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Factors causing scattered boulders located around Hashigui-iwa, the southernmost of Kii peninsula, Japan

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A number of boulders are widely scattered on wave-cut benches around Hashigui-iwa, the southernmost of Kii peninsula, Japan. The boulders are not in-situ because almost all the boulders are composed of volcanic rock derived from Hashigui-iwa dike. They are scattered in several meters to about a hundred meters western from Hashigui-iwa dike. Therefore they are considered to be carried to the present locations by external forces, for example, tsunamis and/or storm surges. We studied whether the boulders can be moved by tsunamis.

Hashigui-iwa is facing to Nankai trough, and the boulders were repeatedly attacked by many huge tsunamis, for example, the 1944 Showa To-nankai, the 1946 Showa Nankai, the 1854 Ansei, and the 1707 Hoei earthquake tsunamis. To verify water velocities on the wave-cut benches around Hashigui-iwa, tsunami numerical simulations were carried out including runup effects. Artificial structures of breakwaters and filled grounds were removed from the topography used in the calculations. As a result, the water velocity on the wave-cut beach was estimated more than 4 m/sec in case of the 1707 Hoei earthquake tsunami (Ando, 1975; TECT).

We also carried out field surveys around Hashigui-iwa, and measured the locations and dimensions of the boulders (Maemoku et al., 2010; JPGU). The number of the boulders is more than one thousand, and some of them weigh more than 100 ton. Moreover, we also measured coefficient of static friction between the boulders and the wave-cut benches. The value of the coefficient was estimated to be 0.8. Thus, we found that the water velocity of more than about 4 m/sec, especially more than about 8 m/sec for large boulders, is needed to start sliding.

We compared aero photographs taken above the wave-cut benches in 1975 and 2007, and checked whether the boulders were moved during the 32 years. All the boulders were considered to stay at the same positions except five small boulders. During the years, no large tsunamis attacked, but some huge typhoons attacked. The five small boulders might be moved by the storm surges and/or sever wind waves due to the typhoons, although they might be moved artificially because Hashigui-iwa is a sightseeing area.

The boulders may be scattered by the past tsunamis, for example, the 1707 Hoei earthquake tsunami, and the distribution of the boulders may indicate a history of the past huge tsunamis. Recently, a geological study reported that some of the boulders were overturned due to the 1707 Hoei earthquake tsunami (Shishikura et al., 2011; JPGU this meeting). Our results supports their results.

Keywords: boulders, Hashigui-iwa, wave-cut benches, tsunami, the 1707 Hoei earthquake