Geochemical fingerprints unravel complex source-to-sink behavior under a variety of forcing conditions: Unparalleled insights from the Ganges-Brahmaputra Delta

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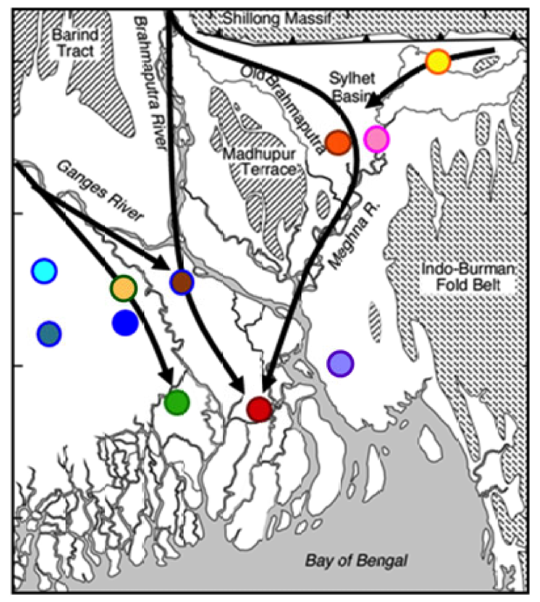
Geochemistry and Weathering

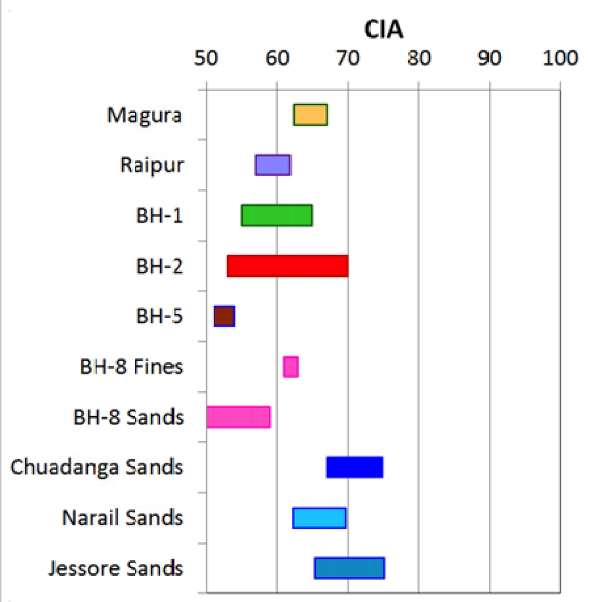


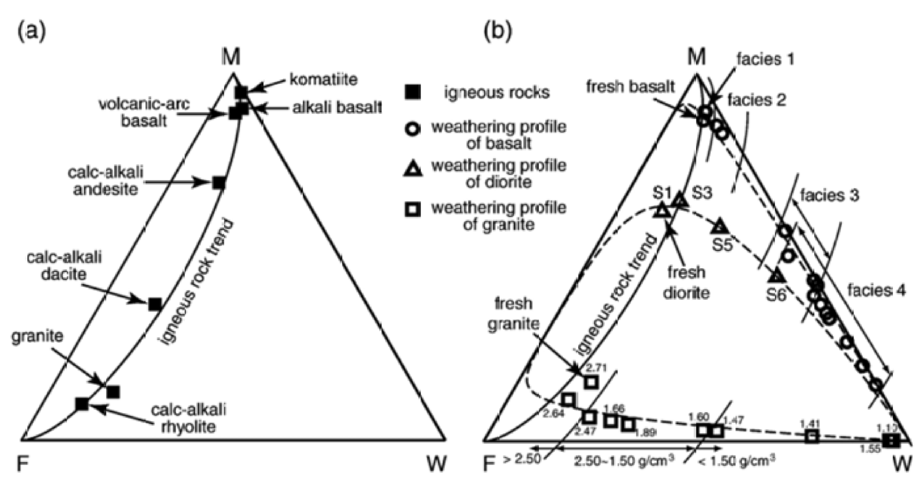
Tools to assess extent of chemical alteration:

