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Sedimentary responses to the Indian Summer Monsoon variations recorded in the southeastern Andaman Sea slope since 26 ka

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ABSTRACT

Paleoenvironment and paleoclimate change in the Andaman Sea during the last 26 ka were reconstructed from high-resolution records of grain-size, major elements and Sr–Nd isotopes in core ADM-9. The values of $\varepsilon_{Nd}(0)$ and $^{87}Sr/^{86}Sr$ were in good agreement with those of Irrawaddy River sediments, indicating a common source of origin. Two sensitive grain-size intervals (3.4–7.5 and 16.8–21.2 μm) were identified; the former was controlled primarily by sea-level change, whereas the latter was related to Irrawaddy River discharge and South-west Current transport driven by the Indian Summer Monsoon (ISM). Proxies of chemical weathering (K/Al) and terrigenous input (Ti/Ca) coupled with sensitive grain-size interval (16.8–21.2 μm population) revealed that the ISM was weak during ~15–26 ka BP and then strengthened gradually to a maximum during ~7–9 ka BP; subsequently, the ISM exhibited a generally declining trend to ~2 ka BP. The variation in the ISM recorded in this work is consistent with ISM variations observed in an open area in the northern Indian Ocean and adjacent continents, implying the evolution of the Asia Summer Monsoon since 26 ka.

1. Introduction

The Indian Summer Monsoon (ISM), which is generated by a cross-equatorial pressure gradient between the Asian continent and the southern Indian Ocean, is a major component of the Asian monsoon system and establishes interactions among the ocean, land and atmosphere (An et al., 2011). The Indian Summer Monsoon results in higher precipitation and river outflow over the northern Indian Ocean and adjacent continents, directly affecting socio-economic development in an area with one of the world's highest population densities (Rashid et al., 2007; Govil and Naidu, 2011). Paleomonsoon changes in the ISM are therefore of global importance and have been reconstructed from terrestrial and marine sediments in the Indian subcontinent and adjacent marginal seas. Reconstruction of ISM intensity was reported first in a study of the western Arabian Sea based on upwelling indices (Kroon et al., 1991). Subsequently, paleomonsoon changes on the millennial-decadal timescale have been reconstructed using various proxies in the sediment records for the Arabian Sea (Schulz et al., 1998; Gupta et al., 2003; Staubwasser et al., 2003; Saher et al., 2007) and the Bay of Bengal (Colin et al., 1998, 1999; Kudrass et al., 2001; Rashid et al., 2011; Govil and Naidu, 2011; Contreras-Rosales et al., 2014), speleothem records in Oman, Yemen, India and China (Shakun et al., 2007; Fleitmann et al., 2007; Sinha et al., 2005, 2007; Cai et al., 2012; Berkelhammer et al., 2012) (Fig. 1A) and lake sediment records in the Indian subcontinent (Juyal et al., 2009; Prasad et al., 2014; Dixit et al., 2014). However, palaeomonsoon record studies in the Andaman Sea remain scarce (Colin et al., 1998, 1999; Rashid et al., 2007), despite their significance for the understanding of ISM evolution.

The majority of paleomonsoon records from the northern Indian Ocean are based primarily on proxies of productivity (Schulz et al., 1998; Kudrass et al., 2001), sea surface temperature and salinity (Gupta et al., 2003; Saher et al., 2007; Rashid et al., 2007,2011; Govil and Naidu, 2011; Saraswat et al., 2013). However, terrigenous-based proxies, such as magnetic susceptibility, clay minerals, major elements and grain-size (Clemens and Prell,

