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The role of Coulomb Failure Stress in 1997 Kagoshima earthquakes

Changjiang Wu[1], Minoru Takeo[2]

[1] Earth and Planetary Sci., Univ. of Tokyo, [2] ERI, Univ. Tokyo

Source processes of the 1997 Kagoshima earthquakes have been investigated in detail using K-net strong motion data. Based on these detailed slip distributions, we calculate the Coulomb Failure Stress (CFS) changes after each earthquake. The calculated results show that, the May 13 earthquakes just occurred in the area where CFS had increased. It suggests that the CFS change caused by an earthquake, even as small as 0.1 to 0.5 MPa, might account for triggering mechanism for other earthquakes.

wo earthquakes with magnitude of about 6.0 (by JMA scaleT) occurred in the northwest part of Kagoshima prefecture, on March 26 and May 13, 1997. These two earthquakes are separated with a distance of only several kilometers. Their aftershock distribution looks like the letter "F", with two parallel zones and one perpendicular. In this study, 54 records of K-net strong motion data distributed at 18 stations have been dealt with to inverse their source processes. Inversion results show that ruptures mainly occurred in the areas of 6 by 10 km, with hypocenter depth of about 10km.

The Coulomb Failure Stress (CFS) changes are calculated using internal deformation which has been given as some closed analytical expressions by Y. Okada(1992, BSSA 82). The results show that, the May 13 earthquake (the second one) just occurred in the area where CFS had increased due to the March 26 earthquake (CFS positive area). On the edge subfaults, there is a small part of slip distribution which contributes little to the fitting synthetic waveform. We take the slip on edge subfualts as contaminated errors and neglect such parts of slip, the recalculated result shows clearly positive CFS changes, ranging from 0.1 to 0.5 MPa, around the hypocenter area of the second earthquake. Moreover, aftershocks since May 13 mainly occurred in the positive area. Aftershocks stopped near the end side of the positive area. All these suggest that such a small increase of CFS produced by the first earthquake greatly encouraged the occurrence of the second earthquake and their aftershocks.

When we take a close look at the aftershock distribution of the first earthquake, we can find that aftershocks showed a tendency of occurring in positive CFS change area. It marks the importance of stress transfer in earthquake occurrence, just the same as those reported by other studies. Reasenberg P.A. et al (1992, Science 255) showed regional seismicity changes responding to the static stress change produced by the Loma Prieta earthquake; Ross. S. Stein (1999, Nature 402) summarized new evidence in favor of the hypothesis that such small stress changes cause large changes in seismicity rate.

According to Rice and Cleary's model (1976, Rev. Geophys. Space Phys. 14), in the area where normal stress drops suddenly during the rupture time, the pore pressure decreases suddenly also. The anomalous pore pressure would recover to proper state after earthquakes occurred. While we calculated the above CFS changes, we introduced an effective friction coefficient (or effective normal stress) and did not take account into pore pressure change. It means that the CFS changes increase during pore pressure recovery. Therefore, the recovery time it takes might account for the time delay between these two Kagoshima earthquakes.

The evidence that such small CFS change (less than 1.0MPa) encourage earthquake occurrence may suggest that, the stress prior to rupture occurrence itself is in critical state. However, it should be noted that what we discussed here is static stress. The rupture process itself is a dynamic problem. Effects produced by the dynamic stress change may play an important role for earthquakes occurring near each other.