Effective rheology of a two-phase subduction shear zone calculated by numerical simple shear experiments

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The physical nature and the rheology of a subduction shear zone play an important role in the deformation and the degree of locking along its interface with the upper plate. Inspired from exhumed subduction shear zones that exhibit block-in-matrix characteristics (mélanges), we create synthetic models with different proportions of strong clasts within a weak matrix and compare them to natural mélange outcrops. Using 2D Finite Element visco-plastic numerical simulations and simple shear kinematic conditions, we determine the effective rheological parameters of such a two-phase medium, comprising blocks of basalt embedded within a wet quartzitic matrix. We treat our models and their structures as scale-independent and self-similar and upscale published field geometries to km-scale models, compatible with large-scale far-field observations. Exhumed subduction mélanges suggest that deformation is mainly taken up by dissolution-precipitation creep. However, such flow laws are neither well-established yet experimentally nor of ample use in numerical modelling studies. In order to make our results comparable to and usable by numerical studies, we assume dislocation creep as the governing flow law for both basalt and wet quartz and by using different pressures, temperatures and strain rates we provide effective rheological estimates for a natural subduction interface. Our results suggest that the block-in-matrix ratio affects deformation and strain localization, with the effective dislocation creep parameters varying between the values of the strong and the weak phase, in cases where deformation of both materials is purely viscous. As the contribution of brittle deformation of the strong blocks increases, however, the value of the stress exponent, n, can exceed that of the purely strong phase.