Diagnostic Characteristics of Extreme Events in South East Coast of India

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Using erosional, as well as depositional features of the 2004 tsunami as proxy for past events, we present new subsurface evidence of past erosional events along the south-east coast of India (Figure 1). Earlier, limited luminescence dating efforts to date paleo-tsunamis (Huntley and Clague, 1996) provided stratigraphically reasonable ages in the range 260 ± 20 to 1,200 ± 95 BP for tsunami-sourced sediments in Washington state and British Columbia. However, truly 'zero age' tsunami samples have not been analyzed in detail and the recent tsunami event provided a unique opportunity to examine the extent of zeroing and hence the first possibility of establishing the 'zero error', if any, in the application of optically stimulated luminescence (OSL) for the dating of paleo-tsunami events. We use OSL dates on relict scarps within a prograded coastal sequence to reconstruct the chronology of earlier tsunamis on the Mahabalipuram coast, situated 55 km south of Chennai on the east coast of India. OSL dates obtained from sediments immediately overlying heavy-mineral concentration (HMC) anomalies associated with relict erosional disconformities (buried scarps) suggest probable tsunami events -ca. ~1,000 and 3,700 years ago.

The identification of tsunami deposits is the first step in tracing past events, yet it is often difficult to distinguish tsunami deposits from those produced by other high-energy event, such as storms (i.e., tempestites). The evidence left by a tsunami in the coastal stratigraphy can assist in providing direct modern analogs for the identification and interpretation of paleo-tsunami in the geologic record (Srinivasulu et al., 2007). Ground-penetrating radar (GPR) imaging has proven to be a successful tool for identifying and mapping sand-rich costal sequences, by providing high-resolution images of the extent and geometry of various facies boundaries (Myers et al., 1996; Buynevich et al., 2007). The diagnostic signatures of erosional events (e.g. HMCs and disconformities mapped in trenches) can be mapped with GPR and their chronology may be established by OSL dating of associated sediments.

Shore-normal geophysical records from Mahabalipuram Beach reveal a series of steep prominent reflections in the shallow subsurface (Figure 2) that can be used as diagnostic signatures of past erosional episodes. Each reflection coincides with a concentration of heavy minerals in sediment cores. HMCs typically contain 3-40% heavy minerals (the GPR response being primarily due to high magnetite content) compared to the background concentration of 5-10%. Although the storm origin can not be ruled out, the extent and height above sea level, as well as geometry of the buried scarp is similar to that produced by the 2004 tsunami. The OSL

dating of the two oldest sand layers from profiles P1 and P2 (Figure 2) yield ages of 1,080 ± 60 (M4) and 3,710 ± 200 (M5) years ago (before 2009). These findings are the first step toward establishing an integrated geophysical and OSL database of erosional events along the south-east coast of India and suggest that large magnitude tsunamis recur relatively infrequently on human time-scales. Such recurrence adds to the challenge of preparing coastal communities along the northern Indian Ocean shorelines for future tsunamis.

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Acknowledgments

Funding from INCOIS, Ministry of Earth Science, India, is acknowledged.

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Figure Captions:

Figure 1. Location of the study area along the east coast of India (profile P1 and P2). Insets show the location of the study area, the area of origin of the 2004 Indian Ocean Tsunami (star) and the ground photographs of profiles P1 and P2.

Figure 2. Topographic profiles and subsurface data of shore-normal transects P1 and P2 (location shown in Figure 1). Also shown are heavy-mineral concentration (HMC; red boxes) and optical dates obtained on sands immediately overlying the HMCs (M1-M7). Segments of the Geophysical Survey Systems Inc. (GSSI) ground-penetrating radar profiles highlight prominent reflections in the upper part of the coastal plain sequence, which are interpreted as erosional disconformities. The OSL ages of samples associated with anomalies M4 and M5 are indicated in years before 2009. MSL- mean sea level.

Figure 1:

