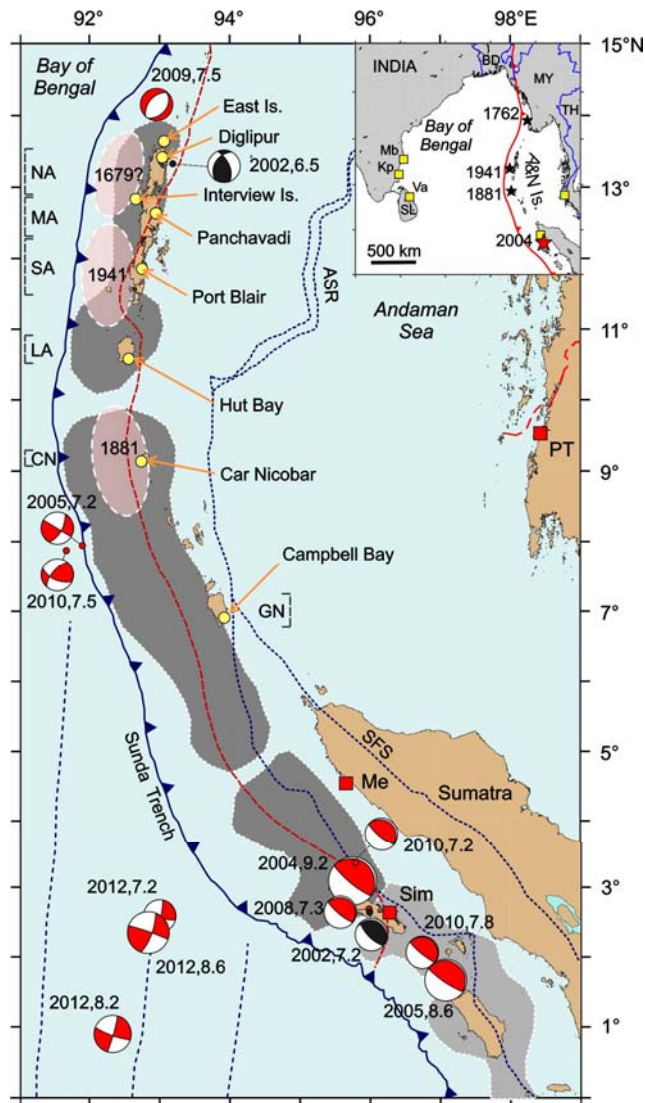


A photograph of a tropical beach. In the foreground, there is a sandy area with green coastal vegetation and several large, weathered palm tree trunks. A long piece of driftwood lies across the sand. To the left, the beach transitions into a rocky shore made of light-colored coral fragments. The turquoise ocean waves are breaking against the rocks. The sky is a clear, pale blue.

# The Pre-2004 Tsunamis in the Bay of Bengal inferred from Geologic Evidence in the Andaman and Nicobar Islands and Southern India

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**Questions:** How often do such events occur? Can we use the 2004-caliber event?



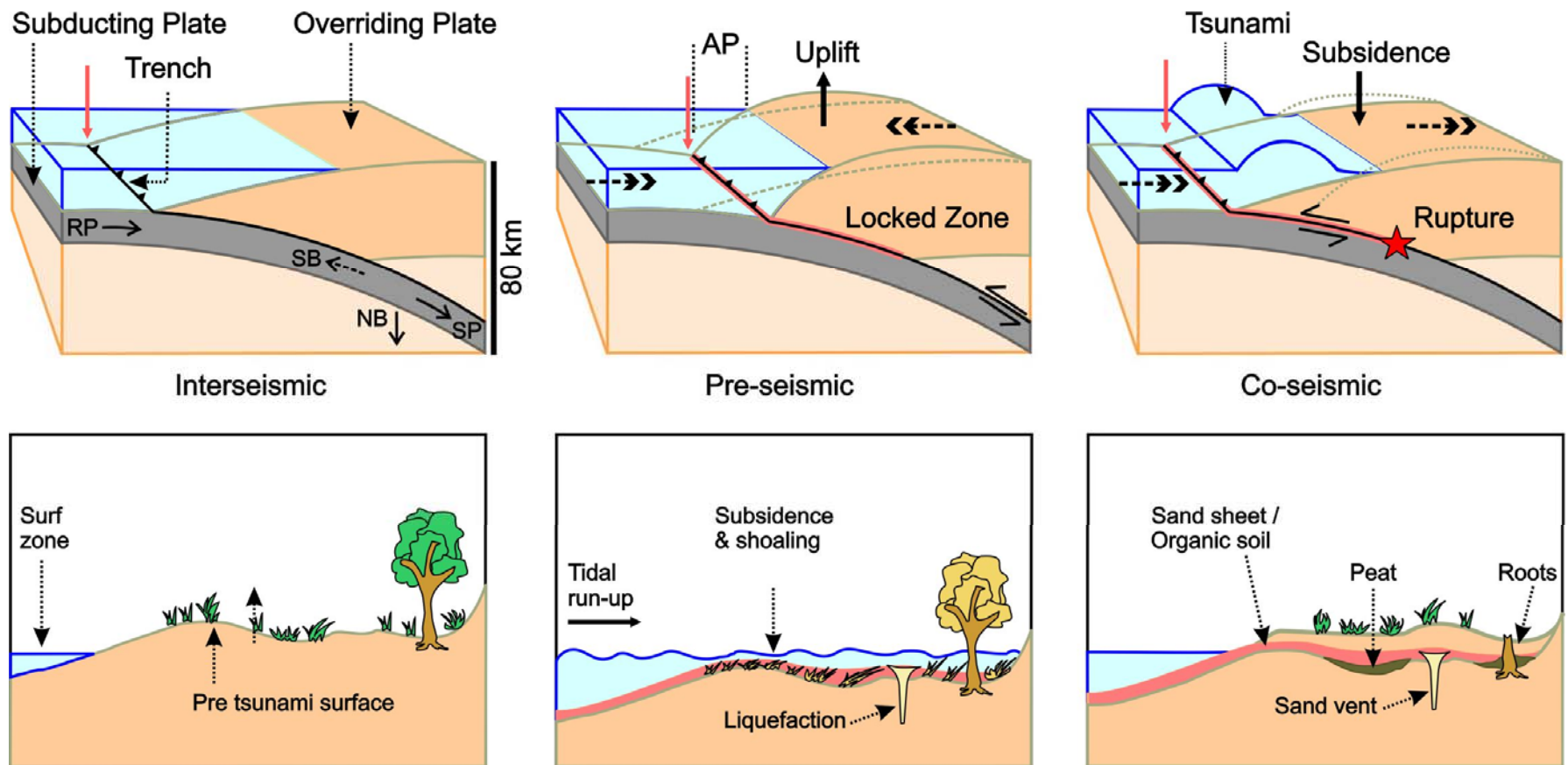
- There was no recognized evidence that the Aceh-Andaman interplate boundary was capable of transoceanic tsunamigenic earthquakes as in 2004.

### **Results from previous studies:**

- The penultimate tsunami at Phra Thong: dated at AD 1300-1450 (*Jankaew et al., 2008*).
- Matching ages (AD 1290-1400) and an additional event (AD 780-990) from Meulaboh (*Monecke et al., 2008*).
- Our previous studies suggest a ~1000 year old tsunami that affected the east coast of India (*Rajendran et al., 2011*).

