

Repeating inland earthquakes in northern Ibaraki Prefecture activated after the 2011 Tohoku-Oki earthquake

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The 2016 M6.3 earthquake in northern Ibaraki Prefecture is estimated to have reruptured the same portion of the fault already ruptured in 2011 by an M6.1 earthquake (Fukushima et al., 2018) in 2011. Since repeated slips with such a short interval are rare in inland area far from the plate boundary, it provides a unique opportunity to investigate the earthquake cycle. In this presentation, we introduce our ongoing study about the generation processes of the 2011 and 2016 M6 earthquakes in northern Ibaraki Prefecture.

We start by relocating hypocenters using precise differential arrival time obtained by the waveform cross-correlation. The target is 13,410 earthquakes with $M > 2$ listed in the JMA unified catalog for the period from Apr. 2003 to Oct. 31, 2018 in the M6.3 and M6.1 earthquake sequences near the Ibaraki-Fukushima border. We applied the double-difference hypocenter relocation method (Waldhauser & Ellsworth, 2002) to the differential arrival times of P- and S-wave based on a similar procedure to that by Yoshida & Hasegawa (2018).

Although the distribution of relocated hypocenters shows some complicated features, there is one dominant planar structure with west-dipping in northern Ibaraki prefecture. Comparison with the focal mechanisms supports that this planar structure corresponds to the fault plane of the 2011 and the 2016 M6 earthquakes. A planar structure of hypocenter did not newly appear after the 2016 earthquake; their aftershocks are concentrated on the existing planar structure. This supports that the 2011 and 2016 M6 earthquakes ruptured the same fault as pointed out by Fukushima et al. (2018).

The existence of repeating M6 earthquakes suggests that there are other smaller-magnitude repeating earthquake sequences along the plane. Based on the precise hypocenter locations and the waveform similarity, we detected many small repeating earthquakes ($M > 2$) along the plane, which surround the large coseismic slip area of the M6 earthquakes. These small repeating earthquakes are estimated to be caused by the afterslip of the 2011 and 2016 M6 earthquakes. According to the empirical relationship between seismic moment and slip amount (Nadeau & Johnson, 1998), the slip amount is roughly estimated to be a few tens centimeter, which is comparable to the slip amounts of the two mainshocks. Moreover, the slip amount after the 2011 earthquake is larger than that after the 2016 earthquake, which is consistent with Fukushima et al. (2018). These suggest the importance of the effects of afterslip for the aftershock occurrence and the earthquake cycle.

Keywords: repeating earthquake, afterslip, the 2011 Tohoku-Oki earthquake