Spatial variability in erosion in the Brahmaputra basin: causes and impacts

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The rivers from the Himalaya supply large quantities of particulate and dissolved materials to the oceans. Among the various rivers, the Brahmaputra ranks highest in contributing to the sediment budget of the Bay of Bengal. The erosion rates among the sub-basins of the Brahmaputra vary over 1–2 orders of magnitude, the highest being in the Eastern Syntaxis basin which is eroding at an enormously high rate of ~ 14 mm yr^{-1}, caused by the high stream power of the Siang river. These contemporary erosion rates are consistent with the time-averaged erosion and exhumation rates derived for ~ 100 ka based on cosmogenic isotopes and geophysical methods. Both the Eastern and the Western syntaxes experience rapid erosion suggesting that the syntaxes, a characteristic feature of the collision belt, undergo rapid erosion under favourable conditions. The rapid erosion of the Eastern Syntaxis has caused important tectonic and geomorphological changes, such as the rapid uplift of this region resulting in the great peaks of Namche Barwa and Gyala Peri, and the nickpoint in the Tsangpo river bed prior to its entrance to the gorge. Further, the rapid erosion makes up about half of the particulate material transported by the Brahmaputra to the Bay of Bengal, an order of magnitude higher than its areal coverage. The high sedimentation rate in the Bay of Bengal over the past ~ 1 Ma can be due to the high erosion rate of the Eastern Syntaxis. The mineralogical and isotopic composition of the sediments seems to suggest this inference.

Keywords: Brahmaputra, Eastern Syntaxis, erosion, Himalaya, Sr–Nd–Os isotope systematics.

ORIGIN and evolution of the Himalaya–Tibet (HT) during the Cenozoic has not only changed the geomorphology of the earth, but has also influenced the global climate and geochemical and sedimentary cycles[1–8]. The rivers draining the Himalaya contribute ~ 25% of the global sediment supply to the oceans. Among the various rivers draining the HT, the Brahmaputra alone supplies ~ 1000 million tons of suspended material to the Bay of Bengal[6–8]. This estimate of sediment supply from the Brahmaputra would be doubled if bed load is also considered[9]. It has been shown[9] that the Brahmaputra basin erodes more rapidly compared to its western counterpart, the Ganga drainage, possibly because of higher run-off in the Eastern Himalaya. Recently, Singh and France-Lanord[10] observed that there are significant variations in the erosion rates among the various sub-basins of the Brahmaputra.

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This study aims to: (i) Quantify the contemporary erosion rates of the various sub-basins of the Brahmaputra system based on the sediment provenance[10] and available data on sediment flux. (ii) Compare the results of this study with the reported long-term exhumation rates and erosion rates from other regions[11–14]. This provides information on the temporal variability in erosion in selected regions of the Himalaya, (iii) Characterize the source of sediments contributing to high sedimentation rate in the Bay of Bengal over the past ~ 1 Ma.

The Brahmaputra river has different names along its stretch of about 2800 km (Figure 1). It originates from the Kailash mountain in the northern slopes of the Himalaya and flows east of the Mansarovar lake. In Tibet, it drains ~ 1300 km along the Indus–Tsangpo Suture and is known as the Tsangpo. After Pai, it enters the Eastern Syntaxis which houses the deepest (~ 5000 m) gorge of the world and takes a U-turn. Near Singing, it turns south to enter Arunachal Pradesh (India), where it is known as Siang or Dihang. The Siang enters the Assam plain at Pasighat, downstream of which it meets with two eastern tributaries, the Dibang and the Lohit, before taking a turn in the WSW direction. In the whole stretch of the Assam plain, the river is known as the Brahmaputra. At the Indo-Bangladesh border, it turns south where it is known as the Jamuna. It meets with the Ganga at Aricha ghat, after which it is called the Padma until the Upper Meghna joins it and together they become the Lower Meghna, which drains into the Bay of Bengal through various distributaries.

In Tibet, the Tsangpo receives tributaries, the Doilung, Zangbo and Nyang Qu; and the Parlung Tsangpo in the gorge (Figure 1). It drains sedimentary rocks and gabbros, dolerite of the Trans Himalayan plutonic batholiths adjacent to the Indus–Tsangpo Suture and granites of the adjoining areas. The Eastern Syntaxis is made of gneisses and calc-alkaline plutons of the Trans Himalayan plutonic belt. Further downstream, in the Lesser Himalaya, crystallines and sedimentaries, quartzite, dolomite and limestone dominate the lithology. The tributaries joining from the Himalaya in the Assam plain, the Subansiri, Jia Bahreli, Manas, drain crystallines and sedimentaries of the Higher and Lesser Himalaya; the eastern tributaries drain the Mishmi Hills composed of calc-alkaline diorite-granodiorite-tonalite rocks of Trans Himalayan plutonic belt, whereas tributaries from the south drain the turbidites with ophiolites of Naga Patkoi ranges[15].

Based on the lithology and climate, the Brahmaputra basin is divided into five sub-basins: (i) Tibet, (ii) Eastern Syntaxis, (iii) Eastern drainage/Mishmi Hills, (iv) Himalaya and (v) Southern drainage (Figure 1).

The climate of the Brahmaputra basin is highly variable. The Tibet drainage is cold and dry and has the lowest run-off among the various basins, ~ 0.3 m yr^{-1}; the Eastern Syntaxis region has the highest run-off, ~ 5 m yr^{-1}. Run-off