The Andaman and Nicobar Islands span and adjoin two-thirds of the length of the 2004 rupture area providing key evidence

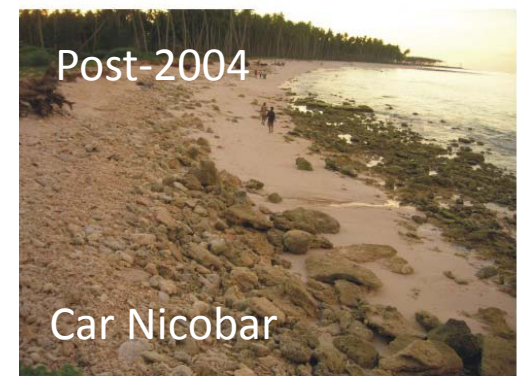
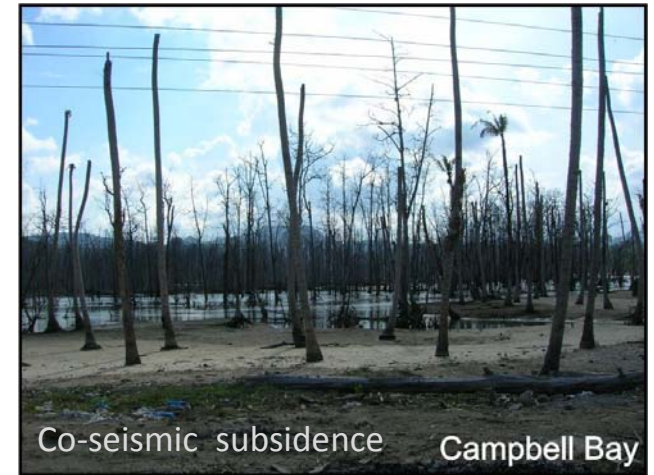
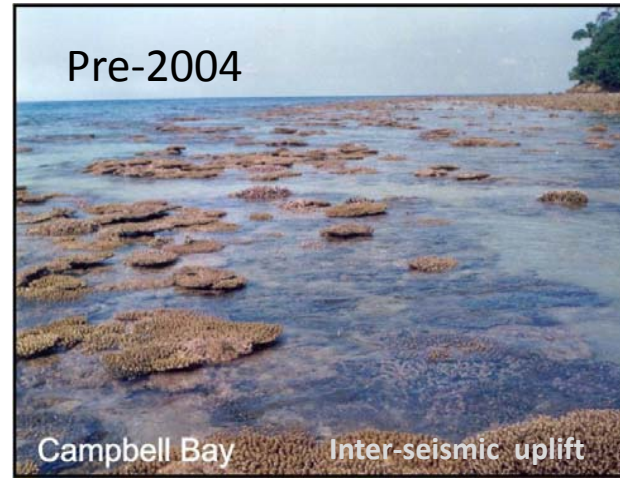
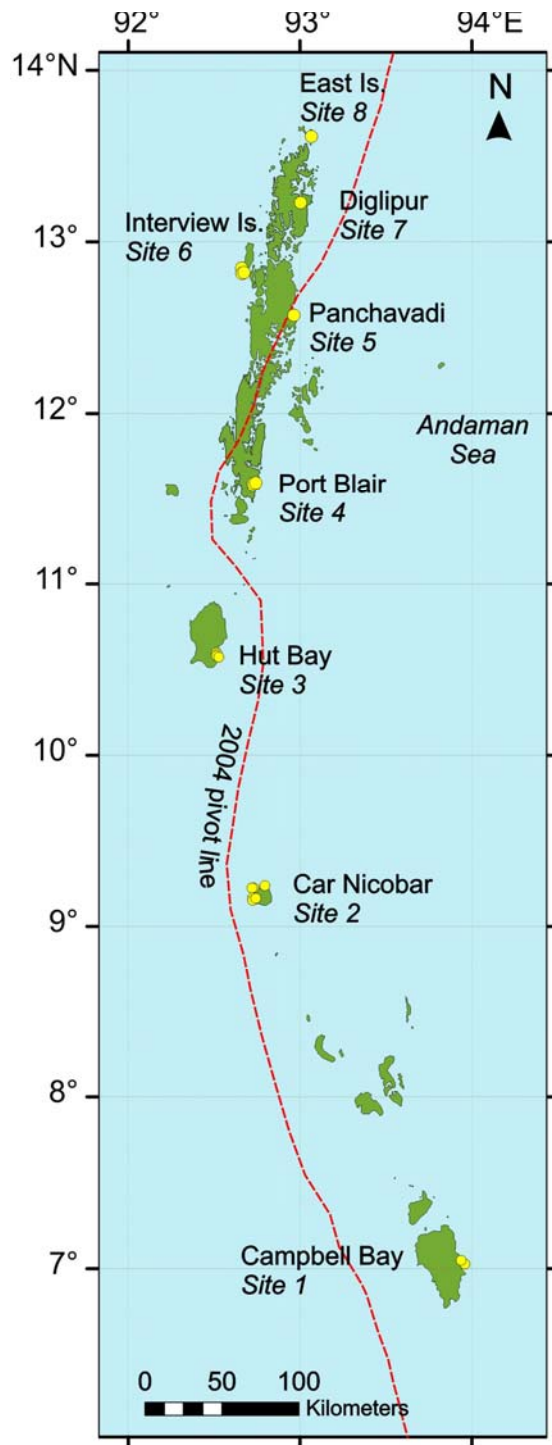




*Modified from Atwater et al., 2006*

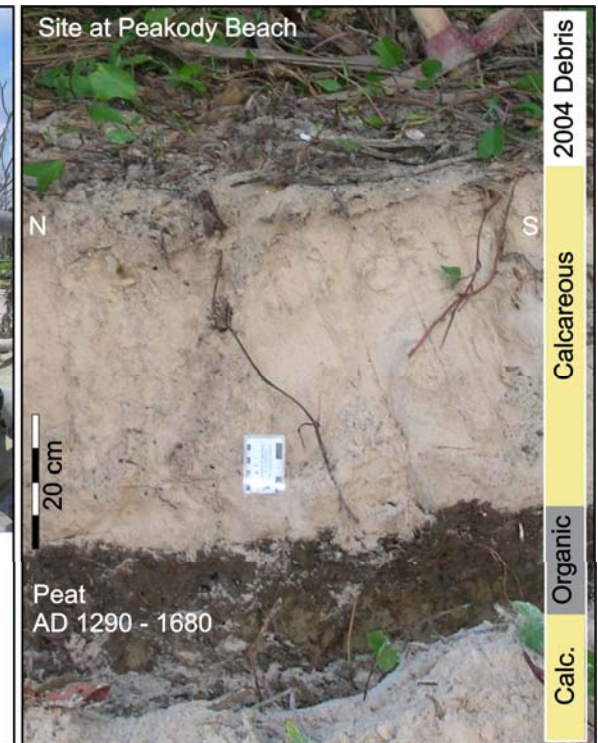
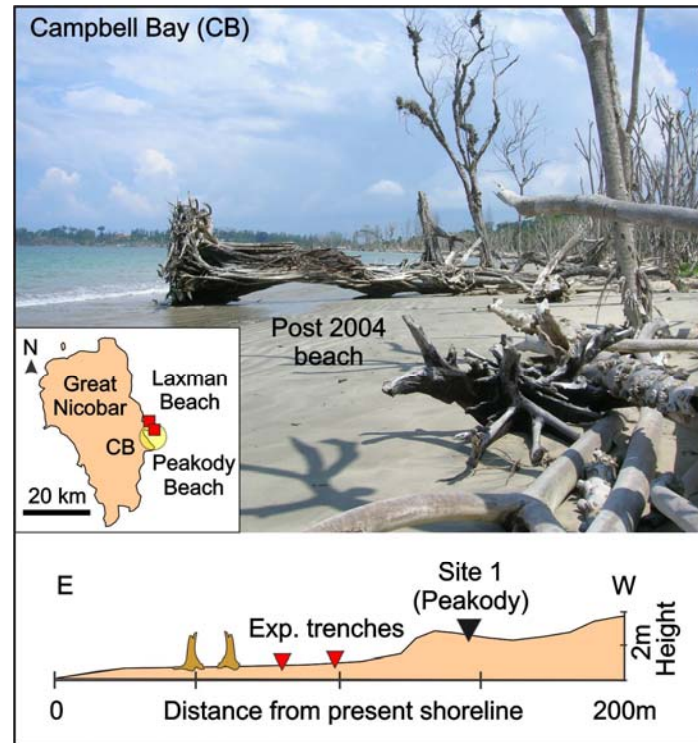
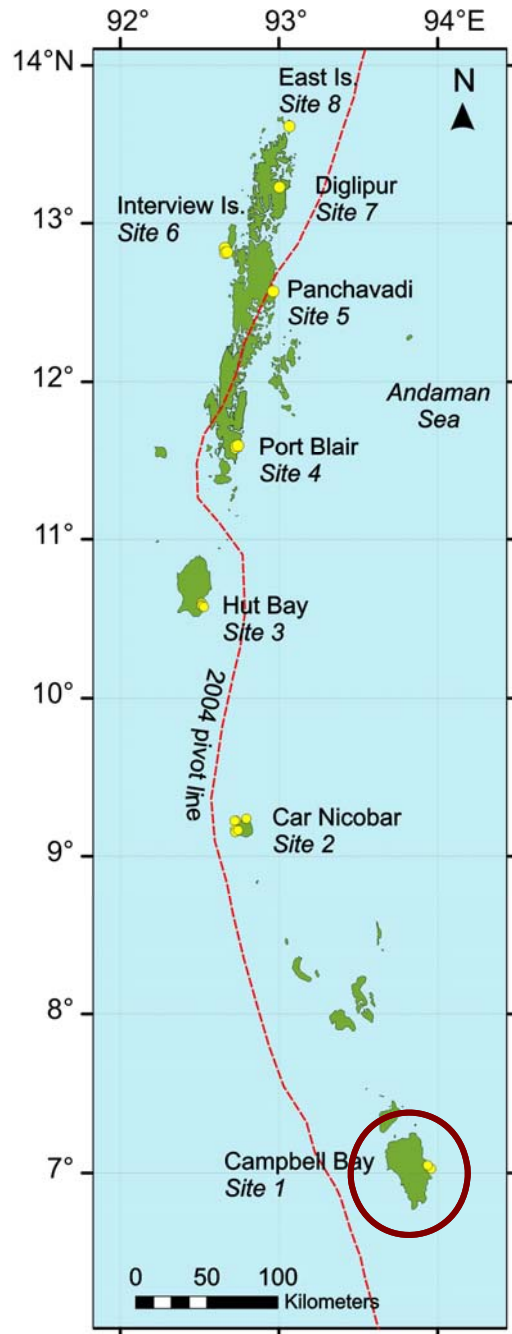
**Coseismic and interseismic plate boundary processes govern geomorphology and stratigraphy of near-source regions.**

