

Inundation and sedimentary features of the 2011 Tohoku-oki tsunami along a 20-km-stretch of coastal lowland

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The 2011 Tohoku-oki tsunami caused severe damage to the coastal regions of eastern Japan and left tsunami sediments on the affected area. We discuss differences in depositional features of the 2011 Tohoku-oki tsunami from the viewpoints of the sediment source and coastal topography as well as tsunami flow height. The study area on the Misawa coast, northern Tohoku, includes a 20-km-long coastline with sandy beaches, coastal dunes and gently sloping lowland and provides an opportunity to examine effects of topography and land use on the features of tsunami deposits. During field surveys conducted from April 10 to May 2, 2011, we described the thickness, facies, and structures of the tsunami deposit. We also collected sand samples at approximately 20-m intervals along thirteen shore-perpendicular transects, which extended up to 420 m inland.

The extent of the coastal lowland affected the flow height and inundation distance. The run-up height was 10 m on a terrace slope in the southern part of the study area, where the lowland is only 100 m wide. On the other hand, the maximum inundation was 550 m and run-up height was 3.2 m on a flat topography in the northern area. The average flow height was 4-5 m on the Misawa coast. The run-up height and slope gradient show a strong positive correlation whereas the run-up height and distance are negatively correlated.

The tsunami eroded coastal dunes and small scarps along the coast. Right behind the eroded dune, the tsunami deposit is more than 20 cm thick and then decreases rapidly landward. In other words, the deposit layer is thick only behind the deposit source. The deposit thickness seems unrelated to flow height or flow depth.

Grain size distribution and mineral assemblage of the 2011 tsunami deposits, beach sand, and dune sand were measured. The 2011 deposit represents a trend of landward fining. The heavy mineral content tends to decrease inland.

This thick deposit is composed largely of medium sand (1-2 phi), which has planar and parallel bedding but does not show apparent upward fining or coarsening. The particle size of the sand is similar to that of the coastal dune sand, suggesting it was the source material of the tsunami sediment. On the other hand, the inland thin tsunami deposit consists mainly of fine sand (2.275 phi), which sometimes shows upward fining. This well-sorted fine sediment suggests deposition from suspension, whereas the relatively coarse sand implies deposition from traction flows. The depositional features of the 2011 Tohoku-oki tsunami deposit are affected mainly by coastal topography and extent of eroded areas and seem unrelated to flow height.

Keywords: 2011 Tohoku-oki tsunami, tsunami deposit, grain size, run-up height, topography, Misawa Coast