Different deformation styles in the source regions of the 2019 Yamagata-oki earthquake and the 1964 Niigata earthquake

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On June 18, 2019, a Mj6.7 earthquake occurred at Yamagata-oki. The source region of this earthquake is adjacent to that of the Mj7.5 earthquake which occurred on June 16, 1964, and in this region, there are few aftershocks right after the 1964 earthquake, and the seismicity rate in recent years is extremely low (Earthquake Research Committee, 2019). This observation suggests that the source region of the 2019 Yamagata-oki earthquake was not ruptured by the Niigata earthquake, but the cause has not been revealed. In order to elucidate the relationship between these two areas, this study compared the characteristics of seismicity between the two areas.

We used the JMA catalog constructed by Japan Meteorological Agency (the Preliminary Determination of Epicenters). We applied HIST-ETAS (Hierarchical Space Time Epidemic Type Aftershock Sequence) model (e.g., Ogata, 2004) considering the spatial dependence of each parameter of the Space Time ETAS model (e.g., Ogata, 1998), to the hypocenter catalog (M1.8) from 1998 through 2019 in order to estimate the spatial distribution of background seismicity rate μ and number of aftershock occurrences K. As a result, we find that μ-value is higher and K-value is lower in the source region of Yamagata-oki earthquake than in that of Niigata earthquake.

In addition to these differences, we find that the b-value, which is one of the characteristics of the seismicity, is lower in the source region of Yamagata-oki earthquake than in that of Niigata earthquake. Moreover, comparing the seismic wave velocity structure obtained by Matsubara et al. (2019), the P wave velocity is lower in the source region of Yamagata-oki earthquake than in that of Niigata earthquake. The difference in seismic wave velocity and characteristics of seismicity between these two areas suggests that the macroscopic behavior in the source region of Yamagata-oki earthquake is more ductile than in that of Niigata earthquake. In more ductile area, microfracture is likely to proceed and it decreases seismic wave velocity. In addition, background seismicity rate (μ) decreases in more ductile area because of low brittleness. Moreover, the results of rock experiments and numerical simulation by Amitrano (2003) imply the increase in aftershock productivity (K) and the decrease in b-value in more ductile area. Focusing on the short-wavelength component of the linear strain rate distribution in the east-west direction (Meneses-Gutierrez and Sagiya , 2016), the different response for the 2011 off the pacific coast of Tohoku earthquake between the source regions of Yamagata-oki earthquake and Niigata earthquake is appeared. These differences may reflect different deformation styles between the two regions.

Keywords: the 2019 Yamagata-oki earthquake, HIST-ETAS model, brittle-ductile

