

Constraint of the ages of historical tsunami deposits on the Ishinomaki Plain

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The research of tsunami deposit has an important role for understanding the paleo-tsunami history. On the Ishinomaki Plain, where the AD 2011 Tohoku-Oki tsunami inundated widely, at least six paleo-event deposits were found by previous studies (Shishikura et al., 2007; Sawai et al., 2012; Takeda et al., 2017). Sawai et al. (2012) correlate the latest three event deposits (Sand K, A, and B) with the tsunamis generated by the AD 1611 Keicho Ohsyu earthquake, the AD 1454 Kyotoku earthquake, and the AD 869 Jogan earthquake, respectively. Among them, the event age of Sand B is well constrained by the To-a tephra of AD 915 and radiocarbon ages, which ensure the validity of correlation with the historical record. However, the event ages of Sands K and A were not well constrained because accurate estimation of these event ages by radiocarbon dating is theoretically difficult. There remains a need to improve the accuracy of these event ages for understanding recurrence interval of tsunamis and comparing with the age of tsunami events in other sites. Therefore, we conducted multi-proxy analyses including radiocarbon dating, and analyses of diatom and pollens for the samples taken from the Ishinomaki Plain and then discuss the age of event deposits formed during the last 700 years.

The field survey was carried out on the coast area of Higashi-Matsushima City, Miyagi Prefecture. Cultivated soil, silt, and peat layers were found in the core samples. In some sites, one or two medium sand layers were found. Diatom analysis, pollen analysis, X-ray CT scan, and radiocarbon dating were conducted for the clearly identified two sand layers. The radiocarbon dating results were calibrated by OxCal Ver. 4.3.2 (Bronk Ramsey, 2009) with IntCal13 (Reimer et al., 2013) and constrained by stratigraphy (Bronk Ramsey, 2008).

Two sand layers (hereafter we call, Sands 1 and 2 for the upper and lower sand layers, respectively) are closely spaced with sandy silt layer of approximately 1–3 cm between them. Two hypotheses can be considered for the formation of these sand layers; they were deposited by different events, or a single event. Eyewitness observation and X-ray CT scan analysis imply that the sandy silt deposits in between these two sand layers contain many sand grains, and clearly different from the peat layer below Sand 2. The radiocarbon dating revealed that the age of sandy silt layer is intermediate between silt above Sand 1 and peat below Sand 2. In addition, sandy silt includes many freshwater diatoms but does not include marine and marine-brackish diatoms; diatom assemblage is clearly different from peat below Sand 2 that contains marine-brackish diatoms but few freshwater diatoms. Thus, sandy silt between Sands 1 and 2 is probably deposited as normal sediment so that Sands 1 and 2 should have been formed by different events.

The ages of Sands 1 and 2 can be constrained as 11 to 408 cal BP and 357 to 538 cal BP (2σ), respectively. These event ages are consistent with the AD 1611 Keicho Ohsyu earthquake and the AD 1454 Kyotoku earthquake, as interpreted by Sawai et al. (2012). The pollen analysis further shows the extensive increase of *Pinus sp.* and *Cryptomeria sp.* in the sediment above Sand 1. This result can be correlated with the afforestation policy by Sendai Domain after mid-17th century as planting Japanese

pine and cedar was encouraged by the AD 1621 Sendai domain' s law (Hanso Date Masamune kensho-kai, 1938). Therefore, Sand 1 has most likely been formed by the AD 1611 tsunami.

Keywords: earthquake, tsunami, AD 1611 Keicho ohsyu earthquake