- Chemical Index of Alteration (CIA)
  CIA = $[Al_2O_3/(Al_2O_3 + CaO + Na_2O + K_2O)] \times 100$
- Plagioclase Index of Alteration (PIA)
  PIA = $[(Al_2O_3 - K_2O)/(Al2O3 + CaO^* + Na_2O - K_2O)] \times 100$
- Weathering Index (W), (Ohta and Arai, 2007)
- Elemental plots – looking for preferential weathering of feldspars and micas

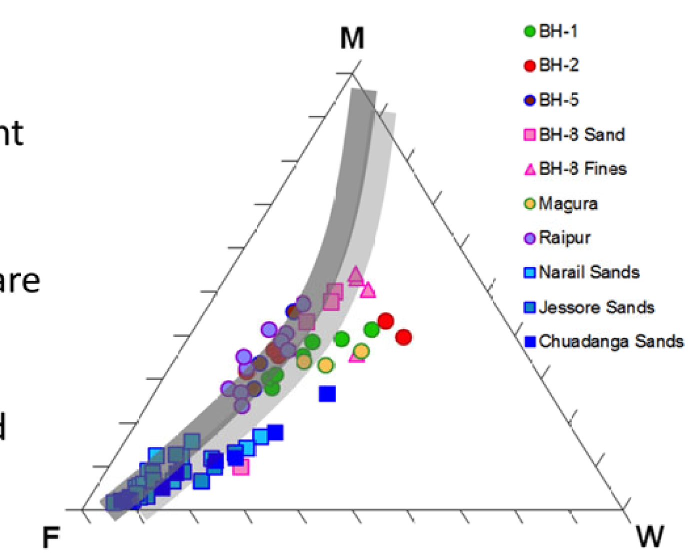
Effects of weathering on Sr geochemistry:

- Sr may be lost from feldspars and micas during weathering processes which could affect overall Sr geochemical signatures used to trace provenance.

