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2004 Indian Ocean tsunami inflow and outflow at Phuket, Thailand

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Abstract

At Bangtao Beach, Phuket, the 2004 Indian Ocean tsunami produced a repeated sequence in which rapid inflow of turbulent water was followed by ponding and then by gradual outflow. Photographs and eyewitness accounts show an initial withdrawal followed by series of inflows. The tsunami left behind a sand sheet as much as 25 cm thick that contains parallel, inclined, landward and seaward lamina in addition to the normal grading commonly reported from tsunami deposits. The sheet contains evidence for two times of vigorous inflow. Each of these is marked by mud rip-ups, medium to coarse sand that grades upward to fine, landward-inclined laminae, and a sharp basal contact. The top of the sand sheet, when observed in the first days after the tsunami, abounded in current dune and ripple bedforms of mostly landward orientation. The tsunami's first positive wave left no onshore sedimentary record in this pitting area. The second wave deposited sand that is much less extensive and slightly finer than that of the third wave. The deposit of both these waves contains multiple fining-upward sequences possibly due to multiple surges in one wave train. The depth-averaged flow velocity estimated from thickness and grain size are in the range 7–21 m/s, whereas, a near bottom threshold velocity calculated from bedforms reveals the order of magnitude difference from 1.74 to 1.03 m/s.
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Keywords: tsunami deposits; current dunes; ripples; flow velocity; bedforms

1. Introduction

Geological study of the sand sheets deposited onshore by tsunamis, as a result of the observation made in both sides of the Pacific after the 1960 Chilean tsunami has expanded in the two past decades (e.g. Konno et al., 1961; Wright and Mella, 1963; Atwater, 1987; Dawson et al., 1988; Bourgeois et al., 1988; Long et al., 1989; Minoura and Nakaya, 1991; Bryant et al., 1992; Hindson et al., 1996; Bondevik et al., 1997; Clague et al., 2000; Moore, 2000; Goff et al., 2000; Fujiwara et al., 2003; Pinegina et al., 2003; Goff et al., 2004; Tuttle et al., 2004; Nelson et al., 2004; Cisternas et al., 2005; Williams et al., 2005; Nanayama and Shigeno, 2006; Jaffe and Gelfenbaum, 2007). The effort has grown further with investigation of the 2004 tsunami, which produced onshore sand sheets not just near the tsunami's source (Moore et al.,

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2006) but also on shores more than 500 km distant—in India (Chadha et al., 2005; Nagendra et al., 2005; Singarasubramanian et al., 2006), Sri Lanka (Goff et al., 2006), Malaysia (Hawkes et al., 2007), and Thailand (Szczucinski et al., 2005, 2006; Choowong et al., 2007; Hawkes et al., 2007; Hori et al., 2007; Umitsu et al., 2007).

This paper focuses on erosion and deposition by the 2004 Indian Ocean tsunami on Thailand's Andaman Sea coast near Phuket, where the sequence of tsunami waves can be inferred, in part, from tourist videos and eye-witness accounts (Choowong et al., 2007). The onshore sedimentary deposits in this area were investigated in the first weeks after the tsunami. By relating these

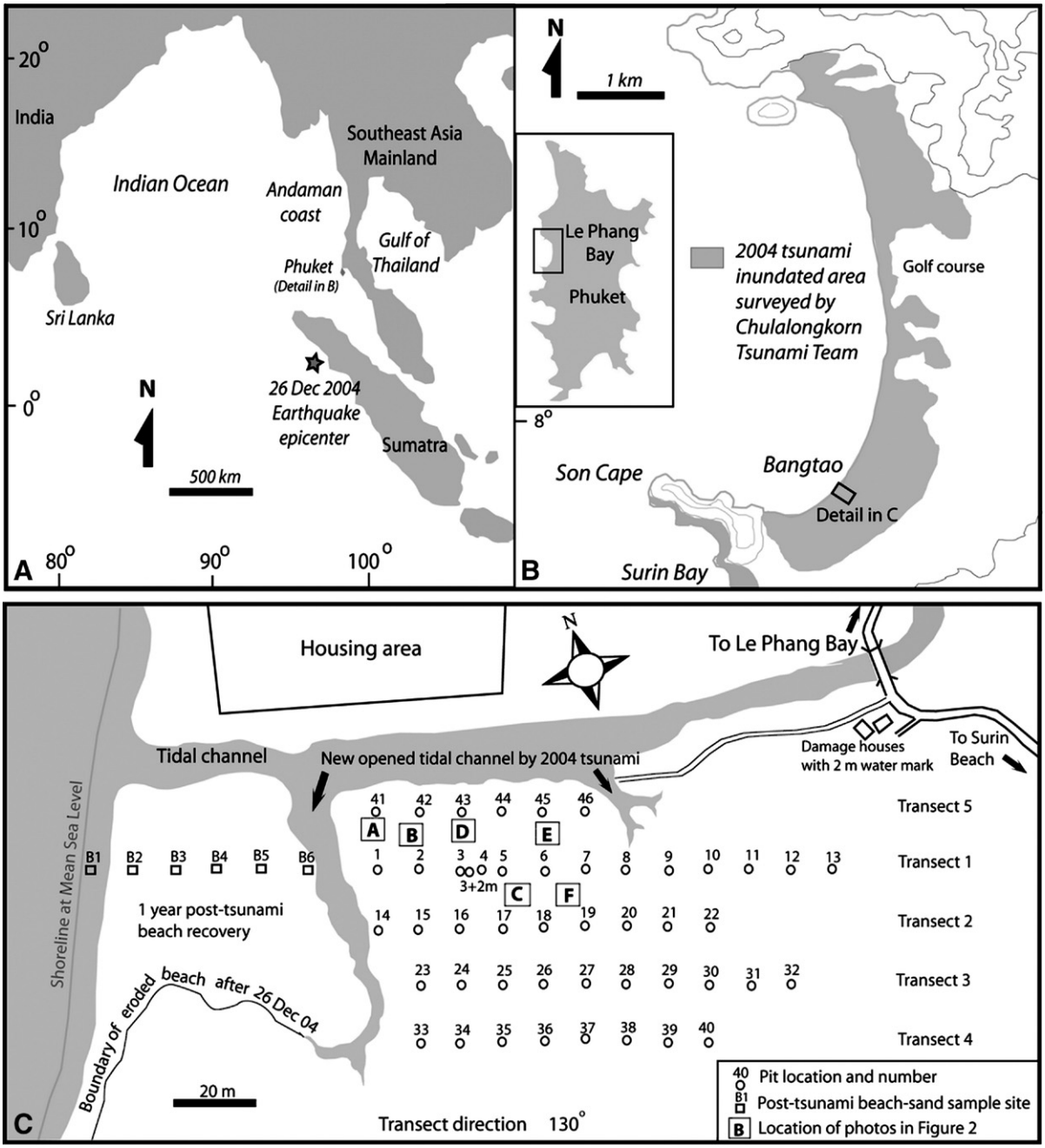

Fig. 1. Maps showing 2004 Indian Ocean earthquake epicenter (A), location of Bangtao Beach, Phuket, Andaman Coast of Thailand with inundated area complied by Chulalongkorn Tsunami Research Team (B) and plane view sketch showing transect lines and locations of pitting (C).

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