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The Effective Rheology of Natural Subduction Shear Zones: Insights from Numerical Simple Shear Experiments

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Determination of the subduction interface rheological parameters is an interesting aspect of geodynamics since it can help better understand the physical nature of plate locking and its relation to surface deformation patterns observed at different time scales (GPS displacements during the seismic cycle). Since direct rheological measurements are not possible, unfortunately, we herein try to determine the effective rheological parameters of a subduction interface using finite element modelling. We use the open source finite element code pTatin to create 2D models, starting with a homogeneous medium representing shearing at the subduction interface. We tested several boundary conditions trying to find the one that can best mimic simple shear experiments performed on rock samples. After examining different parameters including the shearing velocity, the temperature and the viscosity, we added complexity to the geometry by including a second phase. This complexity arose from field observations, where composite shear zone outcrops often characterize the subduction interface. Stronger crustal blocks embedded within a sedimentary and/or serpentinized matrix have been reported for several exhumed subduction zones. We implemented a simplified model to simulate simple shearing of a two-phase medium in order to quantify the effect of heterogeneous rheology on stress and strain localization. Preliminary results show different strength in the models depending on the block-to-matrix ratio.

In order to test our methodology, we first use clast-in-matrix geometries from thin sections taken through lab experiments. In a second stage, we upscale the method to outcrop scale clast-in-matrix geometries. By sampling at different depths along exhumed former subduction interfaces, we expect to be able to provide effective friction of a natural interface. In a next step, these effective frictions will be used as input into seismic cycle deformation models in an attempt to assess the possible signature of fine field observations on the slip behavior of the plate interface.