Evolution of the Indian Monsoon System and Himalayan-Tibetan Plateau uplift during the Neogene

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The Indian monsoon also known as the South Asian monsoon is an important feature of the climate system, marked by seasonal reversals in the wind direction with southwesterly winds in summer and northeasterly winds in winter. The summer monsoon plays an important role in global hydrological and carbon cycles, and affects climate and societies over a large part of Asia between 35°N and 10°S. The monsoon is the lifeline to the people of Asia as region's food production and water supply are largely dependent on the summer monsoon rains. Thus the Indian monsoon constitutes a critical resource for the region's largely agrarian economies.

Considerable efforts have been made toward high resolution (high density sampling of the marine cores) reconstruction of proxy records of monsoon that have helped in the understanding of monsoon evolution, its variability over various time scales, and forcing factors that drive the monsoon on orbital and sub-orbital time scales. However, there are still unresolved questions as to the timing of the advent of the modern monsoon and driving mechanisms of monsoon variability. The elevated heat source of the Himalayas and the Tibetan Plateau is of vital importance for the establishment and maintenance of the Indian summer monsoon circulation through mechanical and thermal factors. But there are different propositions about the attainment of the critical elevation by the Himalayas and the Tibetan Plateau to drive the Indian monsoon, ranging from 35 to 7.5 Ma (Table 1). While the marine records indicate a major shift in the monsoon system between 9 and 8 Ma, the continental records suggest a range from 22 to 7.5 Ma during which time the monsoon may have evolved. The model studies, on the other hand, put the origin farther back in time at ~ 35 Ma. Recent study from China suggests a wet phase in the early Miocene and beginning of an arid phase (weakening of the summer monsoon) across 13-11 Ma (Hanchao et al. 2008). Thus to resolve these issues, a coordinated effort is required to analyze and compare high resolution records from marine cores from high sedimentation areas of the Arabian Sea and the Bay of Bengal as well as continental records of continuity.

References

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Hanchao J, J Ji and Z Ding. 2008. Cooling-driven climate change at 12-11 Ma: multiproxy records from a long fluviolacustrine sequence at Guyuan, Ningxia, China. *Palaeo3* In press

TABLE 1. Evidence and timing of the Himalayan Uplift and Monsoon Intensification (Modified from Gupta et al. 2004)

SOURCE	TYPE OF EVIDENCE	EVENT	TIMING (MA)
Rowley and Currie 2006	Oxygen isotope	Tibetan Plateau	35
Ramstein et al. 1997	Modeling	Monsoons and Paratethys retreat	~30
Guo et al. 2002	China loess deposits	Monsoon climate	22
Wang 1990	Sediments in China	Monsoons	20
Clift and Gaedicke 2002	Indus Fan sediments	Erosion and weathering	~16
Clift et al. 2002	South China Sea smectite mineral	Precipitation and monsoons	~15.5
Spicer et al. 2003	Fossil flora	Himalayan elevation and monsoons	>15
Coleman and Hodges 1995	Tectonics	Himalayan elevation	>14
Blisniuk et al. 2001	Tectonics	Himalayan uplift and monsoons	>14
Chen et al. 2003	Oceanic microfossils	Monsoons and upwelling	12–11
Dettman et al. 2001	Isotopes and land	Monsoons	~10.7
An et al. 2001	Land and marine sediments	Uplift and onset of monsoons	9–8
Kroon et al. 1991	Oceanic microfossils	Monsoons and upwelling	8.6
Filipelli 1997	Weathering and sediments	Monsoons	~8
Quade et al. 1989	Isotopes and flora	Monsoons	8–7.6