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Reconstruction of past tsunami disasters: Evidence from radiometric dating of Porites coral boulders in Southern Ryukyus

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It is important for future disaster mitigation to evaluate the recurrence period and/or frequency of extreme geohazard events such as earthquakes, tsunamis and severe storms. In this study, We focused on fossil coral boulders cast ashore by paleo-tsunamis. A large number of massive coral boulders, locally called Tsunami-ishi, are widely scattered both along the shore and on the reef all over the Southern Ryukyu Islands, Japan. When corals were cast ashore by large tsunamis, their growth should stop at that time and the date of the tsunami event could be confirmed by radiometric dating of well-preserved surface parts of these coral boulders.

Several previous studies reported ^{14}C ages of tsunami boulders. However, in previous studies there were some problems such as selection of samples for dating and conversion of ^{14}C ages to calendar ages, hence previous studies concluded that confirming historical tsunami events were difficult. In this study, unlike reef rock boulders, We focused on *Porites* coral boulders that can be used to determine the exact ages of past events because the age of the coral surface should indicate when the boulder cast ashore by the tsunamis. To determine the exact ages of past disaster events, we also used a high-precision and accurate dating of well-preserved surface parts of massive *Porites* coral boulders cast ashore.

This is the first report that high-precision U/Th dating has been applied to tsunami deposits in Japan. The results confirmed that several *Porites* boulders in Ishigaki Island were cast ashore both by the 1771 Meiwa tsunami, one of the largest tsunami disasters in Japan, and by the 1625 historical tsunami event of unknown cause.

^{14}C dating of 125 samples collected from Southern Ryukyu Islands was also conducted and its dates were converted to calendar ages by using appropriate correction methods. Some huge *Porites* boulders were newly identified as the Meiwa tsunami origin, which are useful for numerical transport model of the boulders and lead to calculate hydraulic values of the Meiwa tsunami. We also newly found several Meiwa-tsunami-derived *Porites* corals in various geological settings on several islands. These results could help to constrain source fault models of the Meiwa tsunami, and lead to specify the location of source fault of the tsunami, which has still been controversial.

^{14}C measurements of 77 *Porites* boulders also suggest that these boulders cast ashore by not only 1771 Meiwa tsunami but also other various paleo-tsunamis during more than last 2,000 years. By stacking probability distributions of calibrated ^{14}C ages of these boulders, some tsunami peaks including 1771 Meiwa tsunami and 1625 historical tsunami were detected. This result indicates that past tsunamis struck Southern Ryukyu Islands in cycles of about 150 to 400 years. Moreover, these peaks also confirmed paleo-tsunamis not described in historical documents but only told as regional legends. This is the first scientific evidence of legend tsunamis.

This study demonstrated that historical and prehistorical tsunamis could be confirmed by accurate dating of *Porites* coral boulders. The methods we developed in this study demonstrate an important application of these boulders for paleo-geohazard studies.

Keywords: Tsunami boulders, Porites spp. coral, U/Th dating, Radiocarbon dating, Paleo-tsunamis, Southern Ryukyu Islands