Structural Heterogeneity in and around the Source Region of the 2018 Hokkaido Eastern Iburi Earthquake, Central Hokkaido, Japan

*Takaya Iwasaki[1], Noriko Tsumura[2], Tanio Ito[3], Kazunori Arita[4], Makoto Matsubara[5], Hiroshi Sato[1], Eiji Kurashimo[1], Naoshi Hirata[1], Susumu Abe[6], Katsuya Noda[7], Akira Fujiwara[8], Shinsuke Kikuchi[9], Kazuko Suzuki[10]

1. Eathquake Research Institute, the University of Tokyo, 2. Graduate School of Science, Chiba University, 3. Association for the Development of Earthquake Prediction, 4. Hokkaido Research Center of Geology, 5. National Research Institute for Earth Science and Disaster Resilience, 6. JAPEX, 7. GEOSYS Inc., 8. JOGMEC, 9. JGI Inc., 10. Schlumberger Ltd.

Central Hokkaido, Japan, has complicated tectonic history of subduction, accretion and collision processes from Late Jurassic to the present. Since Paleogene or Early Miocene, compressional stress regime has been dominated by the dextral oblique collision between the Eurasia and North America (Okhotsk) Plates and the subsequent westward movement of the Kuril Arc due to the oblique subduction of the Pacific Plate. The latter event was responsible for the formation of the Hidaka Collision Zone (HCZ) and the foreland fold-and-thrust belt with a very thick (>10 km) sedimentary package. The 2018 Hokkaido Eastern Iburi Earthquake (M=6.7) took place at a very deep depth of 37 km under this foreland fold-and thrust belt. To understand the mechanism on the occurrence of such a deep earthquake from the surrounding structural heterogeneity, we reanalyzed controlled source seismic data from the 1998-2000 Hokkaido Transect Project by applying advanced processing techniques including CRS/MDRS stacking methods and integrated refraction/wide-angle reflection analyses.

The seismic reflection processing imaged for the first time the NE Japan Arc underthrust eastward beneath the thick sedimentary package. The refraction/wide-angle reflection data were re-interpreted by tomography and ray-tracing methods. The latter analysis with aid of the new structural information from the reflection processing indicate that the crust is very thin (15-23 km) and the Moho depth is 22-30 km. The Pn velocity is a normal value of around 8 km/s. These structural features are well consistent with those in the offshore area of NE Japan, which belongs to the same geological unit. Based on the structural information mentioned above, the aftershock distribution was carefully investigated. Aftershocks relocated by the 3D structure model (Matsubara, 2017) with appropriate station corrections are distributed in a depth range of 7-45 km showing a steep geometry facing to the east. We cannot find any evidence that the aftershock distribution is related with shallow west-verging active faults developed in the fold-and-thrust belt. We think that the high-angle fault of this earthquake was formed by a certain tectonic event before the collision, maybe in Late Oligocene to Middle Miocene. The relocated aftershocks are separated into the upper (7-20 km) and lower (22-45 km) groups. The seismicity gap between them corresponds to the lower crust of our velocity model, probably representing its ductile property. According to our results, more than 80 % of relocated events occurred within the uppermost mantle of our structure model. Possible explanation for this high seismic activity is the cold crust delaminated from the Kuril Arc side, whose existence was is confirmed by a series of seismic reflection profiling in the southern part of the HCZ (Arita et al., 1998; Tsumura et al., 1999; Ito, 2000, 2002) and seismic tomography by Matsubara et al. (2017). This delaminated crustal body prevents the thermal circulation and upward migration of dehydrated fluid to cool the forearc mantle and generate more favorable environment for the brittle failure.

Keywords: Hokkaido Island, Hokkaido Eastern Iburi Earthquake, Crust and upper mantle structure, Controlled-source seismic expeditions, Seismic tomography, Fold-and-thrust belt