Combining lake unloading and postseismic deformation in Western Nevada to infer the rheology of the mantle

H. Dickinson[1], A. Freed[1], W. Hammond[2]
1. Purdue University, West Lafayette, IN
2. University of Nevada, Reno

The mantle beneath western Nevada has experienced multiple loading events, including the loading and unloading of Pleistocene aged Lake Lahontan and a series of 7 earthquakes (ranging from the 1872 M7.6 Owen's Valley to the 1954 M6.9 Dixie Valley) in the Central Nevada Seismic Belt over the last 130 years. The varied loading history in this region allows us to estimate the strength of the lower crust and upper mantle while trying to address the issue of non-uniqueness observed in previous studies. The strength of the mantle can be inferred by measuring its response to large stresses. Stress disperses through viscous relaxation and is transferred back to the Earth's surface, resulting in deformation. This deformation, which is used to constrain our model results, is measured using geodetic and geologic techniques. We have developed 3D finite element models simulating the loading/unloading processes from the historic seismicity and Lake Lahontan. Our numerical models are constrained by GPS, InSAR, and shoreline migration patterns, allowing us to test whether a single Newtonian viscosity structure can explain all of the observed constraints. This study is the first to utilize viscoelastic relaxation of the mantle to model two different loading events in the same region. Our results reveal that while a single Newtonian viscosity structure can explain the GPS and InSAR constrains on postseismic velocities, it cannot be used to explain shoreline uplift associated with lake unloading, which requires a weaker rheologic structure. We conclude that the viscosity structure beneath Western Nevada is not a constant, but varies as a function of stress and potentially other non-linear processes such as transient rheology.

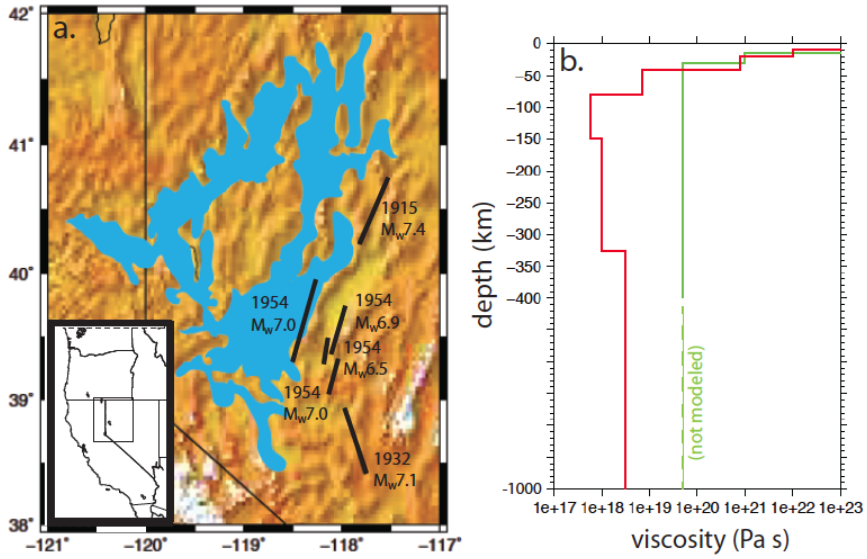

Figure 1. (a) Map of western Nevada showing the two loading sources. The location of Pleistocene aged Lake Lahontan is filled in blue and the earthquakes are shown in black. (b) A depth vs. viscosity plot showing our preferred viscosity structure for the postseismic velocities (in green) and preferred lake unloading model in red.