Spatiotemporal variation of released seismic energy from shallow low-frequency tremor in Hyuga-nada, revealed by ocean bottom seismological observation

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In this study, we estimate the released seismic energy by shallow low-frequency tremors (shallow tremors) and clarify spatiotemporal variation of shallow tremor activity in Hyuga-nada, east off Kyushu. We used the data obtained from the temporal ocean bottom seismological observation for 3 months in 2013 [Yamashita *et al.*, 2015] and long-term ocean bottom seismological observation from 2014 to 2017. The source location and released seismic energy of each shallow tremor was simultaneously estimated by Hybrid Envelope Cross-correlation Method [Maeda and Obara, 2009]. Observation data were obtained by the long-term continuous ocean bottom seismic observation in Hyuga-nada from 2013 to 2017. Site amplification factors were estimated by the coda normalization method [e.g., Sato and Fehler, 1998].

Spatial distribution of released seismic energy rate (energy rate) shows a heterogeneity although the average value of that is generally 10^4 J/s. The regions where the energy rate is relatively small are roughly coincident with the subducting or passed areas of the Kyushu-Palau Ridge. This result suggests that the structure and/or shape of the subducting plate such as seamounts or ridges may have an effect on the frictional property of the shallow plate interface. The 2013 activity was similar characteristics of shallow tremor location in space and time as the previous study, including two migrations episode. In addition, the characteristics of the released seismic energy were revealed as follows: (1) the energy rate was large at the both initiation point and the front of the migration, (2) the total released energy amount of the first migration was larger than that of the second migration, (3) both migrations were stopped at the region of small amount of released energy. Migration episode occurred while the 2015 activity and similar characteristics were documented.

Migration speed of shallow tremor is a few times faster, and energy rate of that is one or two orders of magnitude greater than the deep tremor. Applying the model of Ando *et al.* [2010, 2012] and Yabe and Ide [2014] to the result in this study, the average fault strength of shallow tremor is stronger than that of deep tremor, which leads up to a faster fault slip both brittle and ductile area. As a result, migration speed may become to be faster than deep tremor.

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