Geophysical Research Abstracts
Vol. 14, EGU2012-3661, 2012
EGU General Assembly 2012

Slow diffusive fault slip propagation: direct evidences from high-sensitivity strain measurements.

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Slow earthquakes preceding following or without ordinary earthquakes may play an important role in the stress redistribution process and seismic hazard assessment. They were firstly observed by high-sensitivity strainmeters; characteristic times ranged tens of seconds to several days and sources were fairly shallow. During the last decades several slow earthquakes have been observed at transcurrent margins, extensional areas and almost all subduction zones. The observation of a swarm of small local slow earthquakes by one laser strainmeter at Gran Sasso (Italy) in 1997 led to the first suggestion of the diffusive character of the slow slip propagation along the fault. This feature was later confirmed on the basis of a large number of events – mainly recorded at subduction zones – whose characteristic time spanned many orders of magnitude.

The diffusive character of the rupture propagation was mainly deduced from the observed relationship between seismic moment and characteristic time. The first direct observation of the diffusion process occurred after the 2009 L'Aquila (Italy) earthquake, from the temporal evolution of deformation recorded by two laser strainmeter at Gran Sasso. One of the strain signals is monotonic, while the other one shows a marked minimum. Such features suggest fracture propagation crossing a nodal line on the fault plane, which separates areas capable of producing deformation of opposite sign at the observation point. Strain history at both interferometers is fully consistent with diffusive slip propagation, but inconsistent with contant velocity propagation.

We have searched for other direct evidences of the diffusive rupture propagation, looking at strain records similar to those recorded after L'Aquila earthquake. In particular here we analyze three different events, recorded by (i) three Sacks-Evertson borehole dilatometers at Izu-Oshima (Japan) in 1978, (ii) two long-base laser strainmeters at Durmid Hill, near the San Andreas fault, in 1999, and (iii) one Sacks-Evertson borehole dilatometer at Tokachi-Oki (Japan) in 2003.

In all cases we compare observations and predictions from two different propagation mechanisms along straight paths, namely constant propagation velocity and diffusive process. Source fault geometry and focal mechanism are assumed from the literature.

The analysis of the Izu-Oshima event shows that only the diffusive process is fully consistent with observations. As observed after L'Aquila earthquake, the seismic moment density decreases about linearly with distance along the path, like the steady-state solution of 1D diffusive processes.

In the other two cases we are unable to discriminate the type of propagation, but the release of seismic moment along the path shows unrealistic features, claiming for a deeper insight on the source fault features.