Deep crustal dynamics driven by local reactive weakening (from long-term to short-term)

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Résumé

Mechanisms driving the long-term dynamics of plate interfaces remain poorly-constrained. To date, the rheology of the crust is considered to be controlled by solid-state diffusion processes such as crystal plastic deformation (dislocation creep). Yet, most minerals formed at high-pressure conditions are mechanically very strong (garnet, omphacite, glaucophane, zoisite, kyanite) and can only be deformed plastically at unrealistically high stresses or temperatures. A growing number of studies point to the crucial role of fluid-rock interactions and mineral transformations in the development of crustal shear zones of low viscosity. The rock weakening is interpreted as being induced by dissolution and precipitation processes at grains boundaries in chemical disequilibrium. Here, we tackle the eclogite rheology conundrum by performing the first deformation experiments at high-pressure conditions (> 2 GPa) on a two-phase aggregate representative of the lower crust. Shear experiments were performed in a new generation of Griggs-type apparatus (Univ. Orléans) at 850○C, 2.1 GPa and a shear strain rate of 10-6 s^1. The starting material consists of mixed powders of plagioclase and clinopyroxene separated from an undeformed gabbro (Kågen, Norway) and hot-pressed with a grain size lower than 100 μm. Experiments have been conducted with 0.2% added water. Our results show that strain at eclogite-facies conditions is preferentially localized by GBS-accommodated dissolution and precipitation creep in reactive zones. We suggest that this dominant deformation process take place in rock at chemical disequilibrium in the presence of a free-fluid phase. Therefore, deformation along deep plate interfaces should be initiated and governed by transient and local transformation weakening, allowing long-term deformation at far lower stresses than dislocation creep.

Mots-Clés: Experimental deformation, Eclogite, Metamorphism, Rheology, Seismicity, Subduction

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