**The 2004 earthquake generated typical features observable on the islands of the Andaman and Nicobar. We use them as pointers to similar previous episodes.**

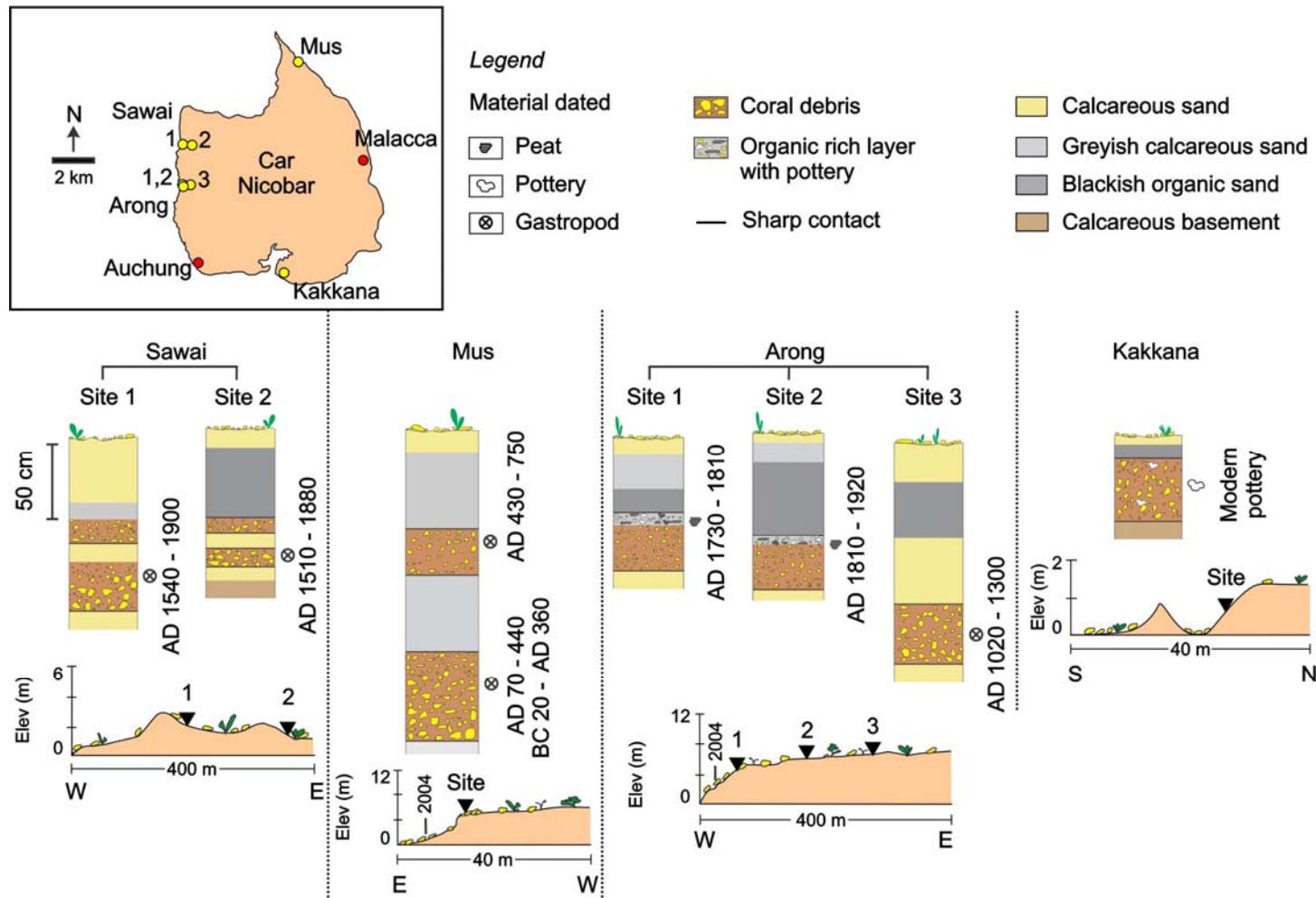


Coseismic features that we studied include subsided mangrove swamps, uplifted coral terraces, peat sand associations and coral rubble.



