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A new magnetic relaxation dating reveals tsunami ages from individual tsunamigenic coral boulders on Ishigaki Island

SATO, Tetsuro[1*] ; NAKAMURA, Norihiro[1] ; GOTO, Kazuhisa[2] ; KUMAGAI, Yuho[1] ; MINOURA, Koji[1] ; NAGAHAMA, Hiroyuki[1]

[1]Department of Earth Science, Tohoku University, [2]International Research Institute of Disaster Science (IRIDeS),Tohoku University

Information about past tsunami hazards, such as their recurrence interval and magnitude, is needed for future disaster prevention and mitigation. Tsunamigenic boulders could estimate a magnitude of tsunami waves to transport them to coastlines, but no information for recurrence intervals has been obtained. In the Ishigaki Island, Japan, there are tsunamigenic boulders consisted of the hermatypic corals. The distributions of large numbers of radiocarbon dating for these boulders determined the timing of past tsunamis. Although the radiocarbon dating is a powerful tool for estimating tsunami age for corals including radiocarbon, information for subsequent transportations of individual coral boulders and for ages of tsunamigenic igneous boulders without any trace of radiocarbon. Paleomagnetic viscous dating could overcome this problem because time-dependent viscous remanent magnetization is acquired parallel to the Earth's magnetic field after the transportation. Furthermore, Neel's thermal relaxation theory on single domain magnetite particles predicts the time-temperature relation for the viscous relaxation. Following Pullaiah et al. (1975), we can derive a time-temperature nomogram for single domain nanoparticle ensembles describing that a remanence acquired during a time at a room temperature in nature can unblock during shorter heating step at higher temperature in a laboratory. We have been applying this relation to the coral boulders in Ishigaki Island, but their emplacement ages determined from this time-temperature relation showed an older age than radiocarbon dating for the same boulders. Here, we revisited the Neel's exponential relaxation model of magnetic relaxation in order to determine the same age as radiocarbon dating by extending the previous time-temperature relation. It is considered that magnetic viscous relaxation of fine-grained magnetite is following an exponential or logarithmic function of time, but the reexamination of previously published viscous relaxation data suggested that magnetic viscous data is fit by a stretched exponential function of time. Using this stretched exponential function, we obtained a new time-temperature relation for estimating accurate tsunami ages. Combined this new relation and statistical data measured by the repeated thermal demagnetizations with a varied duration time, we succeeded to determine the same ages as radiocarbon dating for our coral boulders.

Keywords: tsunamigenic boulder, viscous remanence, time-temperature relation, stretched exponential