

An observational test of the optimally-oriented plane hypothesis

Greg Anderson (U.S. Geological Survey, Pasadena; ganderson@usgs.gov)

Jeanne Hardebeck (U.S. Geological Survey, Menlo Park)

We present a quantitative statistical test of the hypothesis that earthquakes triggered by stress changes generated by a primary event will occur on faults that are optimally oriented for failure, in the sense that they experienced the largest possible stress changes from that primary event (the so-called "optimally-oriented plane", or OOP, hypothesis). We begin by selecting nearby post-mainshock earthquakes from a catalog of events with well-constrained bounded focal mechanisms determined using the technique of Hardebeck and Shearer [2002]. We compute the optimal plane for each event given its catalog location, a finite source model for the mainshock, an assumed value of the Coulomb effective coefficient of friction, and a background stress field determined from stress inversions of pre-event seismicity. We also compute uncertainties in the optimal plane orientation by allowing for reasonable variations in these parameters. We test whether the OOP for a given event is consistent with that event's bounded focal mechanism by determining the rotation necessary for the optimal plane to be contained within the focal mechanism bounds and comparing this rotation to the uncertainties on the optimal plane. We call the percentage of events with compatible OOPs and focal mechanisms the OOP Index (OOPI), and use a bootstrap resampling technique to estimate the significance of our observed OOPI and thus the confidence with which we can reject the optimally-oriented plane hypothesis.

We apply this method to the 1992 Joshua Tree-Landers-Big Bear sequence and find (1) that the OOP hypothesis performs poorly overall, with OOPI less than 60%, not significantly higher than that expected from random chance; (2) the OOPI is higher for the first 2 months following Big Bear (77%) than for the rest of the catalog (59%), with no obvious difference in event location distribution; and (3) Coulomb friction coefficient and regional stress orientations dominate the OOP consistency with observed focal mechanisms.

Hardebeck, J.L. and P.M. Shearer, A new method for determining first-motion focal mechanisms, *Bull. Seismol. Soc. Am.*, 92(6), 2264-2276, 2002