Brittle-ductile mixed rheological behavior in subduction zones controlled by the strength contrast in heterogeneous materials.

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Résumé

A brittle-ductile behavior corresponding to a "brittle" deformation of strong meter-scale mafic lenses embedded in ductily deformed weak metasediments is commonly proposed to explain transient slips, characteristic of the transition between locked and creeping domains in active subduction zones. We propose here that such brittle-ductile rheological behavior is typical of the blueschist conditions, not only in tectonic mélange but also in homogeneous metagabbros. In exhumed blueschist gabbros (Queyras, French Alps), we observe micro-fracturing of clinopyroxene porphyroclasts and the ductile deformation of a lawsonite-rich matrix. The presence of lawsonite and glaucophane suggests a significant amount of fluid circulation fluid overpressure during subduction-related deformation. Two-dimensional large strain numerical experiments are used to constrain the mechanical conditions for brittle deformation of strong clast inside a weak matrix. We run models at imposed simple shear velocity, constant temperature, depth and fluid pressure coefficient ranging between 10-13 s-1 to 10-11 s-1, 280∘C and 700∘C; 25 km and 55 km; and 0.8 and 0.95. Our numerical results show three main types of behavior: 1- entirely brittle deformation (both matrix and clast) at low temperature; 2- ductile deformation of the matrix and either ductile deformation of the clast or very limited brittle deformation of the clast that instead rigidly rotates during shear, at high temperature and 3- ductile deformation of the matrix and brittle deformation of the clast for intermediate temperature. The rheology of this brittle-ductile material is controlled by the strength ratio between the yield plastic stress of the strong clast over the dislocation creep ductile shear stress of the soft matrix. The typical brittle-ductile rheological behavior is only observed when the strength ratio is between 1 and 2. These conditions significantly differ from the theoretical rheological prediction and may be the key to a better understanding of the mechanics of transient slips.

Mots-Clés: mixed brittle ductile rheology, gabbro, subduction interface, transient slips, numerical modeling, strength ratio

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