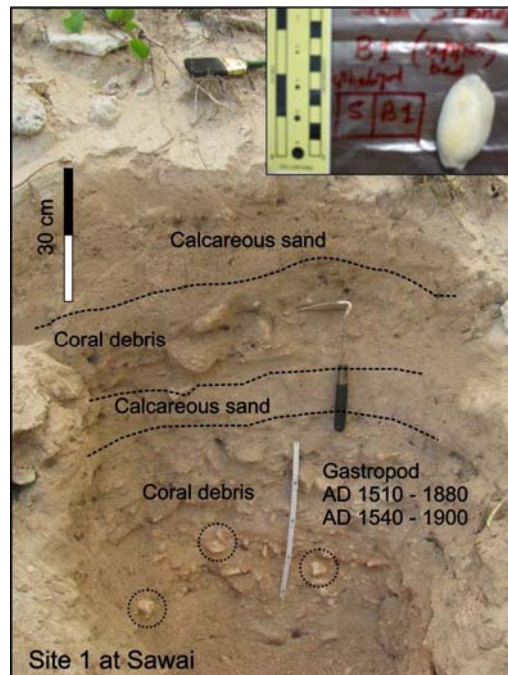
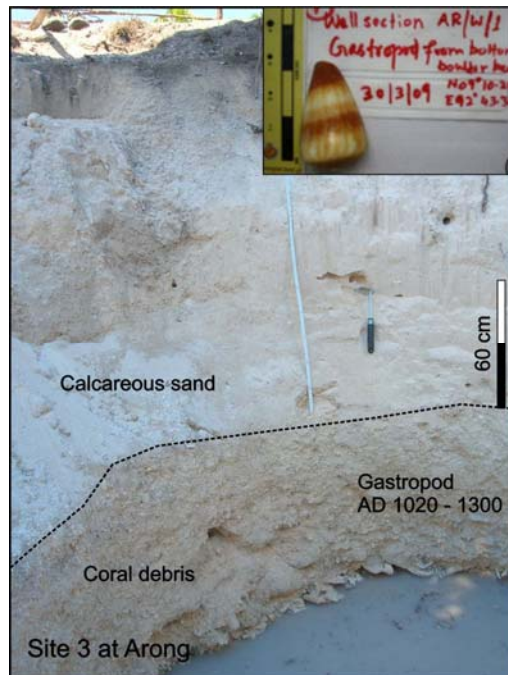
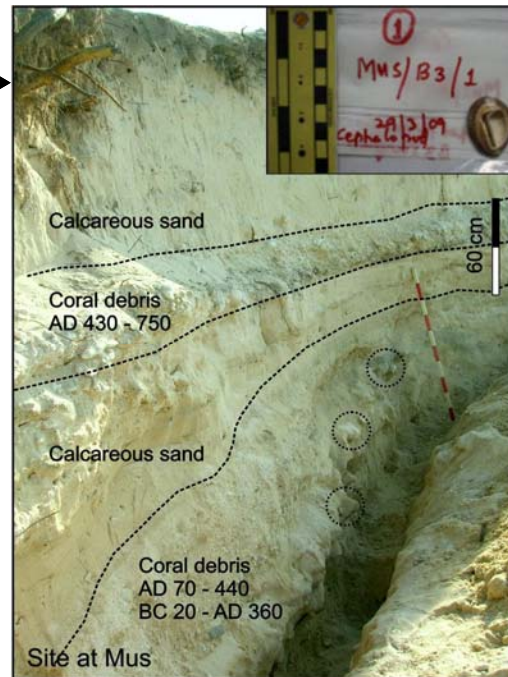
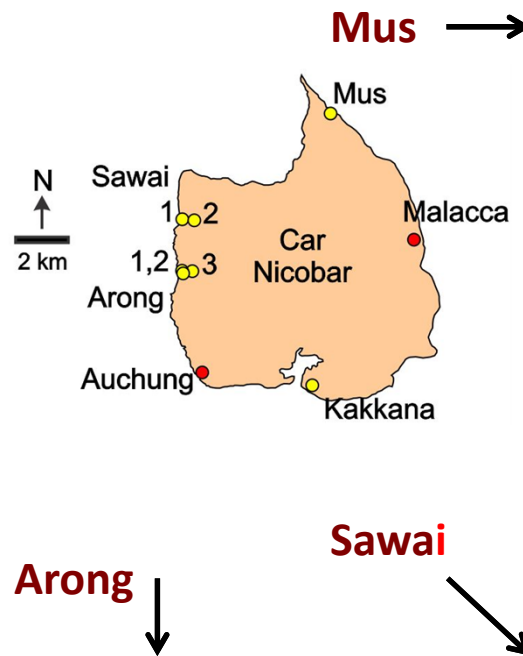


- Sections along the Peakody Beach exposed buried peat of varying thickness as an intervening layer within the beach facies.
- Peat layer at a depth of ~ 60 cm was dated at AD 1290-1680



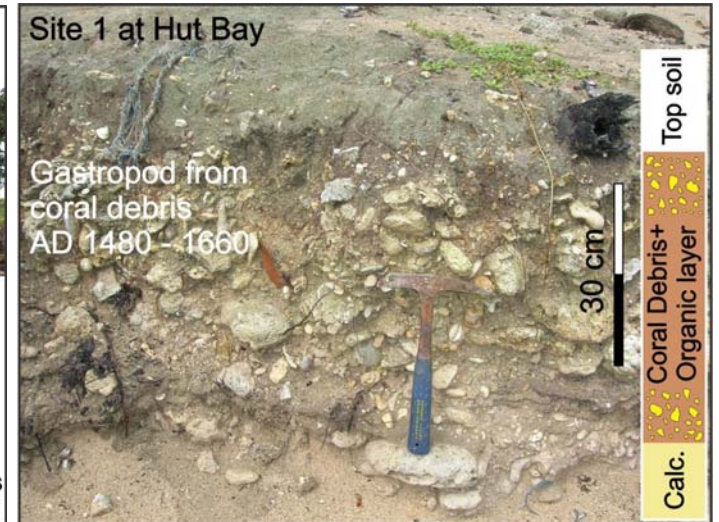
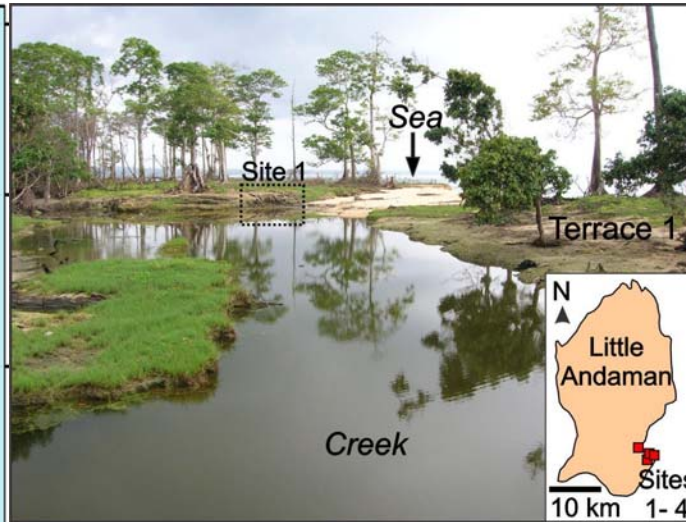
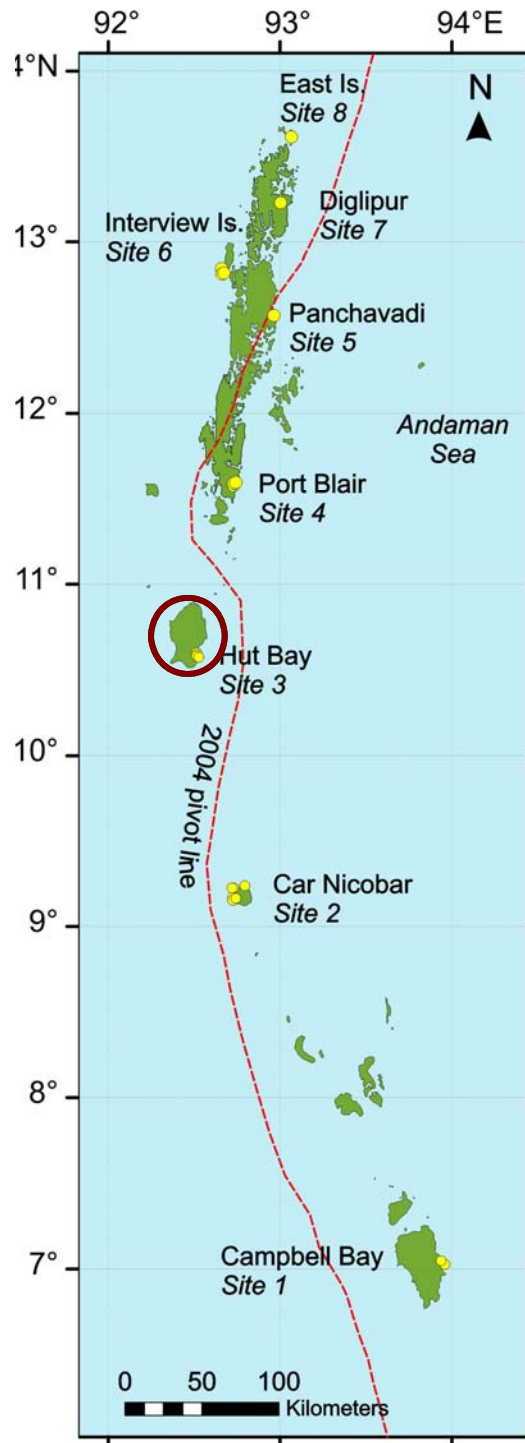
**Observations at Car Nicobar:** Evidence for past sea surges from around the island, where the 2004 tsunami had transported coral debris as far as 500 m inland. Suspended sediment/coral-debris-load mixed with marine shells was characteristic of the 2004 deposits and the older deposits mimic the same.





