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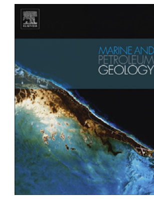

Research paper

A late Miocene–Early Pliocene biogenic silica crash in the Andaman Sea and Bay of Bengal

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ABSTRACT

Variations in the mass accumulation rate of biogenic silica (BSi) in continental margin sediments can be used to reconstruct relative changes in productivity through time in these settings. In the northern Bay of Bengal a lack of long sedimentary records has historically precluded this type of reconstruction. The acquisition of 21 new long sedimentary records during the 2006 Indian National Gas Hydrate Program (NGHP) Expedition-01 has made it possible for the first time to reconstruct paleoproductivity in this important region of the world that is dominated by intense changes in the geological and biological fluxes largely driven by tectonic and climate related mechanisms. In the research presented here, fluctuations in the mass accumulation rate of biogenic opal during the past ~9.4 Myrs are reconstructed using continental margin sediment cores from the Andaman Sea (Site NGHP-01-17A) and the northern Bay of Bengal (Site NGHP-01-19). Within these records, a biogenic silica crash is recorded at ~6 Ma and is consistent with previous geotectonic, geochemical and paleontological studies of the southern Indian Ocean and Pacific Ocean that suggest connectivity, and thus exchange of nutrient-rich water masses, between the eastern tropical Indian Ocean and western tropical Pacific Ocean was diminished as a result of the tectonic restriction of the northerly sector of the Indonesian Throughflow (ITF). The biogenic silica crash at Sites 17 and 19 is consistent with a decrease in surface water productivity that may have been driven by the reduction of nutrient-rich Pacific waters delivered to the Andaman Sea and Bay of Bengal via the northerly route of the ITF. Following the BSi crash at ~6 Ma, subsequent recovery of the BSi mass accumulation rates at Sites 17 and 19 occurred and was perhaps renewed by an enhanced supply of nutrient-rich freshwater from the nearby Irrawaddy and Mahanadi Rivers, which could have occurred during a documented increase in the intensity of the Indian monsoon at ~5 Ma. Although recovery is noted at both core locations, biogenic silica mass accumulation rates did not fully recover in the Andaman Sea. This could be explained by the restricted nature of the Andaman basin and its more distal location from a major source of nutrient-rich freshwater.

1. Introduction

Several DSDP and ODP expeditions in the Pacific and north–central Indian Oceans have documented significant increases in the mass accumulation rates (MAR) of biogenic sediments during the late Miocene–Pliocene (e.g., Leinen, 1979; Woodruff, 1985; Farrell et al., 1995; Dickens and Owen, 1996). These changes mark important shifts in planktonic and benthic productivity, and are especially well developed in oceanographic divergence zones (Peterson et al., 1992; Berger et al., 1993; Dickens and Owen, 1994). The time-coincident nature of biogenic sediment increases in the Pacific and Indian Oceans resulted in the development of the "biogenic bloom" hypothesis that suggests enhanced nutrient upwelling to surface waters in divergence zones led to an increase in the downward flux of biogenic sediments and an expansion of the oxygen minimum zone, enhancing preservation (e.g., Dickens and Owen, 1999). Sediment deposited between 9.0 and 3.5 Ma in

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these ocean basins contain planktonic and benthic fauna that are indicative of high productivity and organic content and redox signatures indicative of low dissolved O_2 (Dickens and Owen, 1999).

Two potential mechanisms have been proposed to explain the origin of the late Miocene–Pliocene biogenic bloom: 1) elevated nutrient supply to the ocean basins via increased continental weathering or 2) a redistribution of nutrients within the oceans resulting from a change in the strength of deep water formation (Dickens and Owen, 1999) or an opening and closing of passages for ocean circulation (e.g., Keller and Barron, 1983; Cortese et al., 2004). Although both scenarios are plausible, a better understanding of the late Miocene–Pliocene biogenic bloom may be achieved as the spatial distribution of its occurrence and its timing are better constrained globally.

Although plausible explanations for the late Miocene–Pliocene biogenic bloom have been proposed and discussed, the subsequent cessation of the bloom has received limited discussion (Keller and Barron, 1983; Farrell et al., 1995; Dickens and Owen, 1999). In this paper, we document the biogenic silica mass accumulation rate (MAR) of sediments located in the Andaman accretionary wedge at National Gas Hydrate Program of India Expedition-01 (NGHP-01) Site 17 (10° 45.1912′N, 93° 6.7365′E) and in the northwestern Bay of Bengal at NGHP-01 Site 19 (18° 58.6568′N, 85° 39.5202′E) and discuss the mechanisms that may have caused an observed abrupt decrease or "crash" in BSi at ~6 Ma at both sites.