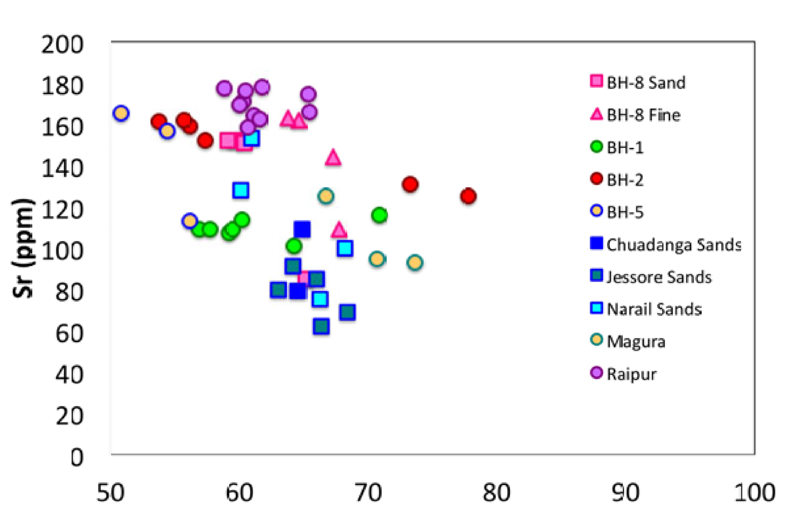




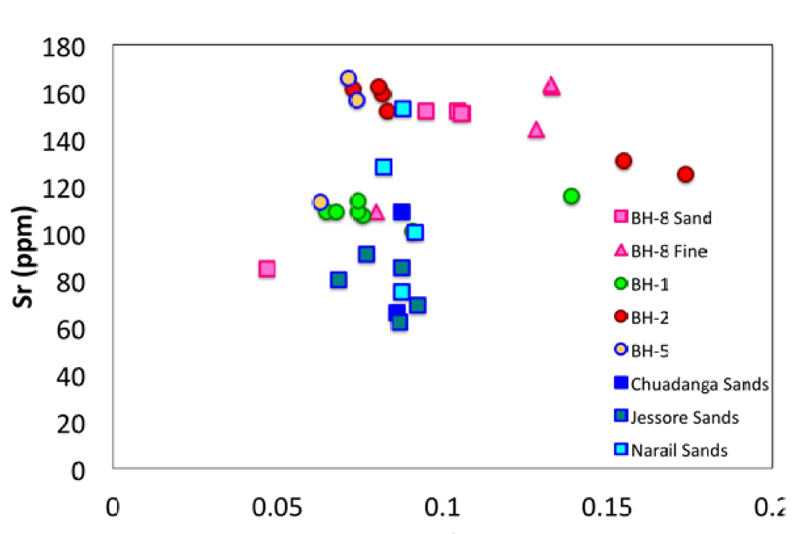
Ohta and Arai, 2007

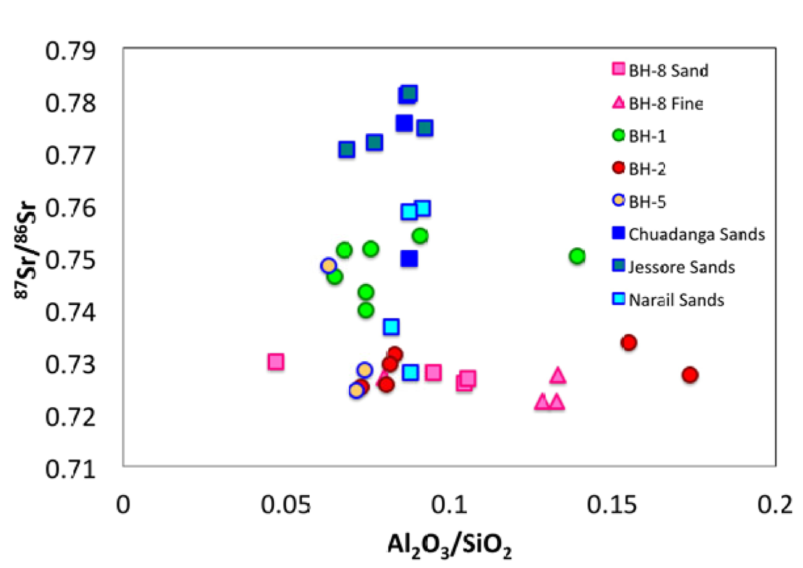


Bulk weathering indices indicate negligible to slight weathering for most of the Holocene delta sediments analyzed. Cases where sediments fall outside the fresh to incipiently weathered zones are typically bulk sediments with clay concentrations >20%. Predominantly sand and silt samples are essentially fresh and would therefore be expected to retain the geochemical nature of the source lithologies from which they were derived.



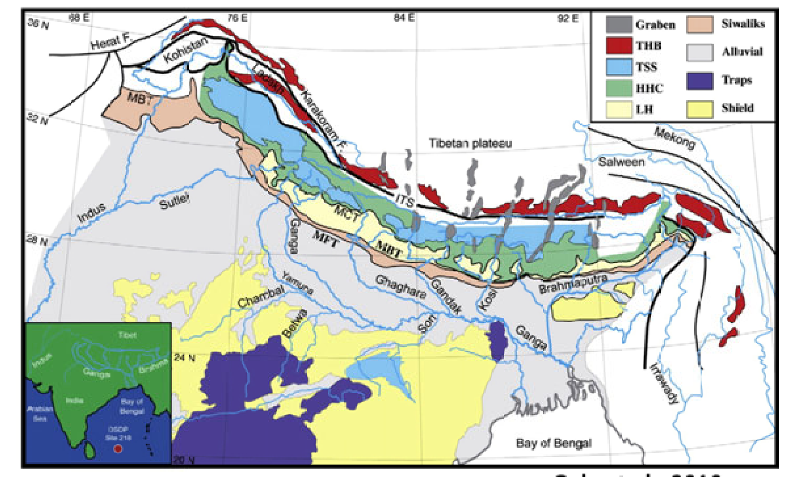
The bulk of Sr in the silicate fraction is carried by feldspars, with plagioclase making up >50% of the feldspar portion. Weathering of plagioclase (~450ppm Sr) can affect Sr concentrations of bulk sediment, but here the weathering is not significant enough to impact Sr provenance signatures.



