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Evidence for a mid-Holocene tsunami deposit along the Andaman coast of Thailand preserved in a mangrove environment

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ABSTRACT

Klong Thap Lamu, a large mangrove-fringed tidal channel along the northern Andaman Coast of Thailand, provides an ideal location to test the hypothesis that a paleotsunami record can be preserved in the sediments of a mangrove forest. The 2004 Indian Ocean tsunami destroyed local swaths of mangrove forest with highly variable widths — up to 300 m. Left in the wake of the tsunami is a thin mantling of laterally discontinuous sand, macerated shells, and localized coral rubble that is being mixed rapidly into the underlying mangrove peat. Transects across the channel's tsunami-modified shore show that the sand layer thins abruptly at the border of the undisturbed mangroves, suggesting that the energy of the wave dissipated quickly as it entered the forest. The distribution and sedimentology of the 2004 tsunami deposit (Unit tI) suggest that any paleotsunami deposit within this mangrove environment should be spatially restricted and thoroughly bioturbated. Sediment cores collected from within the 2004 tsunami zone penetrate a buried coral-shell peat unit (Unit tIII) that tapers inland. Unit tIII is strikingly similar to Unit tI, except for Unit tIII's diffuse sedimentology, which we attribute to extensive bioturbation. Unit tIII also cross-cuts an identified facies boundary that is traceable across the width of the 2004 tsunami zone. Rather than a facies boundary associated with the regional early-to-late Holocene sea level regression, stratigraphic correlations suggest that Unit tIII represents an event horizon (i.e. tsunami). AMS ^{14}C dates on material from within Unit tIII combined with an upper bracketing age suggest that the tsunami event occurred sometime between 2720 and 4290 cy BP. If correct, this tsunami predates the 3–4 tsunami events recognized to the north at Koh Phra Thong. Unit tIII is, however, a potential far-field equivalent of a recently recognized paleotsunami deposit on the southwestern Indian coast ca. 3,710 years before present (Nair et al., 2010).

1. Introduction

The 2004 Indian Ocean tsunami struck the Andaman coast of Thailand without warning (Waltham, 2005). This catastrophic event underscored the absence of data about the frequency of tsunami occurrence along this coast as well as the insufficient preparation of the coastal communities (Rhodes et al., 2006). Our understanding, however, of the frequency of tsunamis capable of impacting the Andaman coast has improved recently with evidence for possibly three pre-2004 events since 2800 cy BP (Jankaew et al., 2008; Monecke et al., 2008; Fujino et al., 2009). The lack of local written historical records leaves the geologic record as the best resource for identifying past tsunamis in Thailand. Finding a paleotsunami record along this section of tropical coast requires the recognition of coastal environments suitable for capturing and preserving tsunami sediment (Atwater, 2007). Elsewhere, many of the well-known paleotsunami records exist along temperate coasts in salt marshes (Atwater, 1987; Atwater and Moore, 1992; Cisternas et al., 2005; Williams et al., 2005) and coastal freshwater lakes (Bondevik et al., 1998; Grauert et al., 2001; Kelsey et al., 2005), but these environments do not exist along Thailand's Andaman coast. Paleotsunami deposits also lie within the sediment of wide beach plains where they are preserved in swales between progradational beach ridges (Nanayama et al., 2000; Pinegina et al., 2003; Jankaew et al., 2008; Fujino et al., 2009). Although the 2004 tsunami left extensive deposits on the beach plains of Thailand (Hori et al., 2007), finding similarly situated ancient deposits along the Andaman coast is frustrated by the near complete disruption of many beaches by extensive 20th century placer tin mining (Schwartz et al., 1995) and subsequent coastal development.

Mangroves represent the tropical analog of temperate salt marshes (Augustinus, 1995). Extensive regions of mangrove forests characterize Thailand's northern Andaman Coast. Unfortunately, intense bioturbation within the mangrove forests most likely precludes the preservation of "classic" tsunami-deposited sheets of sand like those found in temperate salt marshes and coastal lakes (Nanayama et al., 2003; Cisternas et al., 2005; Kortekaas and Dawson, 2007). Based on recent

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reconnaissance studies of the 2004 tsunami deposit along Thailand's northern Andaman coast, we hypothesize that mangrove forests are potential sites for preserving paleotsunami sediment. Below we describe a coral-shell peat layer (Unit tIII) preserved along the Thap Lamu tidal channel (Fig. 1) in the peaty sediment of a mangrove forest, which we interpret as the oldest paleotsunami deposit so far identified along Thailand's Andaman coast.

