Structural heterogeneity under the 2018 Mw6.6 Eastern Iburi earthquake in Hokkaido, Japan and its implications for rupture initiations

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On September 6, 2018, an Mw6.6 (moment magnitude) crustal earthquake occurred at Eastern Iburi on the island of Hokkaido, Japan (hereafter referred to as the Iburi Earthquake), where the northeastern Japan arc obliquely collides with the Kuril arc. It is the first time an earthquake has ever reached a maximum intensity of 7 (on scale of JMA: Japan Meteorological Agency) in Hokkaido. The 2018 Iburi earthquake caused serious damage across Hokkaido Prefecture and adjacent regions, including the death of 44 people, as many as 680 injuries, and a large number of landslides around the town of Atsuma. The focal mechanism solution of the earthquake showed that initiation occurred on either a moderately dipping reverse fault striking northwest (NW), or on a shallow-to-moderately dipping fault striking southeast (SE).

The hypocenter area is characterized by the mutual interactions of three plates: the Pacific plate, the North American (Okhotsk) plate, and the Eurasian plate. This reverse-faulting earthquake occurred close to the Hidaka main thrust belt, whose tectonics are driven by the convergence of the above three plates. The plate boundary between the Eurasian and Okhotsk plates is located near the eastern coastline of the Japan Sea. Under the Iburi earthquake, the Pacific slab is subducting towards the west (W) -NW beneath the Eurasian and North American plates from the northeastern (NE) Japan and Kuril Trenches. In the Hokkaido subduction zone, there have been 18 earthquakes (M_J > 6.5: JMA magnitude) recorded since 1926; however, the majority are interplate thrust earthquakes associated with the Pacific slab subduction, and only five of these occurred at shallow depths under Hokkaido according to JMA focal depths.
The hypocenter determined by JMA indicated a focal depth of ~37 km. Given the focal mechanism solutions and depth, the main-shock was likely an intraplate event within the North American (upper) plate (or Okhotsk microplate), rather than on the interface between the subducting Pacific and North America plates. This was because the iso-depth of the upper boundary for the Pacific slab was about ~100 km beneath the epicenter. Although numerous seismic tomographic studies in the crust and uppermost mantle have been conducted in Hokkaido, the structure in the 2018 Iburi source area remains poorly resolved. It is worth noting that the seismic velocity and Poisson ratio images, together with geology and geothermal data, in the source area could provide some important information for a better understanding of earthquake generation. To investigate the rupture initiation of the earthquake, we conduct a high resolution seismic tomography study to determine the seismic velocity and Poisson ratio structures under the entire Hokkaido arc. Our results indicated that the main-shock was likely located at a blind-thrust fault close to the boundary between the negative and positive seismic anomalies. A strong low velocity and high Poisson ratio body that extended to a depth of ~120 km was clearly imaged northwest of the hypocenter under the back-arc side of the mantle wedge, indicating fluids were released from the subducting Pacific slab dehydration. Fluids released from the great depth of the back-arc mantle wedge would intrude into the positive anomaly from the more saturated negative side in the lower crust, leading to high pore-fluid pressure accumulation in that region. The descending brittle crustal material sandwiched by two negative zones in the hypocenter was sufficiently large, resulting in strain concentration, decrease of rock effective stress in the hypocenter, and contributing to brittle deformation.

Keywords: 2018 Mw6.6 Eastern Iburi earthquake, Fluid pore-pressure concentration, Role of fluids in triggering of earthquake

