

# Crustal movement and direction of principal motion of earthquake caused by the 18 June 2019 Yamagata-ken-oki earthquake of Mj 6.7, northeast Japan

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At 22:22 on June 18, 2019, an Mj 6.7 (Mw 6.4) earthquake occurred with the epicenter off the Sea of Japan off of Yamagata Prefecture (38.6 °N, 139.5 °E, 14km deep). The focal mechanism showed a reverse fault with a compression axis in a WNW-ESE direction (JMA 2019). A maximum seismic intensity of 6 or more at Fuya, Murakami city, Niigata Prefecture on the coast facing the epicenter, and a seismic intensity of 5 or more at Atsumi, Tsuruoka city, Yamagata Prefecture. Observed a seismic intensity of 5 strong and a low intensity of 5 in Baba-cho, and Tsuruoka city and Murakami city were hit by a strong shaking with a seismic intensity of 4 or more (Earthquake Prediction Research Promotion Association 2019). Since the epicenter was very close, about 6 km from the coast, I decided to check for any crustal deformation along the coast following the earthquake from 5:00 am to 6:00 pm on June 19, 2019 immediately after the earthquake. The geomorphological and geological survey was conducted for about 30 km north-south of the coastline from Kobato, Tsuruoka city to Ashiya, Murakami city, Niigata Prefecture, where the shaking was strong. In addition, in order to know the direction of the principal motion around Koiwagawa, Tsuruoka City, where the damage of the roof tiles and tombstones were concentrated in the survey area, the slip direction of tombstones were investigated.

The author investigated cemeteries around Koiwagawa, Tsuruoka City, for five days from June 19, 2019 immediately after the earthquake, in order to estimate the direction of principal motion along the coast. The estimation of the direction of principal motion followed the method of Sawa et al. (1996). Using a clinometer, I measured the direction of movement of tombstones that did not fall and turned in one direction, or horizontally. Four cemeteries were surveyed. At the Hamanaka Cemetery in Oiwakawa, Tsuruoka City, about 6.5 km east of the epicenter, nine tombstones were displaced in one horizontal direction, and the remaining 19 were rotating. Of the nine tombstones shifted in one direction, three are shifted from northwest to southeast and are almost orthogonal to the strike of the earthquake source fault (NE to SW), and the remaining six are shifted to E-W obliquely to the strike of the earthquake source fault. At the hall where buddhist mortuary tablets at the Ryusen-ji temple, about 200m west-southwest of the Hamanaka Cemetery, candlesticks had fallen in the same direction (observed on June 20, 2019). The strike in the longitudinal direction of the hall is N20 °W, and the strike in the lateral direction is N70 °E. In many cases, buddhist mortuary tablets placed on the shelf set in the short direction have fallen forward, but buddhist mortuary tablets on the shelf installed in the longitudinal direction have few jumps or falls. The dozens of candlesticks placed on the longitudinal shelves fell uniformly at S20 °E in the longitudinal direction without falling off the shelves. From the above, it is estimated that the direction of the principal motion at Ryusen-ji temple is N20 °W.

Intertidal organisms were observed to see if there was a relative uplift and land subsidence at 14 locations in the study area, between 5 am and 6 pm on June 19, 2019, immediately after the earthquake. The tide level at Awashima Island observed by the JMA tide table at the observation time is about 10 cm. No evidence was found suggesting a relative uplift and land subsidence that could be determined with the naked eye.

Keywords: the 18 June 2019 Yamagata-ken-oki earthquake, principal motion, crustal movement, geomorphological and geological survey