ECLOGITE AND STRESS

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Material properties and state of stress in subduction zones are poorly constrained by geophysical evidence. Valuable information can be provided by the structural and microstructural record of exhumed (U)HP metamorphic rocks for depths down to > 100 km. Despite being cycled through a high strain-rate mega-shearzone, many exhumed (U)HP metamorphic rocks appear not to be significantly deformed at (U)HP conditions, and others were exclusively deformed by dissolution precipitation creep (STÖCKERT, 2002). In both cases experimental flow laws for dislocation creep pose an upper bound to the magnitude of stress as a function of temperature along the entire trajectory. The inferred maximum differential stresses are generally on the order of 10^0 or 10^1 MPa for the peak temperatures recorded by the rock. The natural record implies (1) strongly localized deformation, (2) predominance of dissolution precipitation creep and fluid-assisted granular flow in the shear zones, suggesting Newtonian behaviour, (3) low magnitude of differential stress, which (4) is on the order of the stress drop inferred for earthquakes, and consequently (5) negligible shear heating. Numerical 2D experiments based on this concept and using best guess flow laws have demonstrated the evolution of a subduction channel and the feasibility of rapid exhumation by return flow (GERYA et al., 2002; STÖCKHERT & GERYA, 2005). The P-T-t paths and structural patterns obtained in the simulations compare well with the natural record. Among the volumetrically important minerals in (U)HP metamorphic rocks, only omphacite in foliated eclogites shows widespread evidence of deformation by dislocation creep. Laboratory experiments on jadeite indicate a significantly lower flow strength in the dislocation creep regime compared to diopside. Based on the results on jadeite, a relatively low flow strength of omphacite solid solution in the dislocation creep regime is anticipated, in accordance with the natural record. Eclogites may be comparatively weak. The (U)HP metamorphism of eclogite cannot be due to very high mean stress $\sigma_{ii}/3$, i.e. tectonic overpressure. While undeformed (U)HP metamorphic rocks indicate a low level of stress along their *entire* path, the record of crystal plastic deformation in (U)HP metamorphic rocks only means that the respective stress levels were reached at a single stage of their history or at a site of stress concentration. Probably most important in subduction zones, high stresses are suspected to built up episodically by quasi-instantaneous loading near the tips of seismic rupture planes, or by dilatation due to rapid phase transformation (LENZE et al., 2005). A typical average shear stress along the plate interface cannot be inferred from such features.

References

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