Sedimentary sequences consisting of coral debris along the coast of Car Nicobar provide evidence of previous sea surges various intervals.

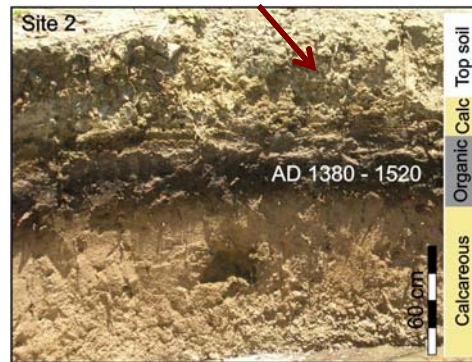
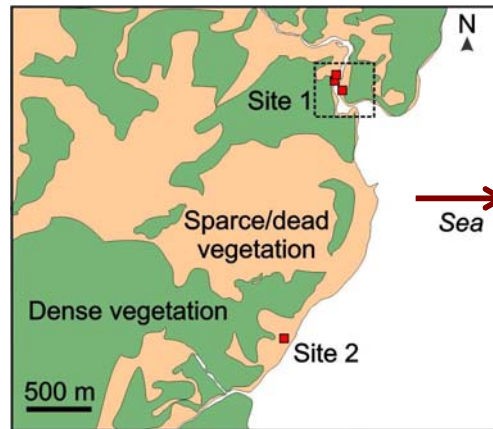
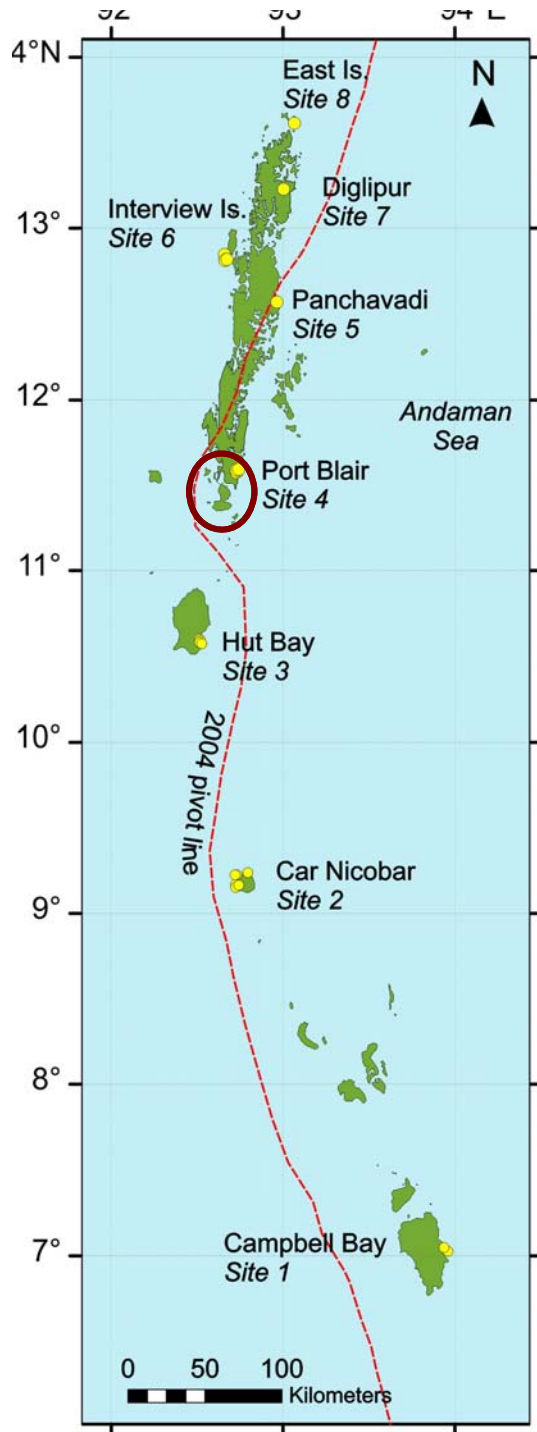
**Ages: AD 70-440; AD 1020-1300 and AD 1510-1900. The latest (1881) is marked by coral debris mixed with modern pottery.**



Along the creeks of the little island of Hut Bay, the 2004 tsunami transported coral debris mixed with sand, as far as 600 m inland.

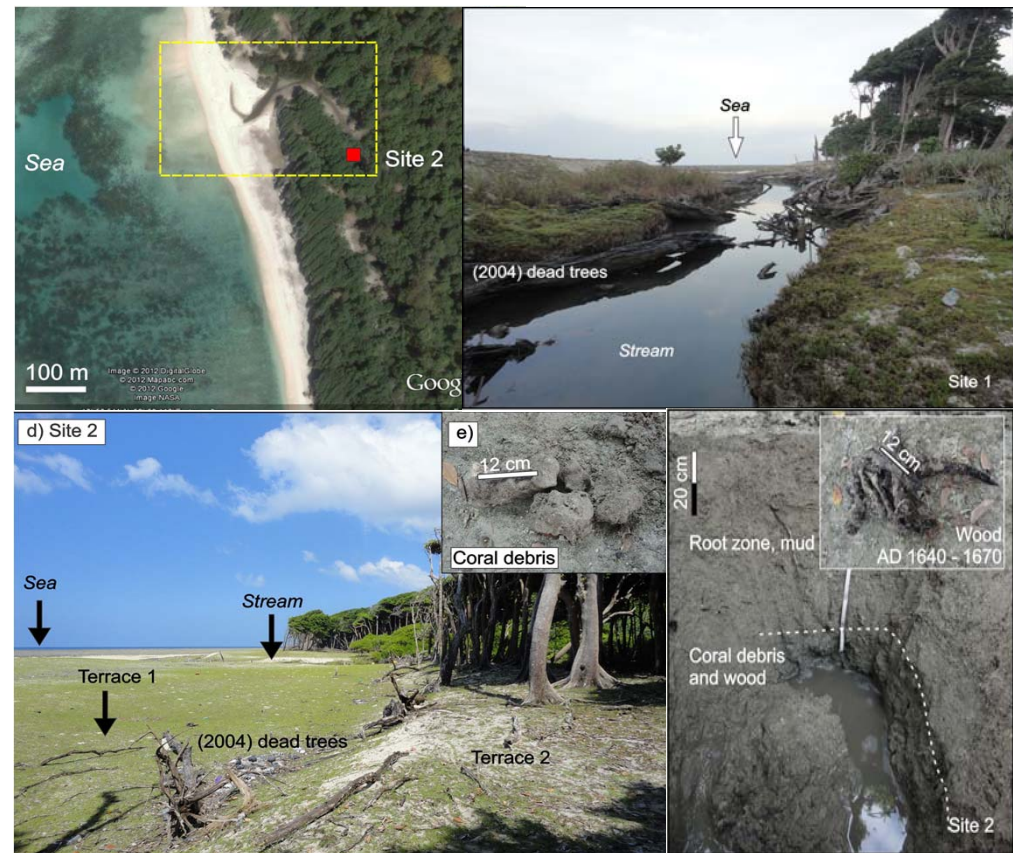
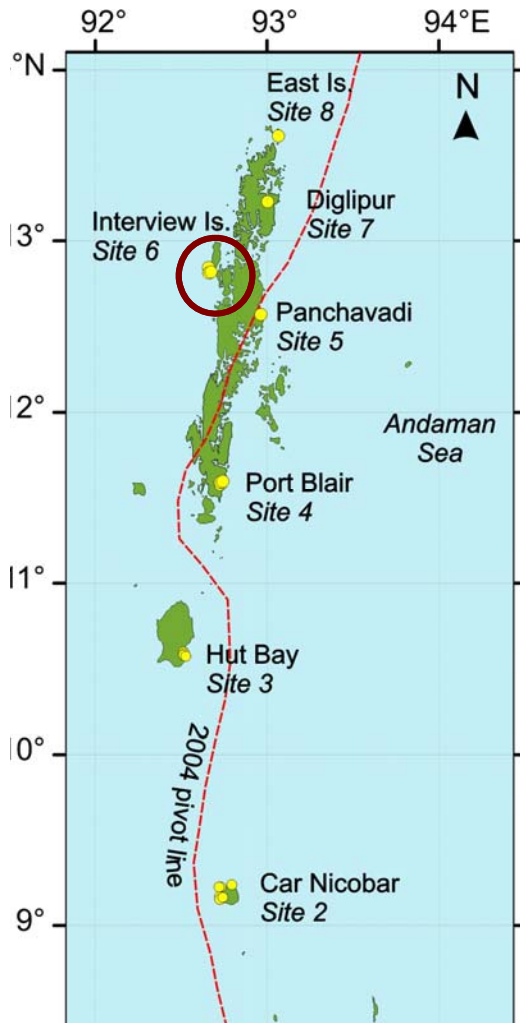
A typical section discussed ~ 500 m inland, exposed a ~ 50 cm thick deposit consisting of loose coral fragments embedded in calcareous sand, mixed with assorted shells. The gastropod age is AD 1480-1680.