2. Regional setting

Thailand's northern Andaman coast reflects approximately 8000 years of sea-level change (Fig. 2). Post glacial, rapid sea level rise ended with an early-middle Holocene high stand (Scoffin and Tissier, 1998; Hassan, 2002; Tanabe et al., 2003; Horton et al., 2005). This high stand produced a submerged, sinuous coastline. A combination of beach progradation and longshore sand drift sealed off large bays fed by relatively narrow tidal channels. Deposition in these bays accompanied by falling sea level throughout the mid-to-late Holocene, resulted in the progradation of mangroves across the bays (Tanabe et al., 2003). This proposed succession exists in other regions where relative sea level dropped, such as that documented in the Gulf of Thailand and parts of Australia, following an early-middle Holocene sea level highstand (Chappell, 1983; Woodroffe, 1992; Tanabe et al., 2003). The 1 km wide Klong Thap Lamu (Fig. 3), a tidal channel north of Phuket Island, forms the entrance to one such mangrove-filled bay. About 4 km upstream of its mouth, the main channel splits with a southern branch that extends between older beach ridges to the east and the narrow modern beach ridge to the west (Fig. 3B). The 2004 tsunami did not breach the narrow modern beach; the tsunami wave entered the channel only through its mouth. The northern branch feeds a dendritic network of smaller channels that extend over 10 km inland with 1–2 km-wide mangrove forests along their edges (Fig. 3B). A >100 m high, 4 km long north–south trending bedrock ridge guards the mouth of Klong Thap Lamu and

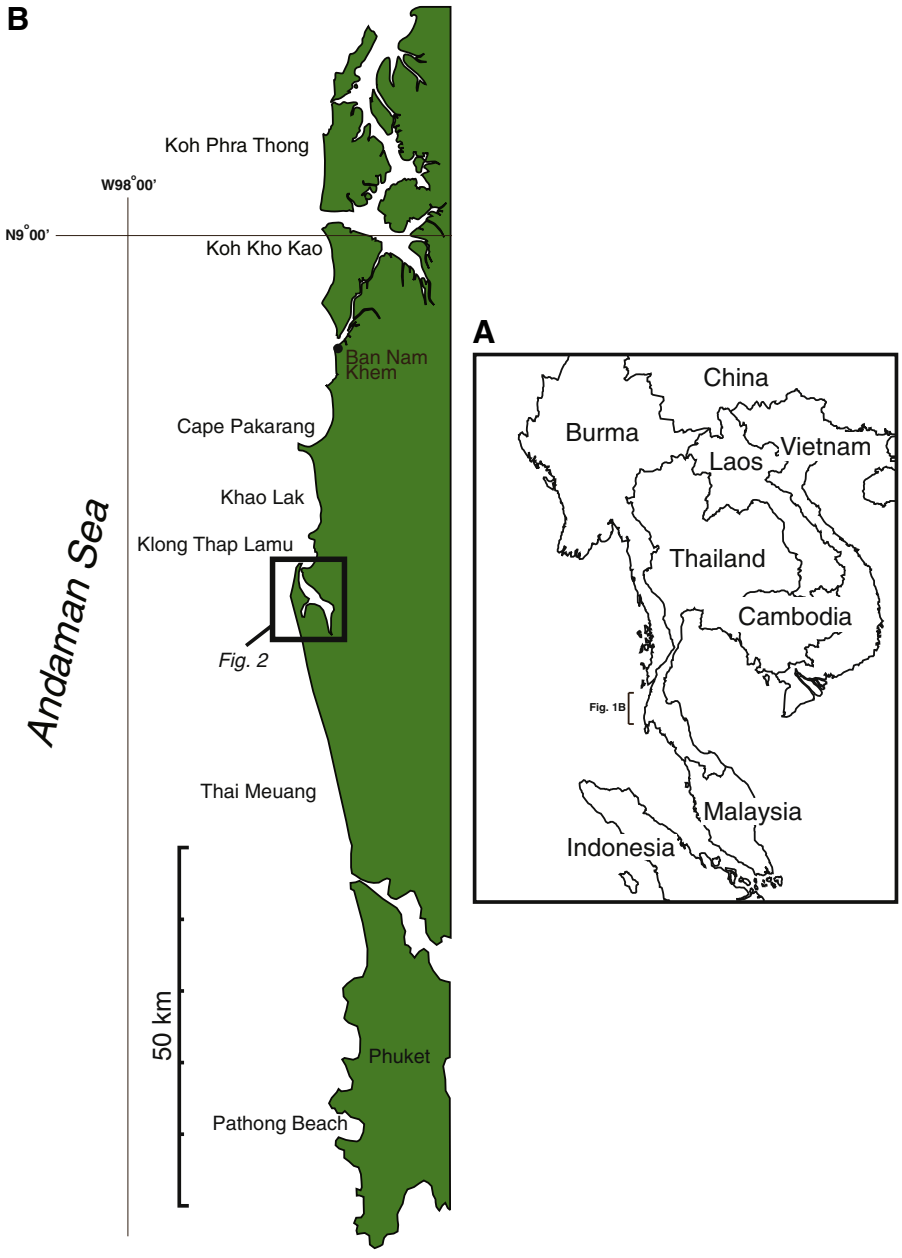

Fig. 1. Index map of Thailand's northern Andaman Coast showing the location of Klong Thap Lamu.