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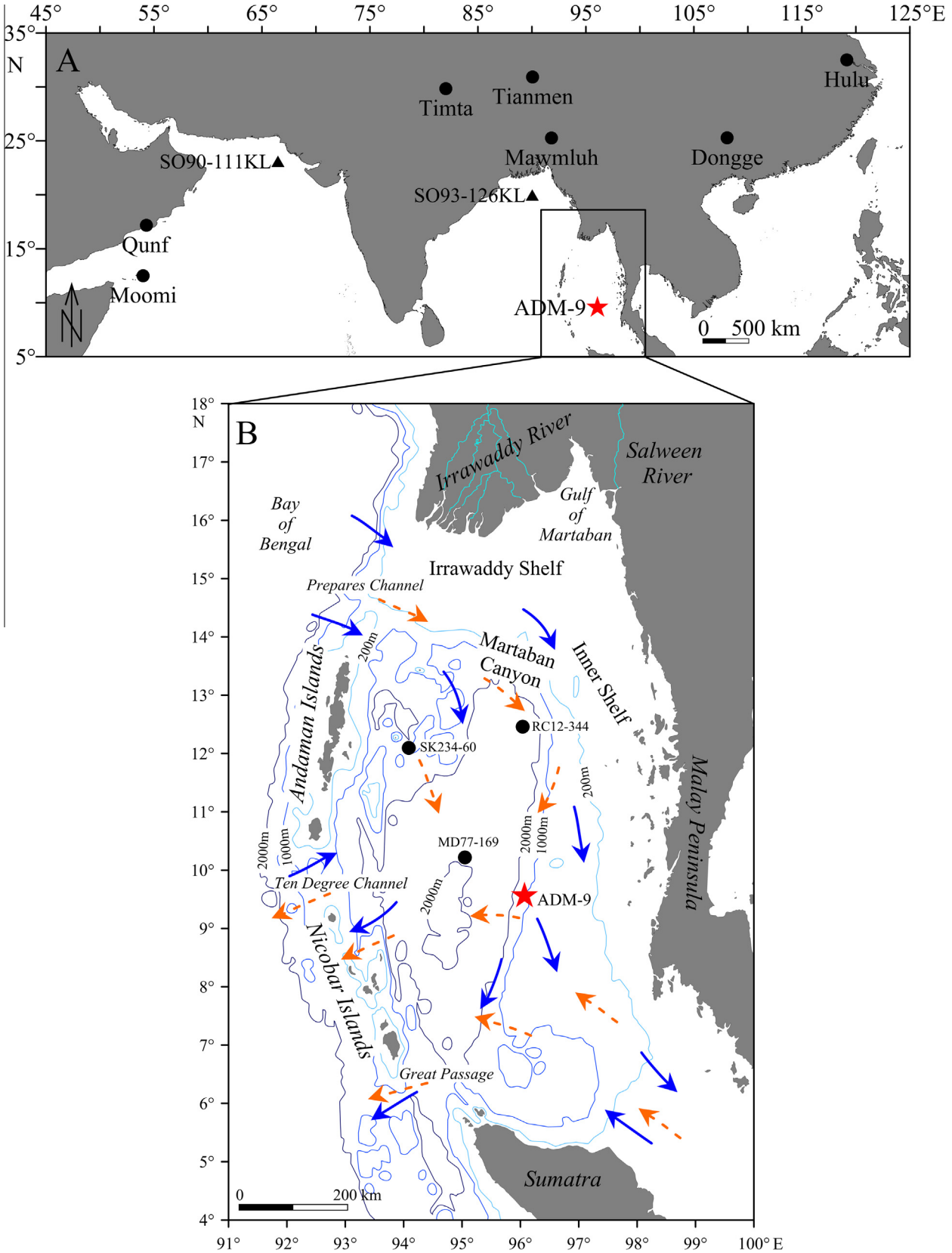

Fig. 1. (A) Positions of ADM-9 (red star) and paleoclimate records from sepleothems (black dots) and marine sediments (black triangles) referenced in the text: Qunf (Fleitmann et al., 2007), Moomi (Shakun et al., 2007), Timta (Sinha et al., 2005), Tianmen (Cai et al., 2012), Mawmluh (Berkelhammer et al., 2012), Dongge (Yuan et al., 2004), Hulu (Wang et al., 2001), SO90-111KL (Schulz et al., 1998) and SO93-126KL (Kudrass et al., 2001). (B) Bathymetric map of the Andaman Sea showing the location of ADM-9 (red star) analyzed in this study, with the major topographic features, major rivers and monsoon currents (blue arrow- South-west Current during summer monsoon, orange dash arrow- North-east Current during winter monsoon; modified from Brown, 2007) mentioned in this study. Black dots are the location of cores referenced in this paper: RC12-344 (Rashid et al., 2007), SK234-60 (Awasthi et al., 2010) and MD77-169 (Colin et al., 1999). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)