A NEW PARADIGM FOR INTERPRETING STRESS INVERSIONS FROM FOCAL MECHANISMS: HOW 3D STRESS HETEROGENEITY BIASES THE INVERSIONS TOWARD THE STRESS RATE

Thesis by

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Abstract

Current stress studies often utilize stress inversions of earthquake focal mechanisms to estimate four parameters of the spatially uniform stress tensor, three principal stress orientations, and a ratio of the principal stresses. An implicit assumption in these studies is that earthquakes are good random samplers of stress; hence, the set of earthquake focal mechanisms within some region can be used to estimate the spatial mean stress state within the region. Numerical simulations indicate some regions, such as Southern California, have sufficient stress heterogeneity to bias the stress inversions toward the stress rate orientation and that stress studies using stress inversions need to be reinterpreted by taking this bias into account. An outline of how to subtract out this bias to yield the actual spatial mean stress is presented.

Numerical simulations demonstrate that spatially heterogeneous stress in 3D can bias stress inversions of focal mechanisms toward the stress rate tensor instead of the stress. Stochastic models of 3D spatially heterogeneous stress are created, synthetic earthquake focal mechanisms are generated using the Hencky-Mises plastic yield criterion, and results are compared with Hardebeck's Southern California earthquake catalog [*Hardebeck,* 2006]. The presence of 3D spatial stress heterogeneity biases which orientations are most likely to fail, a bias toward the stress rate tensor. When synthetic focal mechanisms are compared to real data, estimates of two stress heterogeneity parameters for Southern California are obtained: 1) A spatial smoothing parameter, $\alpha \approx 0.8$, where α describes the spectral falloff of 1D cross sections through a 3D grid for the three principal stresses and three orientation angles. 2) A heterogeneity ratio, $HR \approx 1.25$, which describes the relative amplitude of the spatial stress heterogeneity to

the spatial mean stress. The estimate for α is tentative; however, varying α for $\alpha \leq 1.0$ has little to no effect on the observation that spatially heterogeneous stress biases failures toward the stress rate. The estimate for HR is more robust and produces a bias toward the stress rate of approximately 40%. If the spatial mean stress and the stress rate are not aligned, the average focal mechanism failure mechanism should yield a stress estimate from stress inversions, approximately halfway between the two.

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