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EVOLUTION OF THE INDIAN MONSOON SINCE LATE MIOCENE INTENSIFICATION – MARINE AND LAND PROXY RECORDS

ANIL K. GUPTA
DEPARTMENT of GEOLOGY & GEOPHYSICS
INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR – 721 302
E-mail: anilg@gg.iitkgp.ernet.in

ABSTRACT

A large part of the Indian Ocean and its surrounding continents are influenced by seasonally reversing (summer and winter) monsoon winds (Fig. 1). Variability in the summer monsoon impacts different components of the Earth system, both regionally and globally. The summer monsoon rains are critical for food production, water supply and economic well-being of the Asian societies. The Indian monsoon constitutes a critical resource for the region's largely agrarian economies, as almost two third of India's food production depends on summer rains, so are the rivers that cater to the domestic needs of the region.

The Indian monsoon underwent a major intensification during the late Miocene (10-8 Ma) as observed in marine records of upwelling and sediment deposition (Kroon *et al.*, 1991; Rea, 1992), and a change in continental vegetation from dominant C_3 type to dominant C_4 type plants (Quade *et al.*, 1989). Evolution of the Indian monsoon has been closely related to the uplift of the Himalaya-Tibetan plateau, though there are debates about the relation of the 10-8 Ma event with the elevation changes in the Himalaya-Tibetan plateau. The elevated heat source of the Himalaya and the Tibetan plateau is of vital importance for the establishment and maintenance of the Indian summer monsoon circulation.

The Indian monsoon has varied on various time scales. While long term changes in the Indian monsoon have been linked to the phased uplift of the Himalaya-Tibetan plateau (Zhisheng *et al.*, 2001) superimposed by orbital changes (Bloemendal and deMenocal, 1989), small scale, rapid changes as documented in late Quaternary and Holocene proxy records from marine sequences (Schulz *et al.*, 1998; Gupta *et al.*, 2003), cave deposits (Fleitmann *et*

al., 2003), peat deposits (Hong *et al.*, 2003), runoff in the Bay of Bengal (Kudrass, *et al.*, 2001), and fluvial sediments (Sharma *et al.*, 2004) have been related to boundary conditions including Himalayan-Tibetan snow, North Atlantic variability, Eurasian temperatures, tropical sea surface temperatures, solar activity, vegetation changes, and linkages with the ENSO, Indian Ocean Dipole (IOD) or North Atlantic Oscillations. The late Quaternary and Holocene records of monsoon from the Arabian Sea indicate presence of North Atlantic events: Bond, Dansgaard-Oeschger (D-O) and Heinrich events, indicating that North Atlantic variability may bring pronounced changes in the Indian monsoon on suborbital scales (Gupta et al., 2003; Gupta, 2008).

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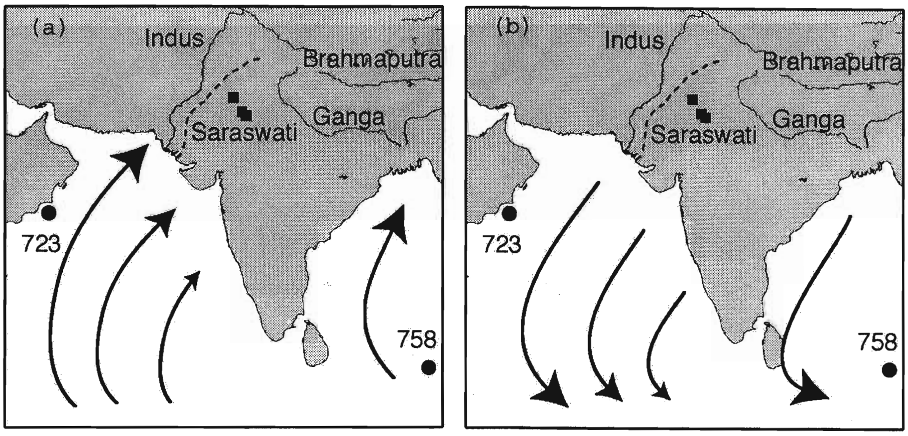

Fig. 1 Reversing winds during summer (July month) and winter (January month) monsoon seasons. Also shown are locations of Ocean Drilling Program sites 723 and 758 which provide well preserved records of summer monsoon variability.