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The Transient Rheology of Accretionary Prisms: Evidence from the Makran Subduction Zone of Iran and Pakistan

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Recent studies of global subduction zones increasingly cite viscoelastic deformation as an important contributor to earthquake cycle mechanics and interpretation. Viscoelastic deformation in the asthenosphere of the overriding and down going plates effects the development of geologic structures, interpretation of interseismic deformation (locking models), and physics-based modeling of post-seismic deformation processes. In this presentation, we explore the existence and importance of viscoelastic deformation in a separate structure of the subduction zone: the accretionary prism. We present recent work on ongoing post-seismic deformation associated with the 2013 Mw7.7 Baluchistan earthquake that occurred within the accretionary prism of the Makran subduction zone of southern Iran/Pakistan. We constrained the Baluchistan earthquake post-seismic transient with Sentinel-1 interferometric synthetic aperture radar (InSAR) time series analysis, and we found that the transient cannot be explained by stress-driven afterslip. Instead, we explored a suite of semi-analytical models of viscoelastic relaxation and found that the transient is well-explained by deformation within a viscoelastic wedge embedded inside the accretionary prism. This viscoelastic wedge extends from the base of the seismogenic zone (6-8 km) down to the Arabian slab interface at 20-25 km depth. We resolved viscosities of 1017-1018 Pa s, and these viscosities are likely transient, as evidenced by the requirement of power-law viscoelastic deformation with a power-law exponent of n = 3.5. The power-law viscoelastic relaxation implies that creep processes, which are common at lower crustal and mantle temperatures, are active at comparatively lower temperatures within the Makran accretionary prism. We stipulate that this may be due to the presence of fluids introduced by sedimentary underplating and hydrocarbon production. Lastly, we highlight the influences of a partially viscoelastic accretionary prism on estimates of megathrust locking. Specifically, we show that the presence of an un-modeled viscoelastic accretionary prism leads to over-estimation of megathrust hazard. These results highlight the importance of measuring active deformation in accretionary prisms through seafloor geodetic observations in other subduction zones where the accretionary prism is submarine.