Aspects of Non-Newtonian Viscoelastic Deformation Produced by Slip on a Major Strike- slip Fault

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Abstract

Non-Newtonian flow occurs in crustal deformation processes on the long timescales associated with large- scale continental deformation, and also on the short time-scales associated with post-seismic deformation. The co-seismic displacement is determined by the instantaneous elastic response of the rocks on either side of the fault surface to the distribution of slip on the surface of the fault. The post-seismic deformation is determined by some combination of visco-elastic relaxation of the medium and post-seismic creep on the fault. The response of the crust may depend on elastic moduli, Poisson's ratio, temperature, pressure and creep function parameters including stress exponent, activation energy, activation volume and viscosity coefficient. We use the von Mises function in describing the non-linear Maxwell visco-elastic creep models. In this study we examine a model of a strike-slip fault crossing a 3D block. The fault slips at time zero, and we solve for the viscoelastic deformation field throughout the 3D volume using a 3D finite element method. We perform parametric studies on the constitutive equation by varying these parameters and the depth of the fault event. Our findings are focused on the fact that the system is very sensitive to the above mentioned parameters. In particular, the most important seems to be the temperature profiles and stress exponent. The activation energy and the pressure are of lower importance, however, they have their meaning. We investigated the relaxation times and the deformation patterns. We took the material properties as typical to dry quartzite and diabase. Depending on the parameters the surface can be deformed permanently or the deformation can decrease. We attempt to compare qualitatively the calculated post-seismic response in terms of the post-seismic displacement history of the earth's surface with InSAR patterns determined from recent major strike-slip earthquakes. Quantitative comparison of the observations with these numerical model results can in principle provide a better understanding of the physical properties of the sub-surface and further insight into the diagnostic properties of the earthquake cycles of major fault systems.

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