Geophysical Research Abstracts,
Vol. 11, EGU2009-1945, 2009
EGU General Assembly 2009

Earthquake rupture on cross-cutting conjugate faults: the 2007 Mw6.6 Niigata-Ken Chuetsu-Oki earthquake

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All materials usually rupture along one dominant plane under a load. However, Earth's interior is so heterogeneous that the rupture mechanism often becomes very complex. The true mechanism (reverse faulting according to its focal mechanism) of the 2007 Mw6.6 Niigata-Ken Chuetsu-Oki, Japan, earthquake is debated. Seismological surveys of the aftershocks and geodetic satellite images of the surface deformation show two main segments, which are crosscutting each other at the middle, namely north-western dipping to the north and south-eastern dipping to the south. How is it possible that such crosscutting conjugate segments are ruptured simultaneously during an earthquake from the mechanical point of view? We numerically simulate dynamic rupture propagation along the inferred fault segments under a tectonic stress assuming the Mohr-Coulomb fracture criterion and the linear slip-weakening law. The results imply that the possibility of simultaneous rupture on such conjugate faults is strictly limited by their fault geometry and that rupture transfer occurs only after rupture on the first segment terminates, independently of the overlapping length of the two segments. This behaviour can be due to the existing geological structure as inferred from the tomography. A possible scenario is that the crosscutting rupture mode at the middle occurs with a time delay, where firstly there is southbound rupture on the north-western dipping segment and secondly northbound rupture on the south-eastern dipping segment along the pre-existing fault structure.