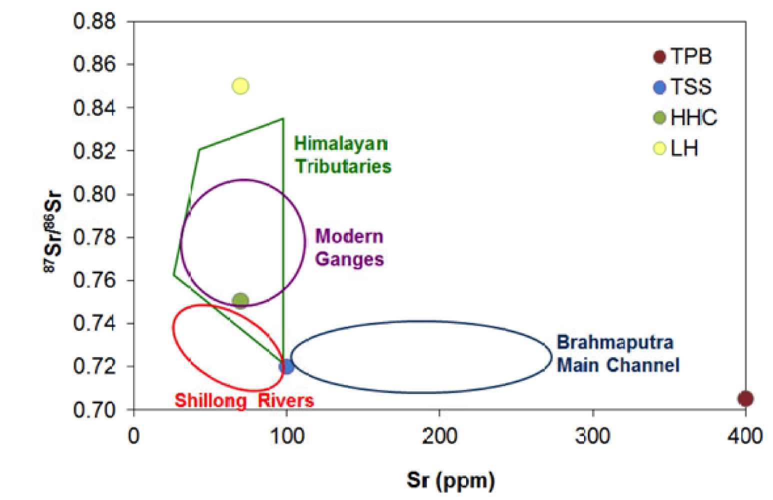


Partitioning of minerals between size fractions is also a concern with using Sr geochemistry to track provenance, but for Holocene sediments, this is not a factor. There is no trend found in $^{87}Sr/^{86}Sr$ with grain size. In the most extreme case shown, BH-2 displays some Sr loss with increasing Al content, but these samples are >30% clay and their proximity to current and historical shorelines introduces the possibility of offshore reworking. In any case, the [Sr] is still falls within Brahmaputra range along with the rest of the borehole. Therefore, weathering in the Holocene is not a concern for application of Sr geochemistry here.

