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TECTONIC PRESSURES: A REVIEW OF PRINCIPLES AND APPLICATIONS

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Rocks in the earth are not perfect fluids at rest. The question is therefore not if pressures are non-lithostatic, but rather if deviations from lithostatic pressure are geologically significant. For tectonic models requiring information on the burial and exhumation history, it is the conversion of pressure (usually estimated from petrological "geobarometry") to depth that is critical and therefore the magnitude of tectonic over- or under-pressure. However, for many other applications (e.g. fluid flow, pressure solution, accumulation of melt), the spatial gradient in pressure is actually more important. Tectonic effects can produce horizontal gradients on the local or regional scale and even reverse the normal vertical pressure gradient (CONNOLLY & PODLADCHIKOV, 2004). This has significant effects on fluid flow and on the driving forces for lateral and vertical extrusion. Discrete rheological boundaries, e.g. across bedding or a porphyroclast, produce correspondingly discrete jumps in pressure, with effectively infinite pressure gradients. The effects of deformation on pressure will be considered in terms of: (1) general effects due to deviatoric stress of a flowing material or a material at failure; (2) effects due to geometrical constraints, e.g. a confined subduction channel or extrusion between rigid indentors (MANCKTELOW, 1995); (3) effects due to rheological boundaries and layering, e.g. inclusions, folds, or boudins; and (4) feedback effects in the deformation of rocks with pressure-dependent rheology, such as Mohr-Coulomb fracture. Considering magnitudes, for brittle failure or frictional slip on an existing fault, the effective pressure during crustal shortening under incompressible plane strain conditions is twice the lithostatic pressure due to the vertical load (PETRINI & PODLADCHIKOV, 2000) and 2/3 of lithostatic pressure for crustal extension. This is the basic reason why brittle normal faults extend deeper into the crust than thrusts (SIBSON, 1974). For viscous behaviour, the increase or decrease in pressure is equal to half the differential flow stress (MANCKTELOW, 1993). For layered viscous materials the increase or decrease in pressure is on the order of the deviatoric flow stress in the competent layer but varies in time and space during heterogeneous deformation, e.g. during folding or boudinage of a layer. Significant tectonic overpressure can also develop in the matrix between converging limbs as folds become tight to isoclinal.

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