Here, the 2004 earthquake led to subsidence of mangroves (> 1m)

- An exposure of subsided tree line was discovered along the 10 m wide creek near Rangachanga, ~8 km south of Port Blair.
- Remains of trunks and roots (*Rhizophora*) occur here in growth position at 1 m depth.
- Samples of *in situ* tree trunks from sites across the creek yielded ages ranging from AD 770-880 and AD 770-1040.

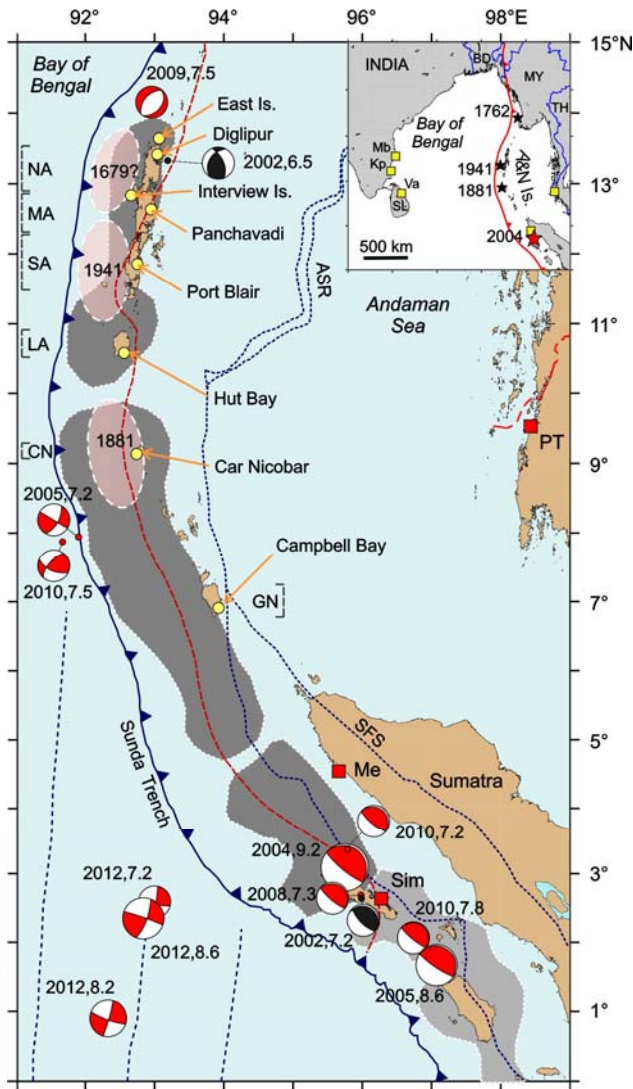


Interview Island, located to the west of the west of the Hinge line was uplifted by 1 m. Debris were transported > 200 m inland.

A section on the southern part of this island, ~200 m from the surf zone, exposed a layer of decaying organic-rich debris, beneath a 50cm-thick deposit of calcareous sand mixed with mud. Wood samples from either banks of this stream yielded calibrated dates of AD 1440-1510 and AD 1450-1520



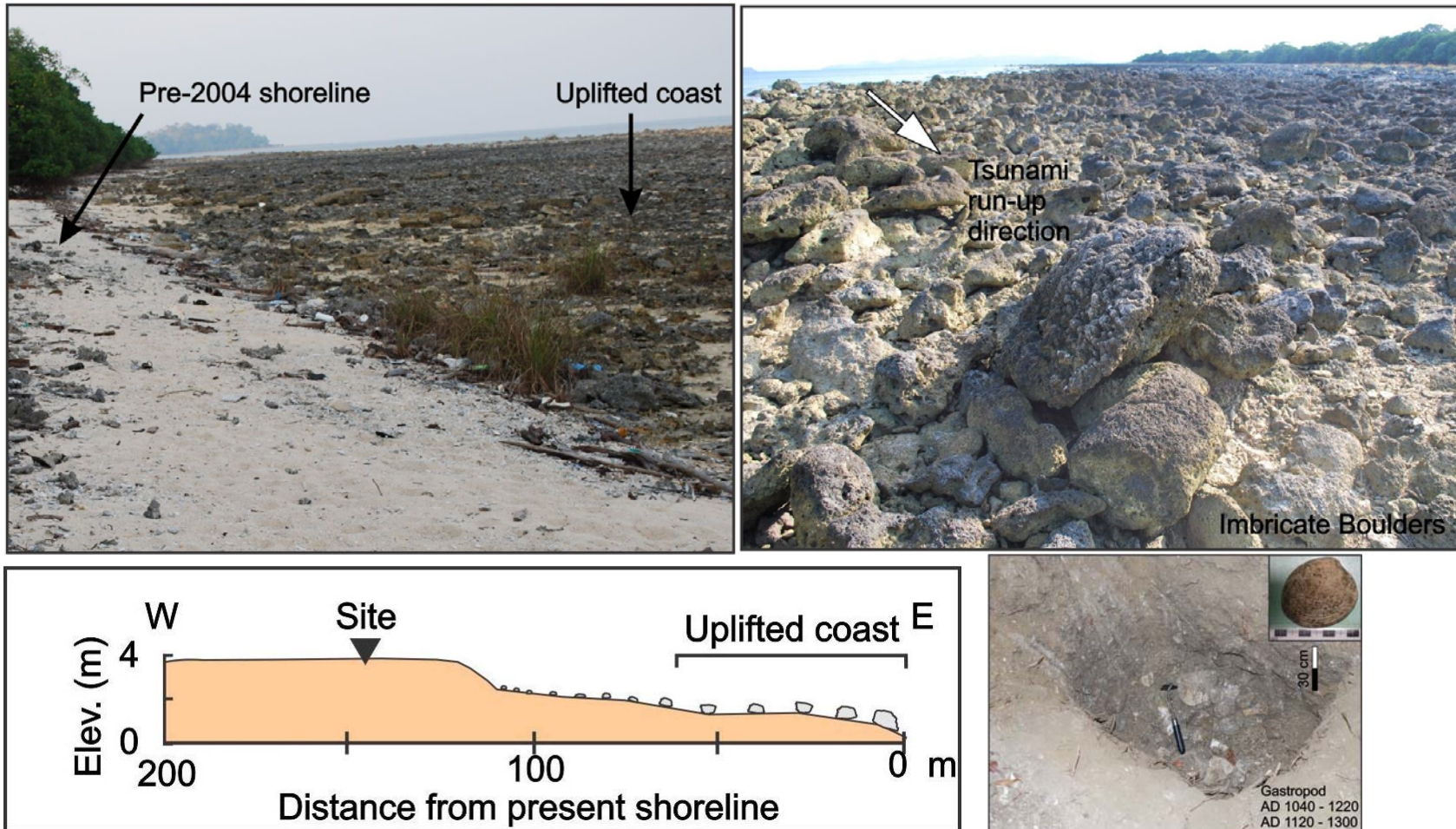
## To East Island the northern limit of the 2004 rupture



