Imaging the distribution of transient viscosity following the 2016 Mw 7.1 Kumamoto earthquake

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Postseismic studies of geodetic data following large earthquakes indicate a wide range of mechanisms contribute to the observed deformation and stress relaxation. Both on-fault afterslip and off-fault viscoelastic relaxation can contribute to the postseismic transient phase of the earthquake cycle. One problem with these (quasi-) dynamic models is that there is a wide range of parameter space to be investigated, with each parameter pair possessing their own tradeoffs. This becomes especially problematic when trying to model both on-fault and off-fault deformation simultaneously. Here, we draw insight from postseismic geodetic observations following the 2016 Mw 7.0 Kumamoto earthquake by utilizing a novel inversion technique.

We present a novel approach to invert for on-fault and off-fault deformation simultaneously using analytical Green’s functions for distributed deformation at depth [Barbot, Moore and Lambert., 2016] and on-fault deformation [Okada 1992, Nikkhoo and Walter 2015]. Using these Green’s functions, we jointly invert InSAR images and GEONET GPS time series following the Kumamoto earthquakes for afterslip and lower-crustal viscoelastic flow.

The calculated strain-rates in the lower crust are directly converted to effective viscosities and we investigate the implications of the effective viscosity structure within an outlier-senstitive Bayesian statistical framework to estimate in-situ parameters, such as temperature. Using our new method, we are able to interrogate the transient deformation in the first few months of the postseismic deformation to obtain these parameters.

The postseismic deformation at Kumamoto brings new insights into the distribution of brittle and ductile crustal processes beneath Japan and can be used to infer lower crustal properties.

Keywords: Rheology, Kumamoto, Geodesy

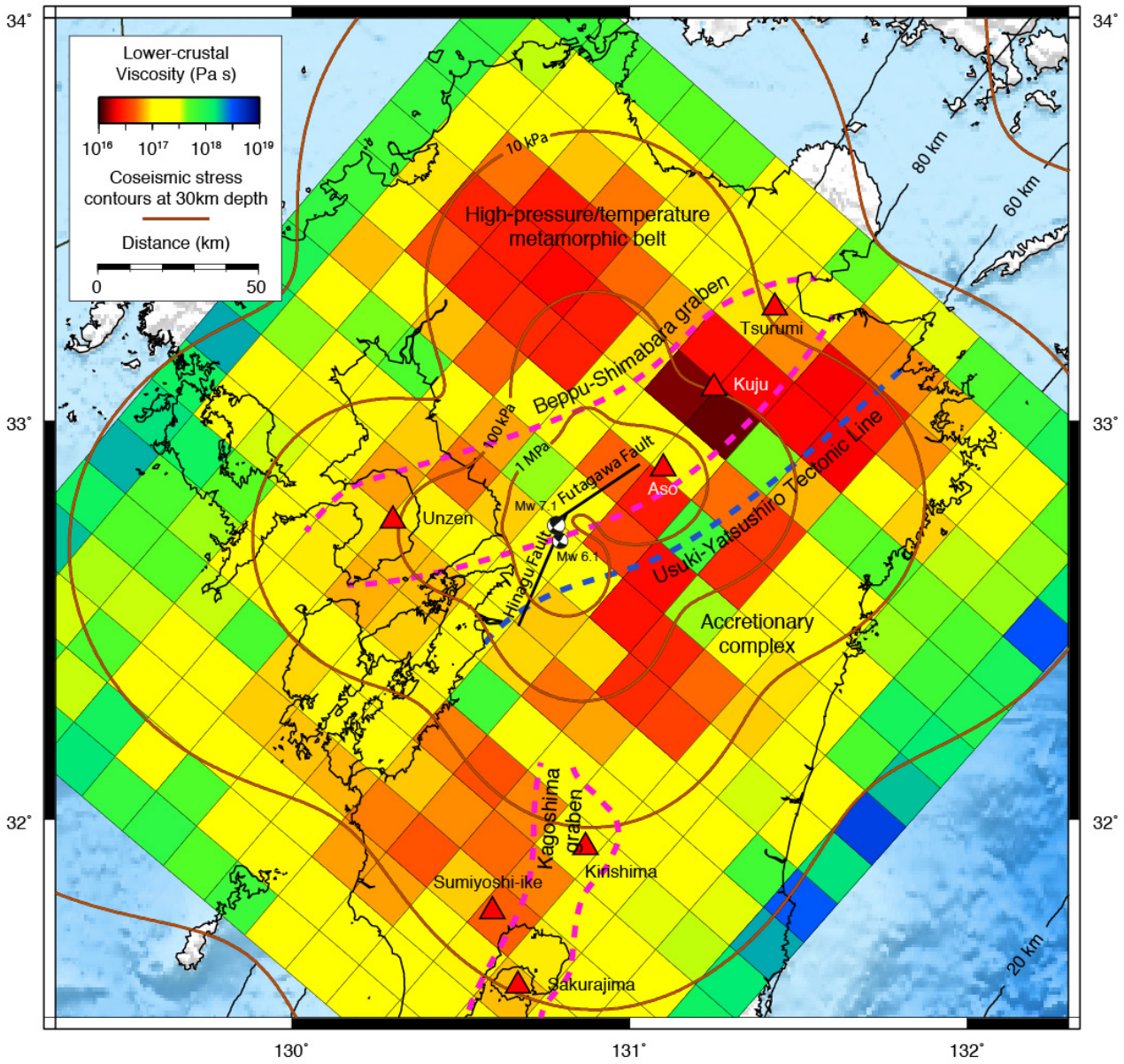

Figure 1 – Transient viscosity structure of the lower crust beneath Kyushu
Transient viscosity of the lower crust with volcanoes marked in red triangles, the Hinagu and Futagawa faults in black, and coseismic stress contours in orange. The regions of low viscosity follow the pattern of coseismic stress change modulated by the distribution of arc volcanism and plutonic bodies in Kyushu, with noticeable low viscosity anomalies beneath Mt Aso and Mt Kuju.