes of higher viscosity (stronger) sandwiched between layers of lower viscosity (weaker). The fragmented blocks are termed boudins, which can occur at all scales, from microscopic to lithospheric. Early studies have showed that boudinage structures are produced by layer parallel extension. It is, therefore, more likely to occur in settings where there is stretching, for example within a ductile shear zone (e.g. a strong layer oblique to the shear diraction), the limb of a fold or a stretched lithospheric block (e.g. the Basin and Range in the western US).

To the present, boudinage was believed to depend on rock rheology, applied stresses, viscosity contrast between strong layer and weaker matrix, thickness of the stronger layer and coupling between layers. We have now experimentally tested the effects of strain rate on boudinage. The models were made of either a thin elastoplastic layer (soft paper) or a viscoelastoplastic layer (cheese) embedded in a viscous matrix of silicone putty (PDMS). The thin layer lied with its length normal to the shortening axis and parallel to the stretching axis, it was shorter than the box length (it did not touch any walls), which means that the thin layer was not pulled by its ends. The model was then subjected to pure shear at different strain rates. The results show that the higher the strain rate the smaller the boudin length, following an exponential curve.

Our interpretation is that: (1) the differential velocity between weaker flowing viscous matrix and stationary stronger layer results in traction exerted by the viscous layer on the surface of the stronger layer; (2) the strength (resistance to breaking) of the strong layer does not vary with the strain rate applied to the viscous matrix, hence the shear stress on its surface (traction due to viscous drag) increases with increasing strain rate. Therefore, the shear stress is enough to break the strong layer into smaller pieces (boudins).