Stress Drop and Slip Vector on a Dislocation in an Elastic Space due to Localized Force Distributions.

M. Bonafe (°) and M. Dragoni

Istituto di Geofisica dell'Università - Via Irnerio 46, 40126 Bologna, Italia

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Summary. — Some earthquake models based on the elastic theory of dislocations are presented. Earthquake occurrence is modelled as the opening of a crack in an infinite elastic medium triggered by the action of localized stress distributions. The fracture is modelled as a continuum of infinitesimal dislocations. This approach allows us to have complete information about the stress field and the displacement field and to make a first step towards understanding the relation between source mechanism and stress distributions.

1. -- Introduction.

The elastic theory of dislocations has proved a useful tool in theoretical seismology. On its grounds one can construct earthquake models of various complexity and thus obtain quantitative estimates of ground deformations, which may be tested by observations. Their common point is to describe an earthquake in terms of a dislocation over a fault surface. The relevance of this theory for geophysical applications was brought out by several authors (1-5), who proposed simple static models.

(*) Also at Dipartimento di Scienze della Terra dell'Università, Via della Montagnola 30, 60100 Ancona, Italia.
A way to characterize a static dislocation in a continuum is that of giving the geometry of the dislocation surface $S$, and the jump discontinuity across it of the displacement field

\[ \Delta u = u^+ - u^- \]

Only in a few earthquakes, however, with faulting reaching the surface, the magnitude of the slip vector $\Delta u$ can be directly measured at the Earth surface and its variation with depth is usually ignored. These features are generally chosen a priori, without caring about the connection between the shape of the dislocation and the force distribution which originates it. Moreover, since the consideration of Somigliana dislocations (*) considerably increases the difficulty, authors usually choose a single constant value for the displacement discontinuity, thus reducing to a less realistic Volterra dislocation. In such a way, one gets no information about the absolute values of stress existing before and after the earthquake, but can only compute the stress drop on the fault surface due to fracture, in terms of the average slip vector observed at the surface. In order to obtain the total stress field after the earthquake, one has to subtract the dislocation stress to the stress present before crack opening: a currently used method is to assume the latter to be equal in modulus but opposite in sign to the value of stresses produced by the dislocation at the middle of the fault surface. Dynamic equilibrium of a plane dislocation surface in the absence of friction actually requires the vanishing of shear tractions over the fault faces. The validity of this approximation is based on the hypothesis that the pre-existing field does not vary appreciably over the fault area before the elastic rebound and in any case gives reliable predictions in this area only. Besides that, the method does not generally allow us to have vanishing tractions over the whole fault surface, but only at its middle point. A more appropriate description of fracture is given by a boundary condition of vanishing shear stress on a given crack surface. Many problems of this kind have been solved in the framework of fracture mechanics. Asymptotical analytical solutions exist in plane strain situations (s) with the boundary condition of constant stress at infinite distance.

The procedure we follow here is to start not from a given dislocation but from a certain localized force distribution present in the medium surrounding the fault surface; the action of these forces induces the dislocation giving out a fracture over the fault surface. It is then possible to compute exactly the initial stress field, i.e. the field present before the seismic event. Once shape,

(*) A Somigliana dislocation problem is the one in which tractions applied to the dislocation surface are given as boundary conditions, while in Volterra dislocations a rigid-body movement is prescribed over the dislocation surface.