Remote triggering of earthquakes as a possible stress-meter: the case of the 2016 M7.3 Kumamoto mainshock

*Bogdan Enescu[1], Kengo Shimojo[2], Anca Opris[2], Yuji Yagi[3]

1. Department of Geophysics, Kyoto University, 2. Graduate School of Life and Environmental Sciences, University of Tsukuba, 3. Faculty of Life and Environmental Sciences, University of Tsukuba

Introduction

Activation of seismicity at remote locations due to the passage of seismic waves from large earthquakes is a well-documented phenomenon (e.g., Hill et al. 1993). However, such distant earthquake triggering is scarce in Japan (e.g., Harrington and Brodsky, 2006) with the notable exception of the remote seismicity activated after the 2011 M9.0 Tohoku-oki earthquake (e.g., Miyazawa et al., 2011). Here we report on a relatively widespread remote triggering of small earthquakes following the 2016 M7.3 Kumamoto (Kyushu) earthquake (an inland, strike-slip event). We hypothesize that the observed, unusual remote triggering might relate with the crustal weakening at volcanoes after the 2011 Tohoku-oki earthquake. In addition, it may also relate with the tectonic stress levels of inland crustal faults.

Data and Method

We have processed waveform data recorded at high-sensitivity Hi-net and broadband F-net stations, operated by NIED, as well as JMA and V-net (NIED) stations located throughout Japan. The waveforms have been scrutinized in both high and low frequency ranges to detect remote events that occurred during the passage of surface waves from the Kumamoto earthquake. Dynamic stresses have been estimated using the approach documented by Peng et al. (2009).

Results and Discussion

The activated seismicity correlates well with the passage at the surface waves from the Kumamoto earthquake. The furthest triggered event was observed in Hokkaido, at ~1630 km epicentral distance, close to Akan volcano, one of the most active in Hokkaido. Another example of remote triggering is that at the Akita-Komagatake active volcano (epicentral distance of ~1191 km), in northern Honshu. Triggering has been also observed at other volcanoes in Tohoku, Chubu, close to Izu Peninsula, and in the southern part of Kyushu (at the Suwanose-jima volcano –the only remote triggering that occurred south of Kumamoto earthquake epicenter). While remote earthquake triggering at volcanoes is predominant, other regions of triggering include Wakayama, Tottori and Noto Peninsula, which correspond to active fault areas.

Since all the analyzed triggering cases take place at epicentral distances more than ~8 times the Kumamoto fault length (30 –40 km, Yagi et al., 2016), we infer that the static stress changes are too small to trigger seismicity at such distances. However, the dynamic stresses are significant, ranging from several kPa to tens of kPa. The threshold dynamic stresses that can trigger seismicity are of a few kPa (e.g., Aiken and Peng, 2014). Since most of the remotely triggered earthquakes have been observed at volcanoes, we suggest that the excitation of crustal fluids may have been the main triggering mechanism. The strong shaking, up to relatively large distances, due to a strong directivity effect, may explain the observed spatial distribution of the triggered earthquakes as well as their long-range extent.

It is critically important to understand why such widespread remote activation has not been observed before for Japan, at similar dynamic-stress levels. We have found out that the regions activated this time, in particular the volcanic areas in Tohoku, have been also activated (from days to weeks) after the 2011 Tohoku-oki earthquake. We hypothesize that mechanical weakening of a pressurized crust in these

regions due to the 2011 megathrust might be responsible for an increased trigger-ability. In addition, the activation of some active crustal faults might be related to the levels of tectonic stress along these fault lines. All these observations suggest that remote triggering might be used as a stress-meter at volcanoes and active faults.

Reference paper:
Enescu, B., Shimojo, K., Opris, A., and Y. Yagi, Remote triggering of seismicity at Japanese volcanoes following the 2016 M7.3 Kumamoto earthquake, *Earth, Planets and Space*, 68:165, doi:10.1186/s40623-016-0539-5, 2016.

Keywords: dynamic triggering, stress-meter, volcanoes, active faults, 2016 M7.3 Kumamoto earthquake

