Geophysical Research Abstracts
Vol. 13, EGU2011-2797, 2011
EGU General Assembly 2011
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Observational tests of dynamic bimaterial effects on natural faults with along-strike symmetry properties of aftershocks

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Theoretical studies indicate that ruptures on bimaterial faults have larger slip-velocity and slip in the direction of particle motion in the compliant solid (referred to as the preferred direction). The results stem from dynamic changes of normal stress near the tips of ruptures on bimaterial faults, which do not exist for faults separating similar elastic solids. For typical subshear ruptures, the changes of normal stress produce dynamic weakening at the tip propagating in the preferred direction (potentially all the way to zero) and dynamic strengthening at the tip propagating in the opposite direction. These dynamic effects can have significant impact on various aspects of earthquake and fault mechanics, ranging from effective constitutive laws and generation of frictional heat to development of rock damage and seismic shaking hazard near large plate-bounding bimaterial faults. Here we examine the relations between spatial symmetry properties of earthquake patterns along 25 faults in California and local velocity structure images to test the hypothesis that ruptures on bimaterial faults have statistically preferred propagation directions. We distinguish between clustered and homogeneous parts of each catalog, using a recently introduced earthquake cluster analysis, and examine asymmetry of offspring with respect to parent events within the clustered portion of each catalog. The results indicate strong asymmetric patterns along large faults with prominent bimaterial interfaces (e.g., sections of the San Andreas fault), with enhanced activities in the directions predicted for the local velocity contrasts, and absence of significant asymmetry along most other faults. Assuming the observed asymmetric properties of seismicity reflect the properties of the parent earthquake ruptures, the discussed methodology and results can be used to develop refined estimates of seismic shaking hazard associated with individual fault zones.