Dynamic triggering with no and/or little time-delay

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Abstract: Remote triggering has been observed immediately after the arrival of seismic waves from large teleseismic events. The triggered earthquakes which are usually reported as increasing seismicity appear to be excited with some time-delay after the wave arrivals, in agreement with a model based on the frictional law. The event triggering without time-delay appears to have a fluid-related mechanism and the triggering process itself should be different from that of the usually triggered earthquakes.

1. Introduction

These days there have been many findings of dynamic triggering of earthquakes due to large earthquakes. After the passage of the seismic waves, earthquakes actively occur and the seismicity becomes relatively high after the excitation. The triggering occurs with some time-delay after the onset of the stress perturbation, which has been explained by the stress loading on the fault planes, when we assume the rate and state frictional law. On the other hand, some event triggering is not accompanied by a time-delay and is excited during and/or immediately after the passage of the seismic waves. The 1999 Chi-Chi, Taiwan earthquake (Mw 7.7) triggered volcanic tremors (Miyazawa et al., 2005). The 2003 Tokachi-oki earthquake (Mw 8.1) triggered deep low-frequency earthquakes (Miyazawa and Mori, 2005). Considering the possible source process of these events, we discuss why the triggering occurred without any significant time-delay.

2. Volcanic tremors triggered by the 1999 Chi-Chi, Taiwan earthquake

After the 1999 Chi-Chi earthquake, we observed the occurrence of frequent volcanic tremors at Aso active volcano, Japan, which is located at a distance of about 1400 km from the epicenter. Immediately after the onset of the P-waves, short-period tremor (SPT) began to occur more frequently, for about 2000 sec, and during and after the arrival of surface waves, 2 micro-earthquakes were observed around the crater (Fig. 1). The frequent excitation of SPT indicates the increase of gas and fluids, which flowed up to the crater from source regions of the long-period tremor (LPT), in the 1−1.5 km deep aquifer region.

For the cases of seismic waves arrivals from other large teleseisms occurred from March 1995 to June 2002, triggering of the tremor was observed from 1998 to 1999. During this period increased thermal supply to the crater was observed while the background activity was relatively low, and the volcanic system beneath the crater was more responsive to external stress perturbations.
Remote triggering of deep low-frequency earthquakes

By using bore-hole seismic data of the High Sensitivity Seismograph Network (Hi-net) deployed by NIED, we detected seismic events triggered in the main part of Japan, by the 2003 Tokachi-oki, Japan earthquake (Mw 8.1). We constructed root-mean-square envelopes from velocity waveforms filtered with a path-band of 5–20 Hz, and statistically compared the changes of the amplitude before and after the passing of the body waves. During the arrivals of the surface waves, we found the excitations of the deep-low frequency (DLF) earthquakes in western Japan ($\Delta = 1000–1400$ km). These types of DLF tremors were recently discovered in this region and have predominant frequencies of 1–10 Hz with magnitudes less than about 2.0 at depth of 30–40 km. A possible source of DLF events is hydro-fracturing in the region where the oceanic crust is subducting.

The surface waves from other large teleseismic events (M $> 7$) have also triggered DLF earthquakes. During the arrivals of surface waves from the 2004 Sumatra-Andaman earthquake (Mw 9.1–9.3), DLF events were periodically observed, especially correlating with the Rayleigh waves. The results indicate that the DLF events were triggered by the surface waves without significant time-delay compared with the dominant periods of the surface waves (20–30 sec).

Discussion and Conclusions

The SPT tremor at Aso volcano and the DLF earthquakes in western Japan are triggered with no and/or little time-delay. This observation suggests that for such triggering cases with fluid-related mechanism, the models based on the rate-state frictional law may not be appropriate and clearly other mechanisms, which involve fluid related sources, are responsible. We cannot discount the possibility that our findings show only the cases, where the physical states of source regions were just in critical condition and events were easily and immediately triggered. We possibly still do not have enough circumstantial evidences to conclude that the fluids play an important role for the triggering without significant time-delay.
5. Acknowledgements
We used Hi-net data by NIED.

6. References