Identification of tsunami, storm, and river flood deposits besed on the multi-proxy evidence on the coastal lowland of Odaka District, Minamisoma City, Fukushima Prefecture, Northeast Japan

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Study of tsunami deposits is significant for mitigation of tsunami hazard, because it helps to assess the scale and periodicity of future tsunamis. However, the unequivocal identification criteria of tsunami deposits have not established yet. Therefore, comprehensive determination criteria based on several evidences are required.

The study area, Idagawa lowland (formerly Idagawa estuary) is located on the coast of the Pacific Ocean, Odaka District, Minamisoma City, Fukushima Prefecture, northeast Japan. Small estuary was formed due to the transgression into the incised valley after the Last Glacial Maximum. The Idagawa estuary was reclaimed in 1929 and it has been used for a rice growing area until the occurrence of 2011 off the Pacific coast of Tohoku Earthquake and tsunami. Even before the 2011 Earthquake, it has been pointed out that the study area has tended to subside during Holocene epoch (Niwa et al., 2017, *Quaternary International*), and has been inundated by several tsunamis (Sawai et al, 2015, *Geophysical Research Letters*). Also, the lowland has poor drainage and has been flooded several times by the river (Fukushima Prefecture, 2004). From these historical records, both tsunami and flood deposits were possibly preserved in the study area.

We took two Holocene drilling cores at seaside and landside of the lowland to study of the event deposits. The two cores are composed of Pliocene basement rocks, backshore sand, tidal flat sand and mud, central basin mud, salt marsh mud with intercalated event sand beds, and artificial fill and paddy soil. Fourteen event sand units are preserved in the salt marsh deposits. The origin of each sand unit was distinguished based on the multi-proxy evidence, radiometric ^{14}C dating, grain size, diatom fossil and geochemical (TS, TOC and $\delta^{13}C_{org}$) analyses, comparison with present tsunami deposits formed by the 2011 Tsunami and with historical tsunami records in Fukushima and Miyagi prefectures.

Most of event sand units thin and fine towards landside, and represented laminations and grading structures. They yield shell fragments, and marine diatom fossils increased in the overlaying mud and/or in the event sand units. Also, the value of $\delta^{13}C_{org}$ demonstrated increasing trend above the event units. These features are similar to 2011 Tsunami deposits, and indicating that they are possible tsunami deposits. While, some sand units represent different features. The sand units thin towards seaside, and yield fresh river diatoms increased above the units. Also, the value of $\delta^{13}C_{org}$ demonstrated decreasing trend in overlain mud. It indicates that they are possible river flood deposits.

We compared the possible tsunami units and historical tsunami records in surrounding areas. Some sand units were corresponded to paleo-tsunami events, such as AD 869 Jogan Tohoku tsunami. In the other hand, a thin sand unit above the possible tsunami sand unit was not corresponded to any historical tsunami records. It can be considered as storm deposits. Nevertheless, there is no historical storm records reported from the study area. It is interpreted that storm surge would not inundate in normal condition because the lowland is protected by beach ridges. However, when large tsunami once occurs, tsunami

events break the beach ridges. As a consequence, storm surge can easily inundate and form sandy deposits.

We excluded the possible storm and river flood deposits, and considered the occurrence intervals of tsunami in this study area. The occurrence intervals of tsunami were calculated to be approximately 700 years, and it consistent with the invasion period of tsunamis reported from Fukushima and southern Miyagi prefectures.

Keywords: Holocene, Environmental changes, Event deposits, Estuary

