Monsoon Intensification in the Himalayas during the Mid-Miocene and its Relationship to Plate Tectonics

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Abstract

The Himalayas have greatly affected the climate in the Asia. The effects are significant and reflected in the erosion and denudation of the Himalayas. The eroded sediments are found in lakes, glacial remnants, and alluvial fans from rivers that empty into the Bay of Bengal and other seas. The formation of the Himalayas began with the suturing of both plates at 65-60 Ma during the Paleocene. The plates collided and uplifted the crust over the course of 50 Ma. The uplift of the Himalayas and Tibetan plateau affected the climate in Asia resulting in monsoon intensification during the Mid-Miocene.

Introduction/Background

- The orogenic timeline for the Himalayan mountains begins in 60 Ma when the suturing of the two plates began.
- The Indian plate was moving approximately 9 meters per century before the collision and was slowed by approximately 50%. This signifies the onset of the uplift which created the Himalayas.
- The Himalayas' major structural divisions are the Indus suture zone (IDS), the Himalaya sedimentary units, Greater Himalaya STethyanequence (GHS) of metamorphic rocks, the Lesser Himalaya (LH) fold and thrust belt, and the Sub-Himalaya Siwalik basin. (Fig. 1)

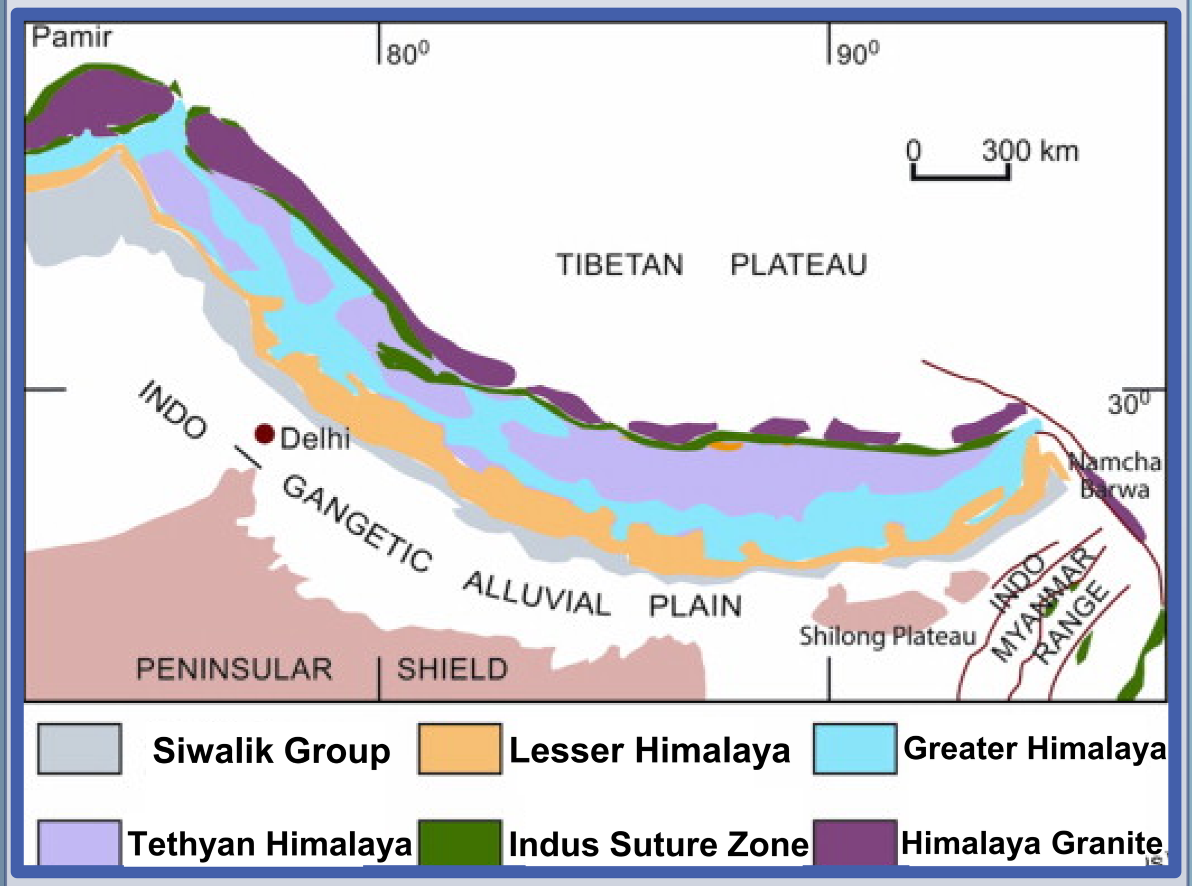

Fig 1: Simplified geologic map of the collision zone associated with the Himalayas.

Supporting Data

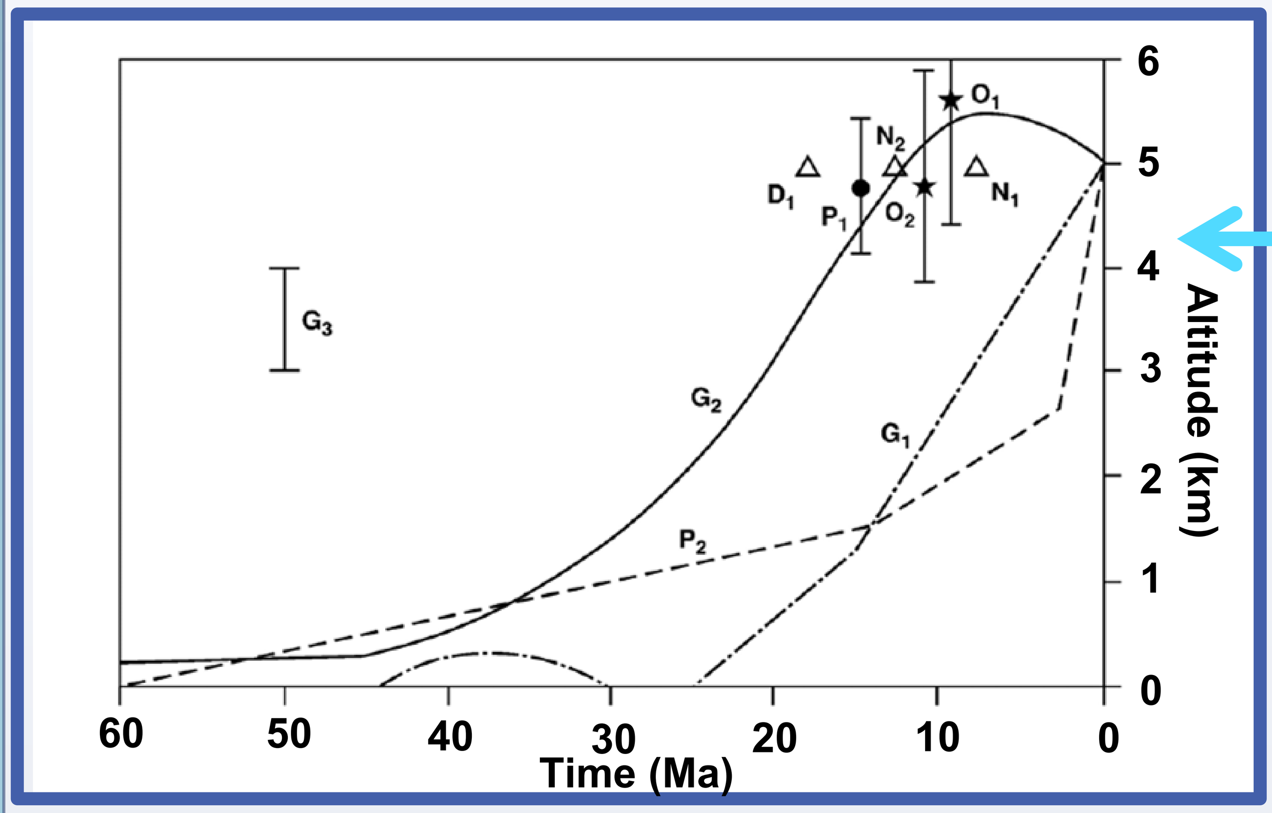

Fig 2: Elevation estimates of the surface of the southern Tibetan Plateau obtained using geodynamic models for lithospheric thickening coupled with assumptions made about the proportion of crust removed by erosion.

