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Clay minerals and Sr-Nd isotopic composition of the Bay of Bengal sediments: Implications for sediment provenance and climate control since 40 ka

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ABSTRACT

Grain size, clay mineralogy, $^{87}Sr/^{86}Sr$, εNd, and AMS^{14}C analyses of deep-sea sediments cored in the central Bay of Bengal are used to reconstruct the evolution of provenances and climate control since the last glacial period. Clay minerals, $^{87}Sr/^{86}Sr$ ratios and εNd values indicate a mixture of sediment from the Himalaya source, Indian Peninsula and Indo-Burman Ranges/Irrawaddy River. These analyses show that the Himalaya Mountains and Indo-Burman Ranges/Irrawaddy River are the main suppliers before the Holocene period, while the inputs of erosion materials from the Indo-Gangetic floodplain and the Indian Peninsula increase during the Holocene period, accompanied by reduced inputs of the Indo-Burman Ranges and Irrawaddy sediments. The regional "source-sink" process is significantly controlled by the climate. Warm and wet climate conditions and enhanced Indian monsoon intensity during the Holocene period are responsible for the increase of sediment input from the Indo-Gangetic Plain and the Indian Peninsula by improving erosion in the source area, input from the floodplain to the river channel and the intensity of the southwest monsoon current. In contrast, due to the decrease of the northeast monsoon current during the Holocene period, sediment input from the Irrawaddy and Indo-Burman Ranges are constrained. Deposition center transition between the submarine fan and shelf during the last glacial period and the Holocene period occurs in response to the sea level change, which controls the sedimentary mode and thus significantly influences the transportation and deposition processes in the Bay of Bengal (BoB).

1. Introduction

The Bengal Fan is the world's largest submarine fan; it is approximately 3000 km long, approximately 1000 km wide and has a total volume equivalent to the Appalachian geosyncline in North America (Curray and Moore, 1971; Curray, 1991; Curray et al., 2003). The development of the Bengal Fan started in the early Eocene and was related to the Tibetan Plateau, which was produced by collisions between India and Asia (Curray, 1994). The two most important rivers around the Bay of Bengal are the Ganges-Brahmaputra Rivers, which drain the Himalayas and are characterized by relatively higher sediment outputs than the other rivers in this area (Kolla and Coumes, 1984). Together with the rivers from the Indian Peninsula (Godavari, Krishna and Mahanadi) and Myanmar (Irrawaddy), they support annual fluvial sediment loads of approximately 1350 million tons, which is equivalent to 8% of the global river supply to the ocean (Milliman and Syvitski, 1992; Milliman and Farnsworth, 2001). Due to the key role that these rivers play in the sediment output to the ocean in the global sediment budget balance, the river basin erosion patterns and their temporal-spatial variations in the source area have attracted much attention (Galy and France-Lanord, 1999; Das et al., 2005; Singh et al., 2005; Huh, 2010; Tripathy et al., 2011, 2014). Compared to one of the two typical "source-sink" systems

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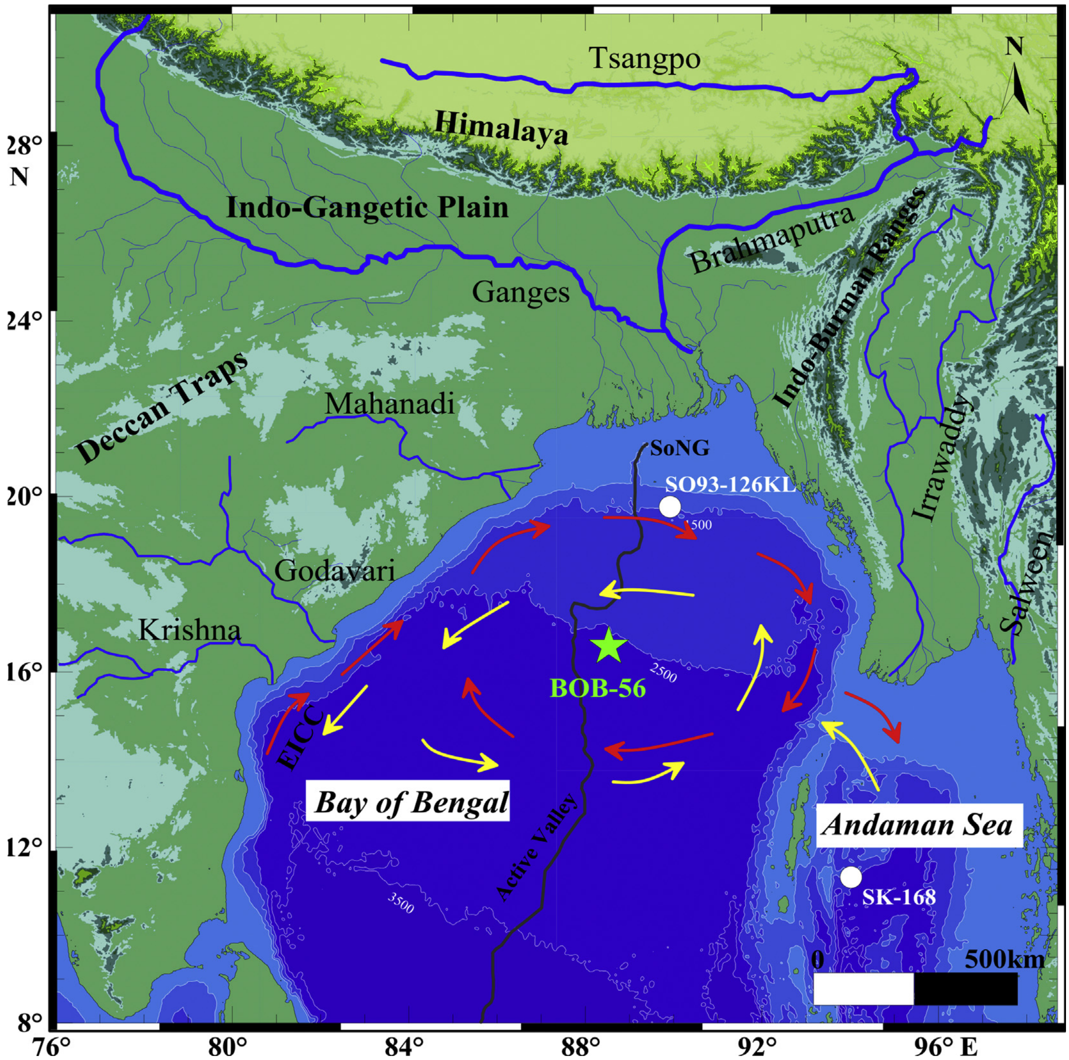