At the East Island coral terraces were uplifted by 1.5 m. As the farthest site along the archipelago, we consider that evidence from this site is crucial to constrain the size of past ruptures.

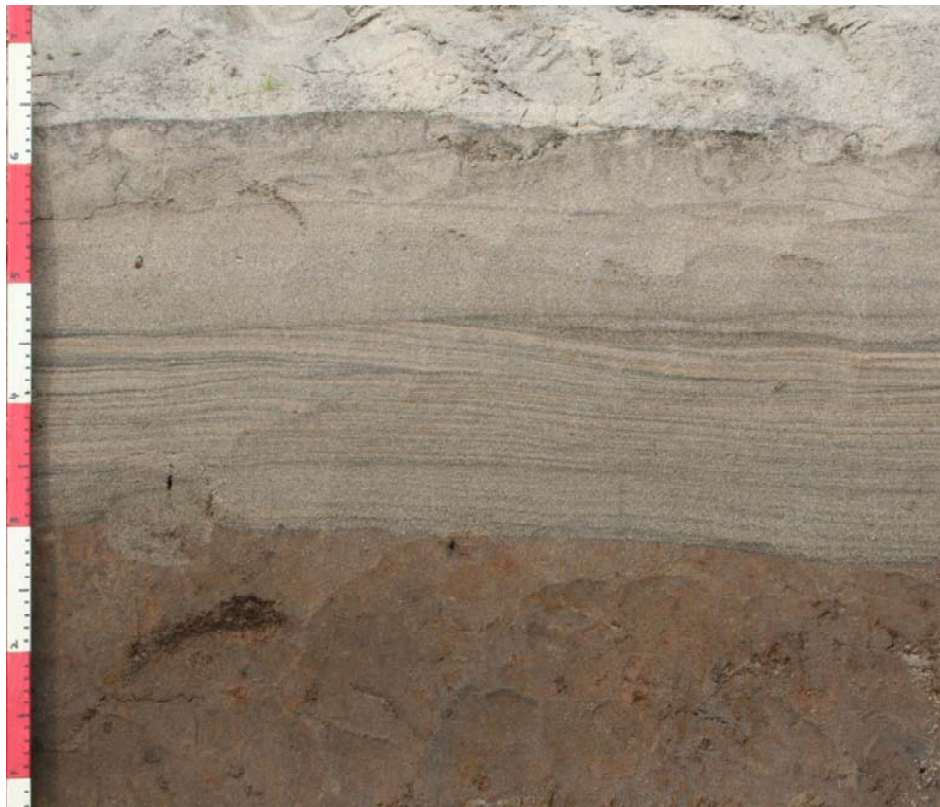
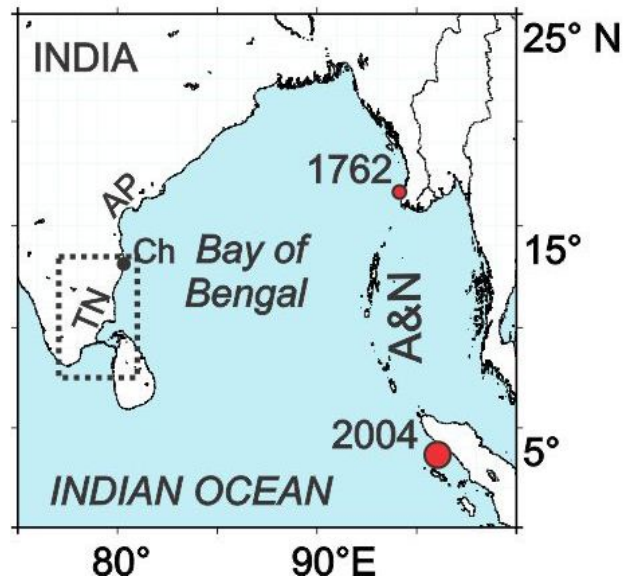


## Uplifted coast and debris deposition on East Island



Trenches exposed a thin layer of cobble size coral debris, at ~50 cm depth, below thick grey calcareous sand. Ages based on two shells provide ages of AD 1040-1220 and AD 1120-1300. Does this suggest a comparable-size pre-2004 rupture?





## The 2004 tsunami deposits from the Tamil Nadu coast

On the East coast of India, the 2004 tsunami reached ~ 1 km inland, with wave heights of ~ 5m at some locations, leading to extensive sand sheets (30-70 cm thick) deposits.

The 2004 tsunami deposits of the Tamil Nadu coast generally consist of three units: the initial laminated beds, the middle massive beds and the top layer showing occasional cross-laminations and channel infills: the bedding characteristics reflecting flow conditions.



- We chose Kaveripattinam, an ancient Harbor (BC 200 to AD 1200) on the Tamil Nadu Coast of South India, for Paleotsunami explorations.
- References to sea flooding in Classic Tamil literature.
- The 2004 tsunami reached ~900 m inland and deposited thin (< 10 cm) veneer of sand.
- We focused on locations near archeological sites.



## Trenches in Kaveripattinam exposed evidence of a previous sea surge that seems to have displaced a previous occupational level