2. Geologic setting

The seafloor sedimentary record in the Bay of Bengal in the northern Indian Ocean is dominated by the Bengal and Nicobar submarine fans, which have received terrigenous sediments from the erosion of the Himalayan Mountains via transport through the Ganges–Brahmaputra drainage systems during the last 15 million years (Curray et al., 2003; Bastia et al., 2010, Fig. 1). The extent of the Bengal Fan is limited to the west by the continental shelf and slope of peninsular India, which formed as a passive margin during the break-up of Gondwana (Powell et al., 1988; Curray et al., 2003; Bastia et al., 2010) and has received terrigenous sediments from the modern Mahanadi, Krishna, Godavari and Kaveri Rivers and predecessor rivers (Fig. 1). Site 19 is located on the slope, above the modern-day depocenter of the Bengal Fan, on the eastern margin of peninsular India, just south of the Mahanadi River discharge. To the east, across the Bay of Bengal, much of the Bengal Fan has been subducted or accreted beneath the Sunda Subduction Zone (Bowles et al., 1978; Curray et al., 2003). As the aseismic Ninety East Ridge continues to approach the subduction zone it also inhibits Bengal Fan sedimentation, isolating the more westerly and previously deposited fan sediments, now known as the Nicobar Fan, from the main Bengal Fan lobe (Bowles et al., 1978; Curray et al., 2003). Farther to the east, the semi-enclosed Andaman Sea is located in a back-arc basin formed by the oblique subduction of the Indian Plate beneath the Sunda Plate (Rodolfo, 1969; Karig et al., 1980; Pal et al.,

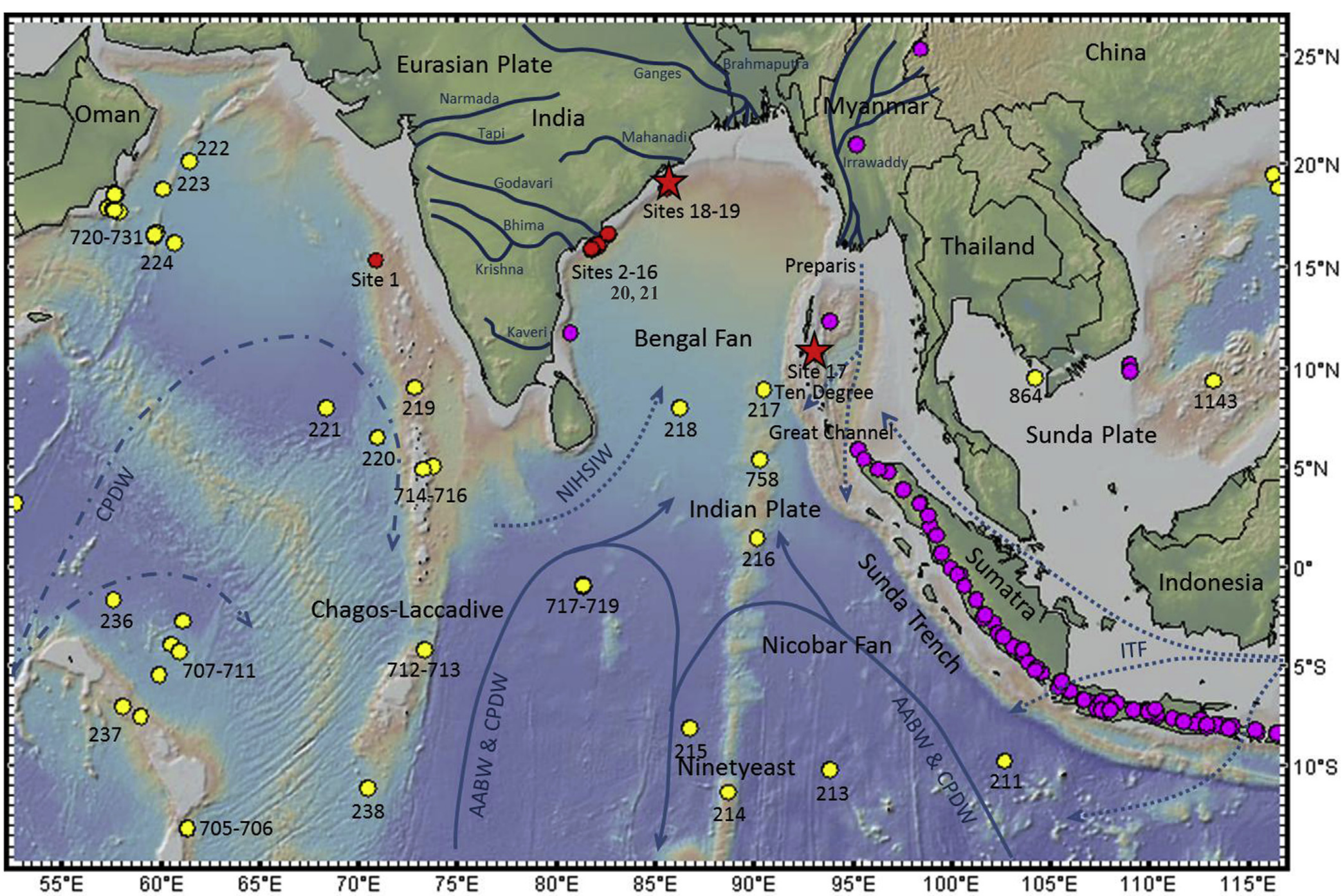

Figure 1. Regional map of the NE Indian Ocean region showing core locations from the 2006 NGHP-01 Expedition (red dots and stars) and existing ODP and DSDP core sites in the region (yellow dots), the location of major rivers entering the NE Indian Ocean and Andaman Sea, generalized ocean circulation, and regional volcanic centers (pink dots). Solid blue lines are deep water masses, coarse dashed lines are intermediate waters, and fine dashed lines are shallow water masses. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)