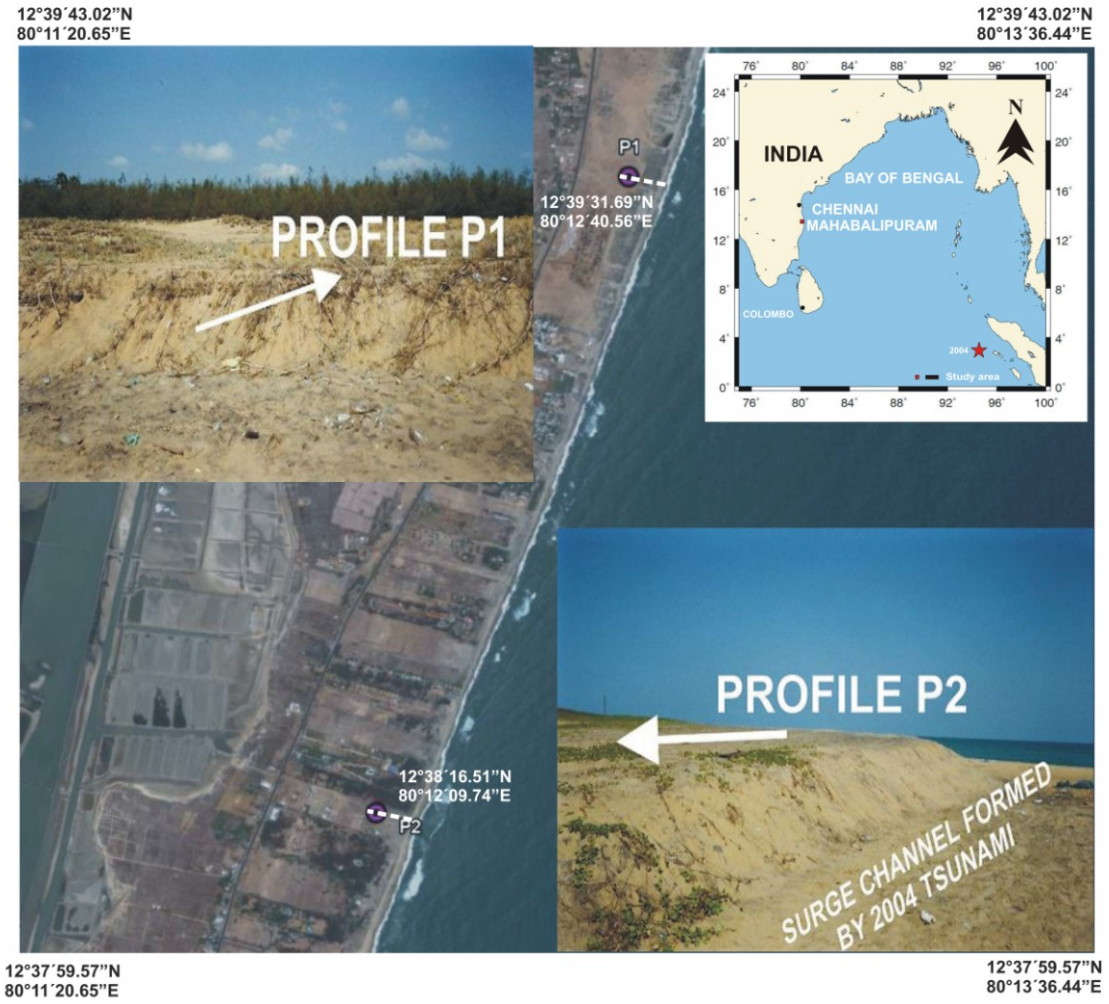
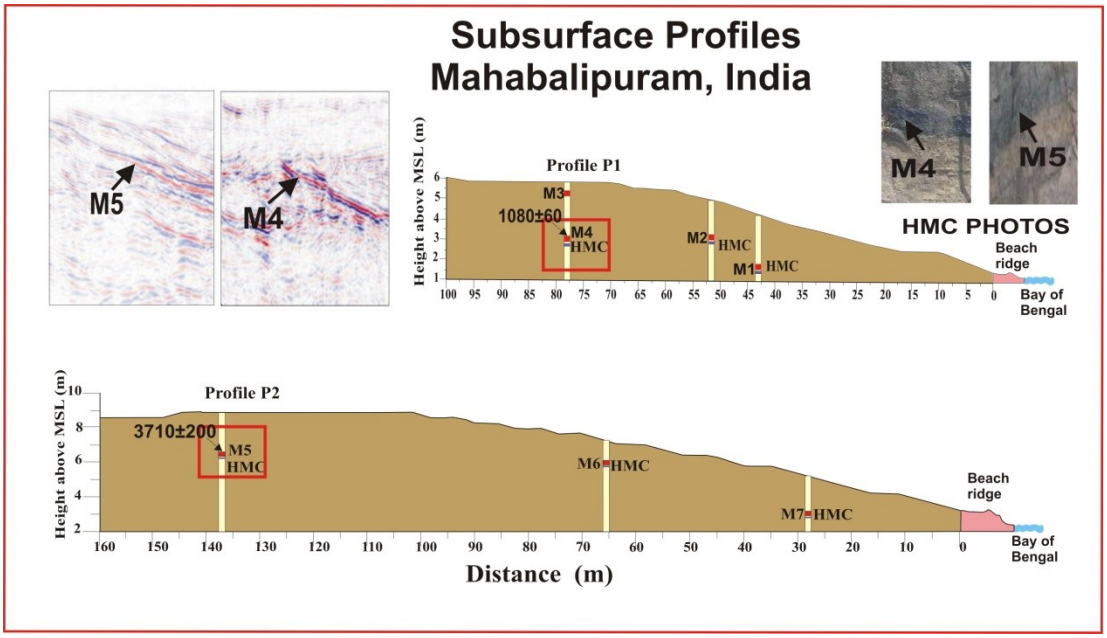

12°39´43.02”N
80°11´20.65”E
12°39´43.02”N
80°13´36.44”E
PROFILE P1
P1
12°39´31.69”N
80°12´40.56”E
INDIA
BAY OF BENGAL
CHENNAI
MAHABALIPURAM
COLOMBO
2004
Study area
12°38´16.51”N
80°12´09.74”E
P2
PROFILE P2
SURGE CHANNEL FORMED BY 2004 TSUNAMI
12°37´59.57”N
80°11´20.65”E
12°37´59.57”N
80°13´36.44”E

Figure 2 :


Subsurface Profiles
Mahabalipuram, India
M5
M4
Profile P1
Height above MSL (m)
M3
1080±60
M4
HMC
M2
HMC
M1
HMC
Beach ridge
Bay of Bengal
M4
M5
HMC PHOTOS
Profile P2
3710±200
M5
HMC
M6
HMC
M7
HMC
Beach ridge
Bay of Bengal
Distance (m)