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Numerical models of tectonic pressure variation during development of common deformation structures

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Pressure variation due to deformation is an intrinsic property of fracture and flow in all materials, including rocks under geological conditions. Strong gradients occur at rheological boundaries (due to inclusions, layers, channels, shear zones, boudin necks, etc) and these gradients are instrumental in driving local pore fluid and/or melt flow during deformation. The pressure distribution in deforming rocks is not static, but changes in space and time. A clear and relevant natural example is the variation during buckle folding of strong layers embedded in a weak matrix. Local pressure gradients and magnitudes can therefore change without any associated change in depth. The magnitude of tectonic pressure is determined by a non-dimensional pressure parameter, reflecting geometry and position, and a scaling factor, with units of stress (Pa), given by the strength of the rock. For viscous materials, tectonic pressure scales linearly with flow stress, or alternatively with the effective viscosity and strain rate. Typical tectonic pressures related to folds, boudins, or strong inclusions are of order 1-2 times the maximum shear stress that the strong material can support. However, even geologically weak materials (e.g. effective viscosity 10^{19}-10^{20} Pa s) can develop very significant tectonic pressures (on the order of many 100's of MPa to several GPa) when the flow is confined, such as during extrusion or convergent channel flow between strong walls, as has been proposed for active subduction zones. The maximum overpressure in this case is limited by the strength of the confining walls, which do not have to be unrealistically strong (or rigid) for the development of significant tectonic pressures.