Fig.1. Geographical setting and hydrography (modified from Chauhan and Vogelsang, 2006) of the Bay of Bengal. Location of BoB-56 core is represented by the green asterisk and referenced cores, SO93-126 KL in the northern Bay of Bengal and SK-168 in the western Andaman Sea, are represented by the white circles. The red and yellow arrows show the SW and NE monsoon currents, respectively). SoNG: Swatch of No Ground, the biggest submarine canyon in the Bay of Bengal. EICC: East Indian Coastal Current. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

in the East Asia continent margin (Yang et al., 2015), i.e., the large river "source-sink" system (represented by the Yangtze River), the "Bengal depositional system" (Curray, 2014) has a higher river runoff, larger sediment load (Milliman and Farnsworth, 2001) and greater elevation difference from its "source" to "sink" areas (i.e., from the highest mountain in the world beyond 8000 m to the deep sea below 4000 m). When sediment is produced from the erosion of the Himalaya and transported by the Ganges-Brahmaputra Rivers, bypassing the floodplain, river mouth, delta, continental shelf, slope, and submarine canyon to the Bengal Fan, it forms a full path of sediment from its "source" to "sink". The enormous supply of material, large developed river systems, typical monsoon climate and active land-sea interactions make the Bay of Bengal a natural laboratory for sediment "source-sink" research.

Existing studies have reached a consensus that terrigenous detrital material is the primary type of sediment in the Bay of Bengal and that Himalaya is the main provenance, with minor contributions from the Indian Peninsula and Southeast Asia (Iyer et al., 1999; Weber et al., 2003; Pattan et al., 2008; Joussain et al., 2016; Li et al., 2017a, b). Some studies have also provided supplemental information about the sediment source in the Bay of Bengal, which have mainly emphasized the contribution of several minor sources to the edge area of the Bay of Bengal, such as materials produced by Sri Lanka and the weathering of central Indian Basin seamounts (Kessarkar et al., 2005), as well as Sunda Arc volcanic material (Weber et al., 2003; Phillips et al., 2014). Pelagic/hemipelagic (Kessarkar et al., 2005) and contourite (Fang et al., 2002) deposition are also important types of deposition in the Bay of Bengal. In view of the spatial distribution of these provenances, the sediment sources in the eastern Bay of Bengal are mainly "Himalaya + Indo-Burman Ranges/Irrawaddy" (Prakash Babu et al., 2010; Joussain et al., 2016), while those in the western Bay of Bengal are mainly "Himalaya + Indian Peninsula" (Kessarkar et al., 2005; Tripathy et al., 2011, 2014), and the central Bay of Bengal is suggested to have a single "Himalaya" supplier (Galy et al., 2008) or signals from the Indian Peninsula and Myanmar were usually ignored. The "Active Valley", which was the active turbidity channel during the last glaciation, is the main channel for the transportation of Himalaya materials to the submarine fan by turbidity, and it overflows to deposit fine fractions (Curray et al., 2003). Thus, the input from the Himalaya is closely related to the strength and frequency of turbidities, while the monsoon surface currents are the main dynamics for the transportation of Indian and Myanmar materials. During periods when the strength of turbidities was relatively weak, such as the Holocene, the Indian Peninsula and Indo-Burman Ranges/Irrawaddy input signals must have been