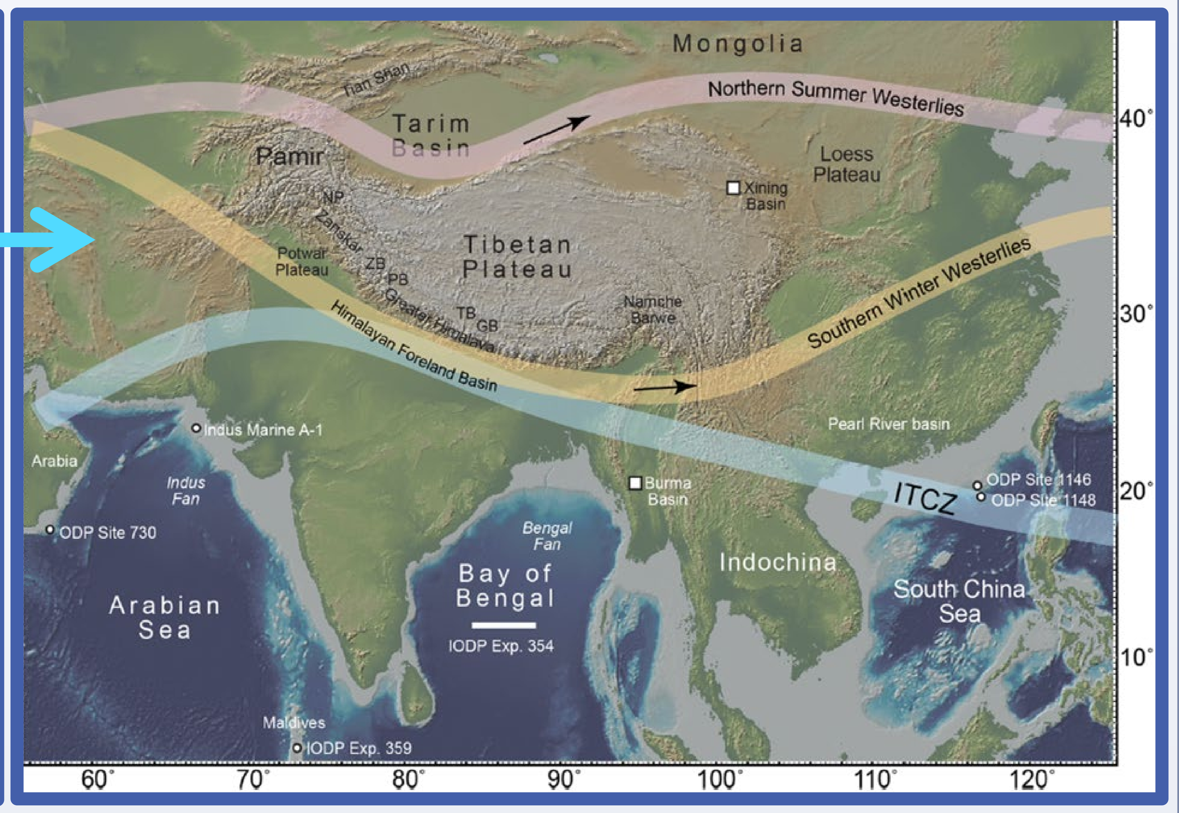

Fig 3: Shaded topographical and bathymetric image of Asia, as well as the location of the primary atmospheric belts, the Westerly Jet and the Intertropical Convergence Zone (ITCZ) (Figure taken from Clft, P. et al, 2018).

