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# The crustal viscosity gradient measured from post-seismic deformation: a case study of the 1997 Manyi (Tibet) earthquake

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The viscosity of the crust varies mainly with depth because of increasing temperature. We attempt to measure that variation using the signature of post-seismic surface displacement measured after the 1997 Manyi (Tibet) earthquake. Constraining that variation of viscosity is important if we are to predict more accurately the evolution of stress in the crust during the earthquake cycle. We previously used 3-D finite element calculations of the surface displacement history following a strike-slip fault event, to show that the surface displacements for a linear Maxwell visco-elastic model in which viscosity decreases exponentially with depth (the DDV model) are closely similar to those for a uniform viscosity (UNV) model, for a specific apparent (UNV) viscosity ($\eta_u$). The apparent viscosity that best-fits the DDV model displacement decreases with distance from the fault, and the rate of the change of $\eta_u$ with distance from fault reflects the vertical gradient of the viscosity. In the present study we apply that knowledge to the interpretation of an InSAR dataset of the surface deformation in a three year period following the 1997 Manyi (Tibet) earthquake [Ryder et al., GJI, 169, 1009 - 10027, 2007] in order to estimate the vertical viscosity gradient beneath the region. We analyse the rates of displacement after an initial period (165 days) in which post-seismic slip is probably significant. We infer a clear signature of the vertical viscosity gradient in the crust based on the observed decrease of $\eta_u$ with distance from the fault. We infer that the 1997 Manyi event occurs within an upper layer which is effectively elastic on the time-scale of the inter-seismic period, $\sim$ 420 - 850 yrs [van der Woerd et al., GRL, 27, 2353-2356, 2000], and the vertical viscosity gradient in the crust is consistent with empirical power law creep measurements of the upper crustal materials. These new constraints on the vertical viscosity gradient of the Tibetan crust advance the knowledge of the crust and assist in better understanding of the earthquake cycle.