Recognition and Reconstruction of Flow Conditions from 2004 Indian Ocean Tsunami

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The 2004 Indian Ocean tsunami left unique physical evidence of its impact, including, erosional landforms that affect pre-tsunami topography and abundant sedimentary structures on and within a sediment layer. The most significant data applied to this thesis came after a field record of surficial sedimentary structures that show as the indicator of flow direction on the fresh surfaces of tsunami deposits. Thus, the major aims of the thesis was to recognize and reconstruct flow conditions, to distinguish and compare the characteristics of 2004 tsunami deposits among several localities from the Andaman coast of Thailand.

Bedforms generated by tsunami flow were extensively recorded. Dunes and ripples, type of bedform shapes, were employed to understand flow regime in places where detailed sedimentology was carried out in this thesis. Bedforms with 2- and 3- dimensional shapes recorded at Bangtao area, Phuket Island were tremendously preserved and they showed a transition landward during flow velocity decreasing. The morphology of bedforms included symmetrical and asymmetrical dunes, slightly straight-crested, straight-crested, sinuous-crested and linguoid-crested ripples. These patterns of bedforms suggested that they formed under certain hydraulic conditions. A compound dune has ripples superimposed on their stoss and lee sides. Unlike ripples, dune size seems to be not related to the grains size of the bed material but is much related to the flow depth. This implied that the bedforms resulted from the interaction between large eddies in the flow and the sediment bed. 2-dimensional dunes develop under somewhat lower flow strengths than 3-dimensional dunes and they tend to be relatively long and low and straight-crested. Dune and ripple produced by the 2004 tsunami inflows were generated in the relatively lower flow regime, whereas the antidune structures at Lamson National Park were inferred to be created in the upper flow regime.

Two approaches were employed in this thesis at Bangtao area, aiming to estimate the velocity of the inflows. The first uses a simplified depth-averaged tsunami flow speed. The results for the 2nd inflow imply flow speeds of 19 m/sec at 30 m inland and 15.5 m/sec at 80 m inland. For the 3rd inflow, the velocity ranges from 21 m/sec at 30 m inland to 7 m/sec at 160 m inland. Results of calculation in a near bottom threshold velocity from mean grain diameter and ripple spacing of bedforms imply a velocity of 1.74 m/sec for the biggest current dune and 1.03

m/sec for typical ripples.

Flow conditions of 2004 tsunami generally started with a leading withdrawal seen all along Thailand's Andaman coast. Most or all of the erosion and deposition occurred in the transformation and depositional stages. During the transformation stage near the coast, tsunami wave showed as erosional wave with turbulent head. This erosional wave entrained offshore sediments during the movement of the wave along the shoreface into beach zone. This situation of turbulent made turbid by stirring up sediments. After tsunami turbulent head was hit the beach zone, the flow speed reduced. With very high grains concentration in flow, the rapid deposition, most likely from bed-load and suspended-load conditions occurred on the ground surface as bed deposits. High grain concentration in flow and fast flow speed favored for normal grading and reverse grading sequences to be preserved.

The depositional features and preservation potential of 2004 tsunami deposits were identified into four types in respect to different topographical configurations. Type A represents the deposition features formed in flat topography, as a case of Bangtao area, Phuket Island, and Lamson National Park, Ranong. In Type A, antidune and dunes structures could be preserved. Type B deposited in channel embayment, as a case of Pakarang Blue Village Resort, Phang-nga where thick depositional sequences were recognized within the embayment. Type C represents difference thickness and the depositional styles in large-scale beach ridges and swales, as a case of all transect lines from Phrathong Island. In Type C, preservation potential for tsunami deposits was excellent and not much influences from post-tsunami surface disturbance. Type D displays the variability of the deposition in large-scale irregular topography, as a case of Bang Niang transect, Khao Lak, Phang-nga.

Final thesis interview on 15 February 2008; (back left to right) Dr Ken-ichiro Hisada (advisor; University of Tsukuba), Dr Naomi Murakoshi (co-advisor; Shinshu University), Dr Futoshi Nanayama (committee; Geological Survey of Japan, AIST), (front left to right) Dr Kenshiro Ogasawara (committee; University of Tsukuba), Montri Choowong and Dr. Yugiro Ogawa (committee; University of Tsukuba).