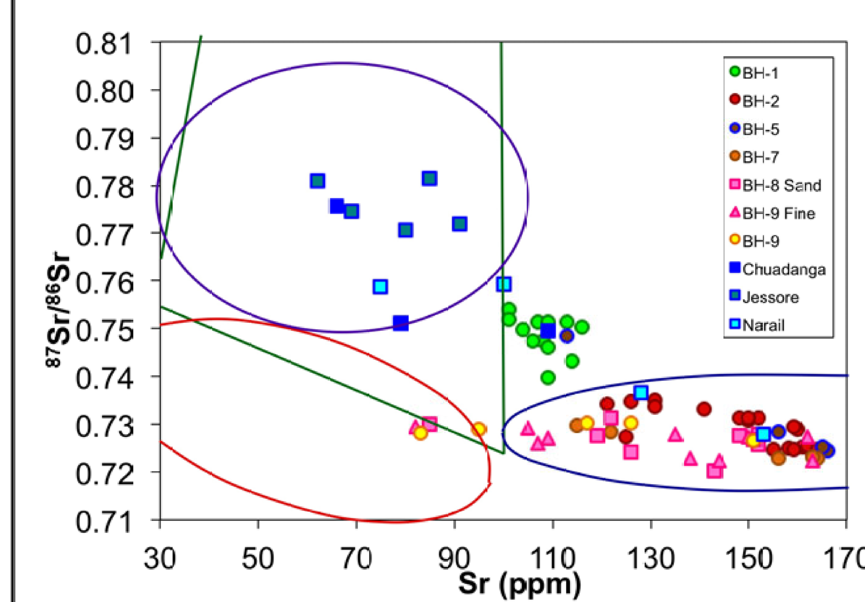
Provenance

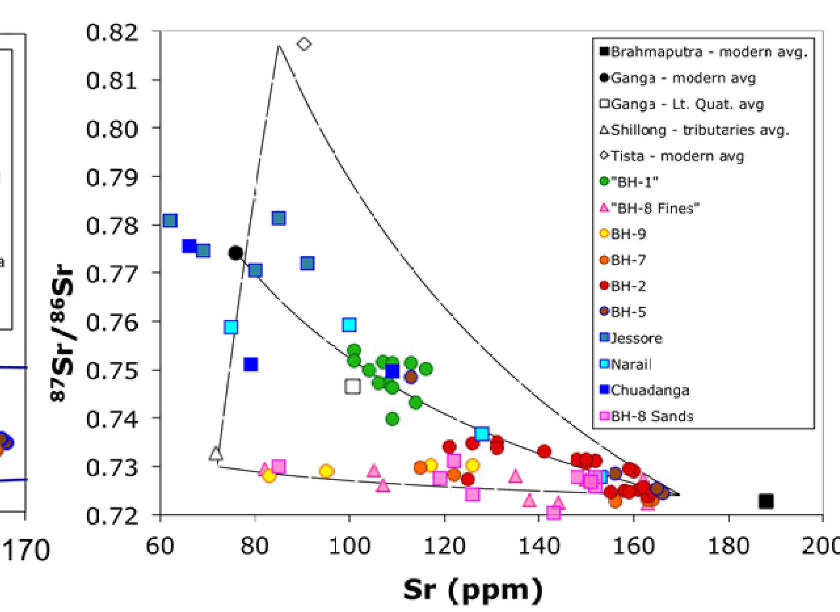


Galy et al., 2010

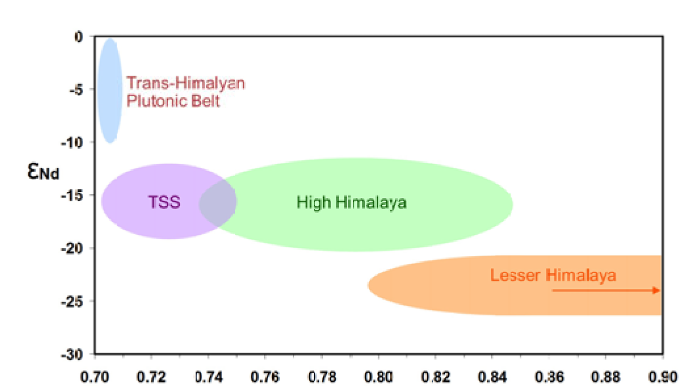


Himalayan source lithologies have distinct geochemical signatures. Modern Ganges sediments are derived primarily from High Himalayan Crystalline Rocks, while Brahmaputra sediments contain significant inputs from Tibetan sources as well minor inputs from the Shillong Plateau. These varied inputs result in unique bulk sediment Sr geochemistry that can be traced throughout sedimentary deposits across the delta.

