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Tectonic stress and pressure fields in and out of elliptical inclusions

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Shear zones and competent layers and boudins represent viscosity heterogeneities in the rock mass. Differences in viscosity impel differences in strain rates between such heterogeneities and their surroundings. Under mechanical equilibrium, normal and shear forces must be equal across any interface. The Kolosov-Muskhelishvili equations solve this equilibrium for viscous inclusions in a viscous medium. Mohr-circle diagrams further illustrate the state-of-stress of viscous heterogeneities. Systematic investigation of the stress equilibrium at such interfaces shows that the mean stress, equivalent to pressure, is not continuous across viscosity boundaries. The results predict that pressure and stress perturbations depend strongly on the orientation of the long axis of the elliptical heterogeneity with respect to the far-field stresses. A viscosity ratio of 10 between the inclusion and the surrounding material is sufficient to produce pressure discontinuities virtually equal to the magnitude of the strength of the strongest rock under the considered physical conditions. Comparison of the analytical solutions with thermo-mechanical models confirms pressure incongruity and suggests that dynamic parameters such as pressure and temperature vary spatially and temporally within deforming, two-viscosity rock systems. As a corollary, the dependence of metamorphic phase equilibria on thermodynamic pressure and temperature implies that shear zones, taken as weak inclusions, and boudins taken as hard inclusions may not record lithostatic pressure during deformation.