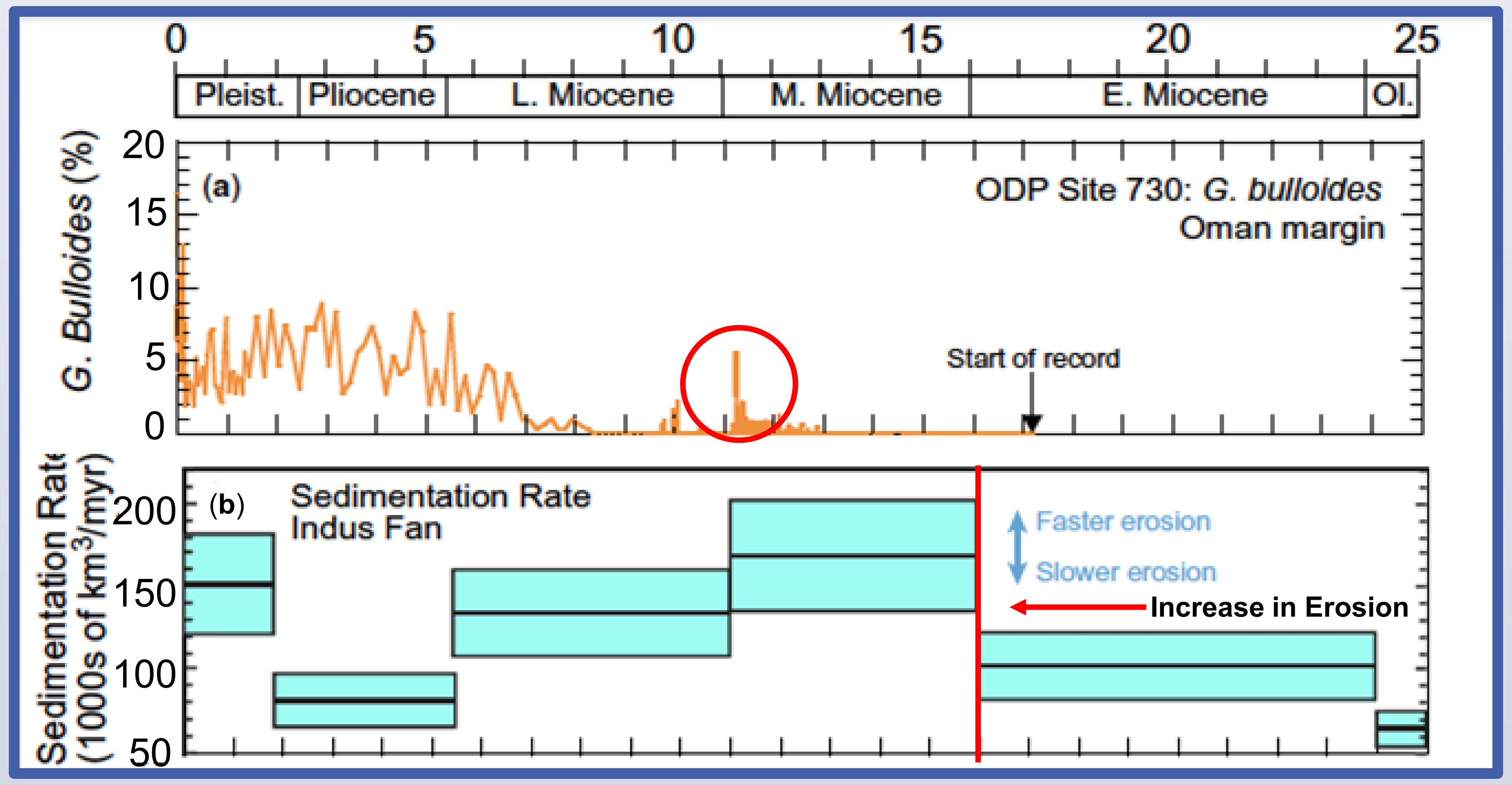

Fig 4: (a) Abundance of *G. bulloides* on the Oman margin as a proxy for the summer monsoon wind strength. (b) Rates of sediment supply to the Arabian Sea calculated from regional seismic data. (Figure obtained from Clift, P., Webb, A.G., 2018)

