Geophysical Research Abstracts
Vol. 21, EGU2019-5735, 2019
EGU General Assembly 2019

Shallow rheological transition along the subduction plate interface and their impact on tremor and earthquake nucleation

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Block-in-matrix rock units typically occur along subduction plate interfaces where accommodation of deformation occurs both by viscous and elastic strain. Usually they are visualised to consist of mechanically strong blocks the within a relatively weak matrix. Triaxial deformation experiments on blocks and matrix from the Osa Mélange in southern Costa Rica reveal that this block-in-matrix assemblage is characterised by blocks which are mechanically weaker than their surrounding matrix. Triaxial deformation experiments were conducted on samples of both the altered basalt blocks and the indurated volcanoclastic matrix : these revealed that at 60 MPa of confining pressure the volcanoclastic matrix's strength is 7.5 times higher than that of the altered basalt, and 4 times higher at 120 MPa, with the altered basalt experiencing multi-stage failure.
Analysis of blocks and matrix in the Osa Mélange reveal that the basalt blocks have been weakened by mechanical brecciation and hydrothermal alteration while their surrounding volcanoclastic matrix has been significantly indurated by compaction, diagenesis, and the development of mechanically strong lenticular fabric. As the Osa Mélange was not subducted to significant depth, this inversion of the rheological relationship must occur early in the subduction process.
Analytical and numerical modelling has been used to test stress accumulation and block vs. matrix failure for the case of "inverted" rheological conditions, and to compared these results with the "typical" scenario where mechanically strong blocks are within a relatively weak matrix. Weaker blocks can fail seismically when deforming within a stronger matrix. The failing blocks display a constant fault size, and continue to fail while the matrix becomes more stressed with tremor-like characteristics. Weaker block failure leads to the matrix becoming more stressed around the blocks so that it too can fail within the vicinity of the blocks, eventually leading to throughgoing failure of blocks and matrix. Tremors, therefore, does not relieve the stress in the matrix, and the region can still slip in a megathrust event.