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Broadband Approach To Quantification Of Lithospheric Deformation On Scales Ranging From Earthquakes To Fault Systems

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Verification of lithospheric deformation models depends on the ability to assimilate deformation measurements on a range of scales. Early models of lithospheric deformation, which have been derived from a c. 50-year record of seismological observations, are successful along rapidly-deforming plate boundary fault systems, but fare poorly in low-strain regions or broadly-deforming continental fault systems, which are characterized by low surface strain accumulation rates and very long recurrence times (> 1 ka) for large ruptures. Disagreement in deformation rates implies either discrepancies in measurement techniques ("The Rate Debate"), or that deformation may be scale-dependent with variations over intervals as short as a few hundred years.

The northern Basin and Range Province is well-suited to assess the significance of variability in deformation ranging from tens of years to hundred thousands of years and beyond, because published space-geodetic, seismic, paleoseismic, morpho-tectonic, and geological deformation rate studies are available for comparison. Over a 10-year period, space-geodetic measurements define two broad (100's of km) zones of strain accumulation near the eastern and western boundaries of the Province, with a region of no-strain accumulation in the center (Bennett et al. 2003). Over a 100-year period, historic and instrumental seismicity data define three narrow (tens of km) belts of activity within the geodetically active zones, separated by two "aseismic regions" in the west and the center of the Province, respectively. Over the 10-ka period, paleoseismic data show that most large surface-ruptures occurred in the currently seismically active regions. On the 500 ka to 1-million-year period, however, most of the many range-bounding faults reveal at least one fault scarp in Quaternary alluvial deposits (e.g., Dohrenwend 1996), yielding a broadly-distributed deformation pattern averaged over the past million year. For at least some of these range-front scarps new paleoseismic and cosmogenic nuclide studies yield recurrence intervals of 20 ka or more.

The observations on the 10-year to 10-ka scale appear consistent with the microplate concept. However, given that microplates are defined on a lithospheric length-scale of a million years or longer, the observations from significantly longer periods (1 Ma) rule out the "microplate" concept for the Province. The integration of the short-term seismic and geodetic data with the longer-term paleoseismic and morpho-tectonic data leads to a different model, whereby the Province acts as a broadly-deforming region with a complex pattern of migrating strain accumulation and release on the short time scale, and propagating fault systems on the longer time scale. Models of lithospheric deformation can be consistent with observables recorded at different periods despite apparent „discrepancies". Thus assumptions about "matching" or "linear" rates" may be inappropriate where different measurement methods capture differing time periods, spatial domains, and represent different parameters of the 4D-deformation path.