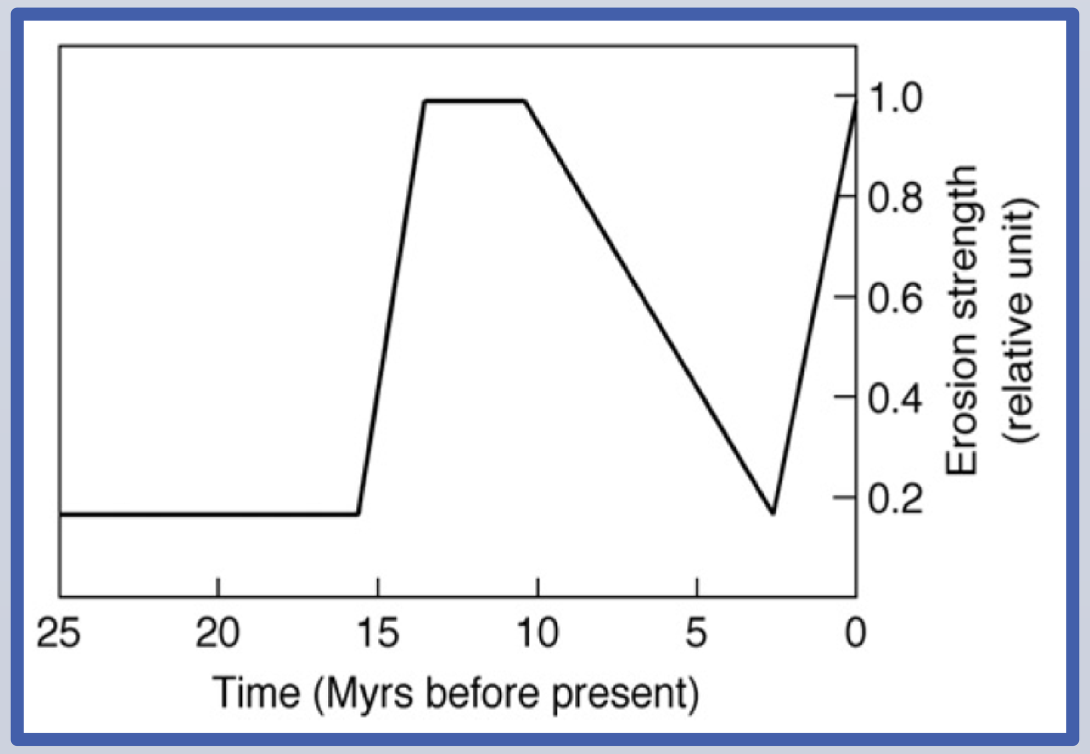

Fig 5: Variations in erosion strength since 25 Ma relative to present day, constrained by chemical and mineralogical indicators from sediments in Bengal Fan, Arabian Sea, and South China Sea. (Figure obtained from Iaffaldano, G. et al., 2011).

Results

- The Tibetan Plateau creates a heat source in the lower atmosphere during the summer, that produces a low-pressure system over central Asia, which draws in warm humid air from the Indian ocean. Airflow is forced upwards when it impinges on the physical barrier of the Himalaya, causing intense monsoons in the southern slopes. (Fig. 2 , Fig. 3)
- Initial increase at 11 Ma is an indicator for monsoon intensification. (Fig 4a)
- Periods of fastest exhumation were also times of rapid erosion and, furthermore, correlate with times of wettest climate, although all of these processes outlast the 17 Ma end of most proposed channel-flow periods. (Fig. 4b)
- Chemical weathering of silicate rocks is a major sink for atmosphere CO2 and therefore, if linked to uplift, it provides an explanation for long term cooling during the Cenozoic. (Harris, 2006) (Fig. 5)

Conclusions

- The both the elevation and surface area of the Tibetan Plateau are significant in creating the intensity of the effect of atmospheric circulation
- Stable oxygen isotope data linked to the intensity of rainfall and preserved in fossil mammal teeth and bivalve shells indicate that a monsoonal climate has existed in SW Asia since 10.7 Ma, but that intensity of rainfall decreased after 7.5 Ma
- Erosional fluxes, which are constrained by quantifying the delivery of siliciclastic sediment to the continental margins of SE Asia, have increased at the same time that these chemical weathering indices strengthened, also suggesting stronger precipitation at the beginning of the Miocene

References

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