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Thickness and grain size fluctuation of the 2011 Tohoku-oki tsunami deposit in Sendai and Joban coasts, Japan

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In general, tsunami deposits thin and fine landward, although local microscopic topographic features give strong effects to the distribution trend of the deposits. For instance, post-tsunami field surveys after the 2011 Tohoku-oki event revealed that the thickness and grain-size varies significantly because of the small-scale undulations (Nakamura et al. 2012), redistribution of the vented sediments from liquefaction (Goto et al. 2012) and scouring at the lee side of engineering structures (Takashimizu et al. 2012). Investigation of local variability of thickness and grain-size of modern tsunami deposits are a key to better understand of the formation process of the tsunami deposits. However, it is usually difficult to consider such local effects in case of paleotsunami events. Therefore, it is rather important to clarify the characteristics of general thickness and grain-size trends and the physical formation process of tsunami deposits from modern examples. Such findings can be applied for estimating the size and hydraulic behavior of paleo-tsunamis.

In this study, the 2011 Tohoku-oki tsunami deposits were investigated along twelve shore-normal transects on the coastal lowland in Miyagi and Fukushima prefectures, northeast Japan. Inundation distances at each transect ranged from 0.6 to 4.1 km. Trench surveys of the tsunami deposits were conducted at over 500 sites from April 2011 to November 2012. Deposit thickness, grain-size and sedimentary structures were documented and samples were retrieved from each site. Grain size of the tsunami deposit was measured using settling tubes.

Total thickness of sand and mud, and thickness of sand layer generally showed a landward thinning trend in each transect. Between 1.5 and 2 km inland from the shoreline, the total thickness was less than 10-15 cm, and father inland (over 2-2.5 km) it was thinned below 5 cm. The sand layer was less than 10-15 cm in thickness between 1.5 and 2 km inland, less than 5 cm from 2 to 3 km inland, and $<$0.5 cm at further inland (more than 2.5-3 km from the coastline). The thickness of mud layer was less than 5 cm at each location and there was no obvious landward trend. Mean grain size showed a landward fining feature up to 2 km inland, but it showed a fluctuation ranging from 1.5 to 2 phi. Meanwhile, the grain size rapidly fined landward down to 3 phi at 2-2.8 km from the shoreline.

We found a general landward thinning trend of the total thickness of the tsunami deposits. However, the thickness was largely varied in a zone up to 1.0-1.5 km inland. In this area, the thickness was likely to be sensitive to the local undulation of topography. According to the grain size analysis, bed-load transport might have been dominated in this section. Along short transects ($<$ 2 km), there was no remarkable difference in the thickness of sand layer near the coastline and at the inundation limit. Hence, it is likely that the sediment-transport capacity of the tsunami was well maintained at least 2 km inland. Besides, absence of the thick tsunami deposits ($>$0.5 cm) between 2 and 3 km inland may explained by the following reasons: (1) limited sand supply from the source (i.e. sand dunes developed within 0.5-1 km from the coastal line; Szczucinski et al. 2012), (2) decreasing in sediment transport capacity because of reductions of the flow speed and depth during tsunami inundation.

< References >
Goto et al., 2012, Geology, 40, 887-890.
Nakamura et al., 2012, Sedimentary Geology, 282, 216-227.
Szczucinski et al., 2012, Sedimentary Geology, 282, 40-56.
Takashimizu et al., 2012, Sedimentary Geology, 282, 124-141.

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