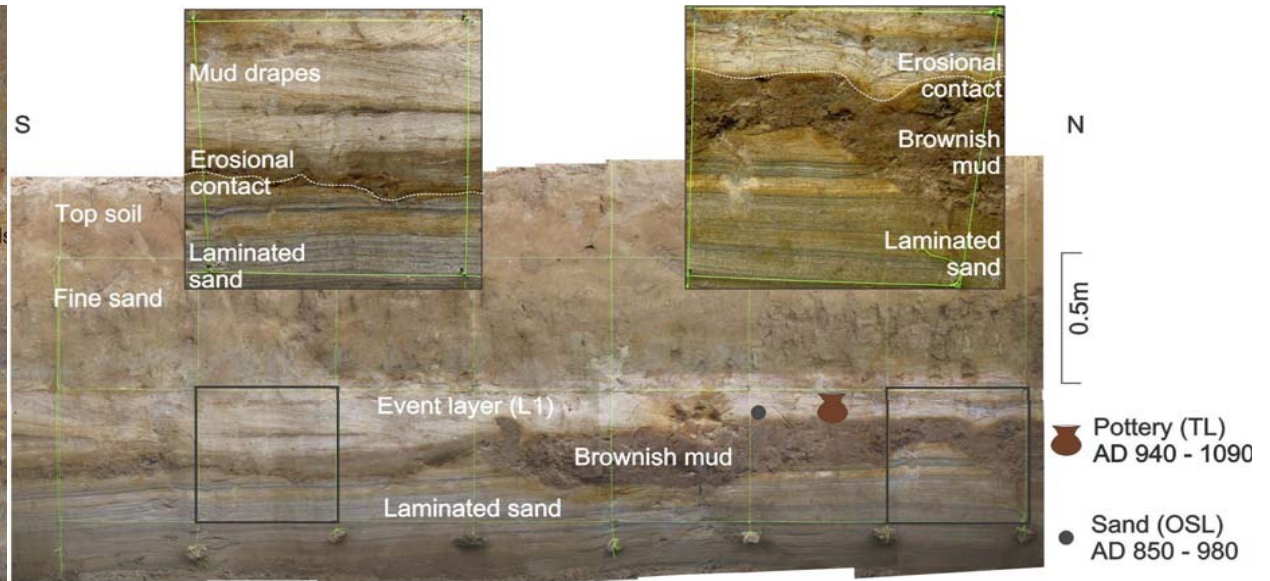
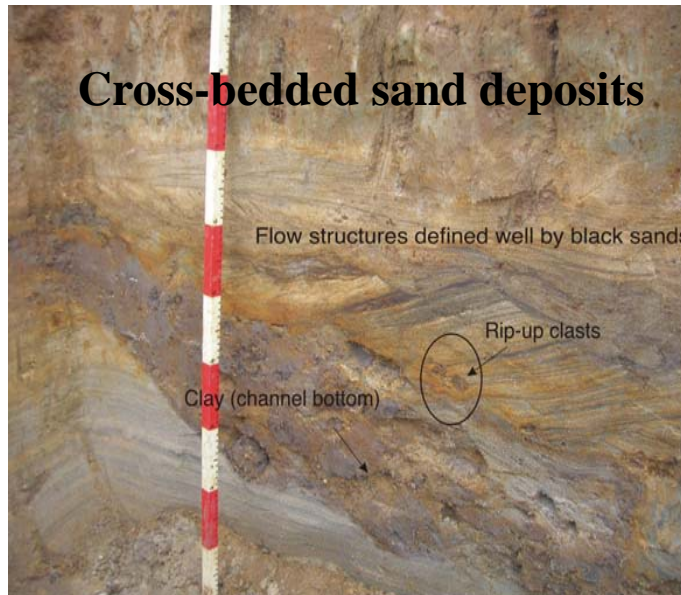
TL date based on potteries:  
 $993 \pm 73$  yrs.

Literary references to sea surge that destroyed the ancient port city.

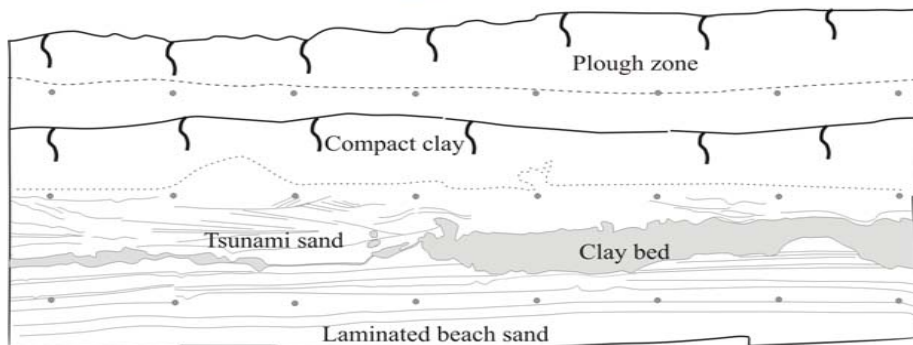
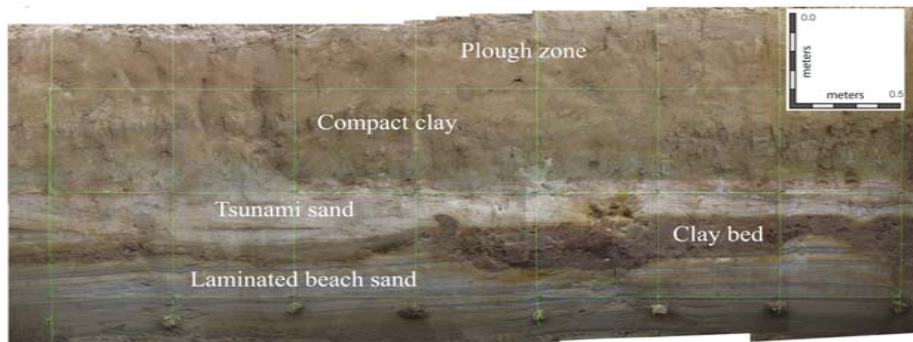
Contemporaneous evidence for destruction at the 9<sup>th</sup> century Mamallapuram temple, 150 km north, where we dated a previous sea surge at ~ 1000 years ago.

Rajendran et al (2007; 2011)

## Cross-bedded sand deposits

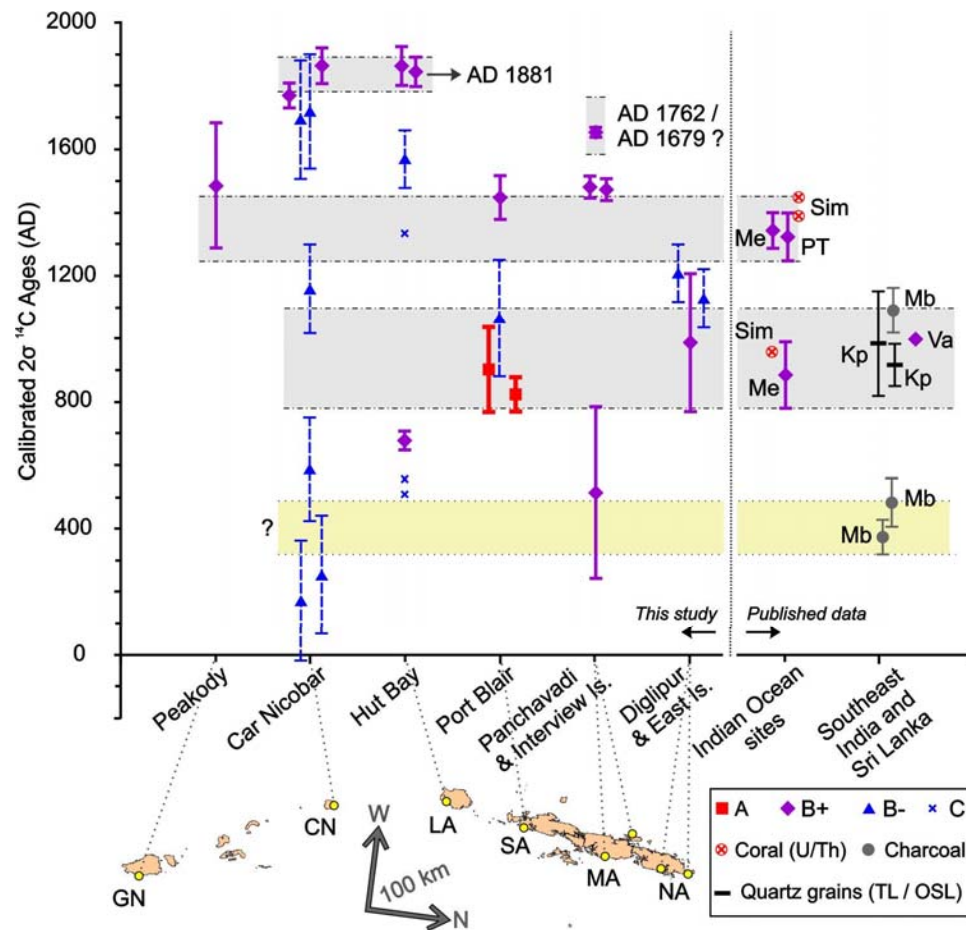


## Trench P8 within a swale



Up to 30 cm thick inland tapering partly cross-bedded sand sheet in a lying over a clay bed with sedimentological features analogous to a large-scale wash-over event, which is dated at  $1091 \pm 66$  years (OSL age).





The combined regional database from the A&N Islands suggests that the 800-1100 year old event is comparable to the transoceanic nature of the 2004 tsunami.

Another transoceanic tsunami or tsunamis occurred around AD 1450, for which evidence is more compelling from Thailand and Indonesia

Thank you