A MODEL FOR SEISMICITY RATES OBSERVED DURING THE 1982-1984 UNREST AT CAMPI FLEGREI CALDERA (ITALY).

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Abstract

In order to model seismicity during the 1982-1984 unrest at Campi Flegrei caldera (Italy), we compute static stress changes caused by an inflating source in a layered half-space. Stress changes are evaluated on optimally oriented planes for shear failure, assuming a regional deviatoric stress with horizontal extensional axes trending NE-SW. The inflating source is modelled as inferred by previous studies from inversion of geodetic data with the same crustal model here assumed. The area affected by the largest Coulomb stress changes is elliptical. Inversely slip over the source can be discouraged by the assumed regional stress. These results are in agreement with observations concerning seismicity developed during the 1982-1984 unrest at Campi Flegrei. In order to evaluate rates of stress change, we assume that the temporal evolution of uplift observed by tide-gauge at Pozzuoli, normalized to the maximum value, was due mainly to time dependent processes occurring at the inflating source. Then we attribute the same normalized time dependence to each component of average stress change in the region affected by observed seismicity. We then model seismicity rate changes associated to the time-dependent stress changes, by following the approach indicated by Dahlen (1994) on the basis of the rate- and state-dependent rheology of faults. The seismicity rate as a function of time resulting from the model is in general agreement with observations; in particular the observed correlation with the deformation rate history is present also in model results.

2. Induced stress-changes

In order to model seismicity during the 1982-1984 unrest at Campi Flegrei caldera (Italy), we compute static stress changes caused by an inflating source in a layered half-space, with a code used by Wang et al. (2006). Stress changes are evaluated on optimally oriented planes for shear failure (OOPs), assuming a regional deviatoric stress with horizontal extensional axes trending N30°E (e.g. Troise et al. 2003). The inflating source is modelled as inferred by previous studies (Amoruso et al., 2006) from inversion of geodetic data with the same crustal model here assumed (Table 1). In particular we model stress changes due to a point-like, vertical, penny-shaped spheroid located near Pozzuoli at 4.8 km depth. Stress changes are evaluated at 3 km depth, the average depth of seismicity observed during the 1982-1984 unrest at Campi Flegrei. In Figure 3 the maximum shear stress associated to the regional stress is equal to 5 MPa, comparable with the largest shear stress changes caused by the inflating source. The area affected by the largest Coulomb stress changes (dark red area in Figure 3) is elliptical in agreement with the observed distribution of earthquakes during the 1982-1984 unrest (Aster and Meyer, 1988). Inversely slip over the source is discouraged by the assumed regional stress, so that fault mechanisms are mostly normal with oblique components near the source. These results are in agreement with observations of the 1982-1984 Campi Flegrei swarm (e.g. Troise et al., 2003): Only decreasing the amplitude of regional stress with respect to the value we assumed we obtain OOPs with thrust mechanisms over the inflating source, in agreement with previous studies of stress changes induced by volcanic sources in homogeneous half-spaces (Feuillet et al., 2004). We evaluate the average static values of shear and normal stress change on OOPs in the region where most of seismicity produced during the unrest episodes located (i.e. within the white box in Figure 3). In case of Figure 3 the average shear stress change is around 3.6 MPa and the normal stress change is tensile around 0.5 MPa.

4. Concluding remarks

Previous applications of rate- and state-dependent friction to swarm-like seismicity in volcanic areas (e.g. Toda et al., 2002) were mainly devoted to explain the spatial distribution of seismicity rates or they did not consider the effect of slowly evolving stresses. Previous applications of rate- and state-dependent friction to swarm-like seismicity in volcanic areas (e.g. Toda et al., 2002) were mainly devoted to explain the spatial distribution of seismicity rates or they did not consider the effect of slowly evolving stresses. Previous applications of rate- and state-dependent friction to swarm-like seismicity in volcanic areas (e.g. Toda et al., 2002) were mainly devoted to explain the spatial distribution of seismicity rates or they did not consider the effect of slowly evolving stresses. Previous applications of rate- and state-dependent friction to swarm-like seismicity in volcanic areas (e.g. Toda et al., 2002) were mainly devoted to explain the spatial distribution of seismicity rates or they did not consider the effect of slowly evolving stresses. Previous applications of rate- and state-dependent friction to swarm-like seismicity in volcanic areas (e.g. Toda et al., 2002) were mainly devoted to explain the spatial distribution of seismicity rates or they did not consider the effect of slowly evolving stresses. Previous applications of rate- and state-dependent friction to swarm-like seismicity in volcanic areas (e.g. Toda et al., 2002) were mainly devoted to explain the spatial distribution of seismicity rates or they did not consider the effect of slowly evolving stresses. Previous applications of rate- and state-dependent friction to swarm-like seismicity in volcanic areas (e.g. Toda et al., 2002) were mainly devoted to explain the spatial distribution of seismicity rates or they did not consider the effect of slowly evolving stresses.