

## Recurrence of similar surface ruptures associated with the M 6 earthquakes of 2011 and 2016, northern Ibaraki, Japan

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The Mw 9.0 Tohoku earthquake of 2011 triggered unusual normal-fault-type earthquakes in the southern part of Abukuma mountains, a fore arc mountain of northeast Honshu arc, Japan. Most remarkable earthquake swarm has occurred in the northern part of Ibaraki prefecture with two of moderate earthquakes, Mj 6.1 of March 19, 2011 and Mj 6.3 of December 28, 2016 earthquakes.

We conducted a field survey on the surface ruptures on January 5, 2017, and found a surface ruptures and destruction of artificial structures such as roads and a bridge caused by faulting. These ruptures were found in a 2.5-km-long section with a trend of NNW-SSE along a linear discontinuity of satellite radar interferometry image provide by the Geospatial Information Authority of Japan (2016). At Mochiyama (N36.821, E140.610) in the northern part of the section three ruptures zones cross a paved road at a low angle. We measured the fault displacement at about 15 cm in vertical across the 6-m-wide rupture zone, and 5-6 cm in horizontal-dip component for each of two rupture zones. Some of fissures seem to be older than the 2016 earthquake because those had filled with dirt. Aoyagi et al. (2015) reported that some ruptures appeared associated with the 2011 event at the same location. At the Shin-Koyama bridge site (N36.806, E140.626) in the southern part of the section many of fissures appeared across a prefectural highway running perpendicular to the linear discontinuity of interferometry image. The fissures occurred in a 170 m section of the paved road and the bridge completed in 1993. The total amount of width of those fissures reaches 29 cm. The fault displacement occurred in two steps, because some of new fissures and destructions appeared along the repaired ones. The distribution pattern and amount of displacement are very similar between those two events. Those fissures occurred on both sides of the bridge, suggesting that they are fault origin, not due to landslide. At the 0.5 km southern point of the bridge, new and old minor fissures also appeared on the pavement of a forest road. Along further 3-km-long southern section of the linear discontinuity of interferometry image, 1-2 cm-wide fissures were observed.

Our findings of two steps of surface rupturing suggest that the 2011 and 2016 earthquakes produced the similar surface faulting repeatedly with only 6 years of interval. The ruptures occurred in a Mesozoic granitic batholith where neither of geological and geomorphological faults has mapped. Repeating of 2011 and 2016 small surface faulting might be the characteristics of triggered events on immature fault.

### Reference:

- 1) Aoyagi, Y., Onuma, T., Oku, T. and Sasaki, T., 2015, Proceedings of the Symposium on Fault Displacement Evaluation, 31-38.
- 2) Geospatial Information Authority of Japan, 2016, <http://www.gsi.go.jp/BOUSAI/H28-ibaraki-earthquake-index.html>. (Feb. 15, 2017, last access)

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