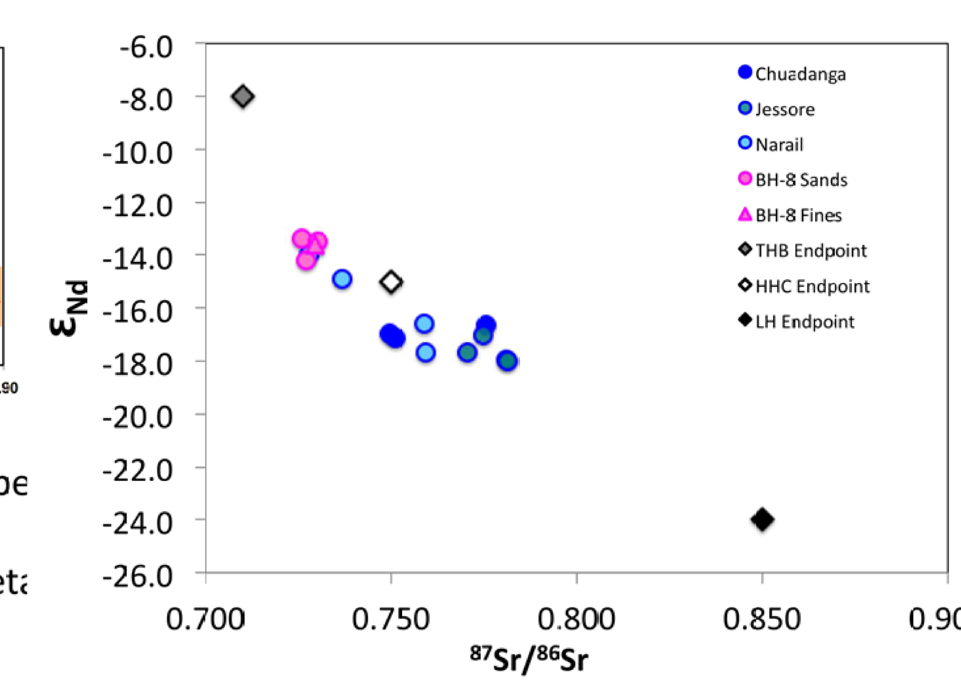


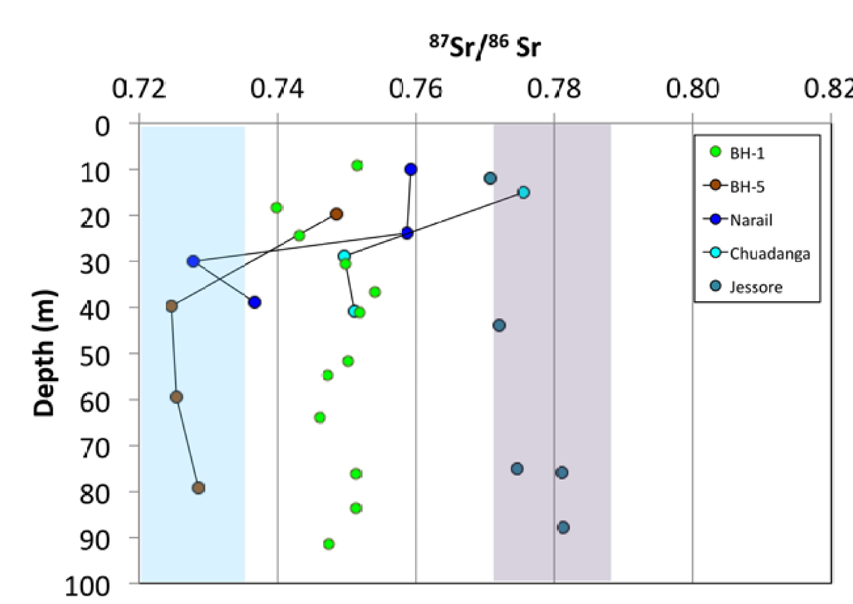


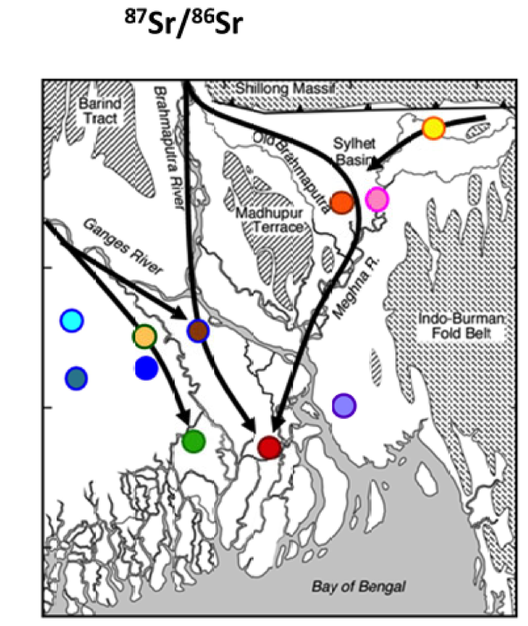
Sr geochemistry reveals great detail about sourcing of sediment throughout the delta. The Brahmaputra provides sediment to the eastern and central portions of the delta, while Ganges influence is limited to the western delta (with some mixing in the central delta). The Brahmaputra is responsible for more Holocene sediment deposition on the delta than previously estimated based on current flow paths. With such distinct end-members, mixing curves have been calculated so that even regions of mixed inputs can be more specifically characterized.



Sr findings are supported by Nd isotope as well, though analyses are more difficult to perform, and reveal less det[ail] than is found using Sr concentrations.

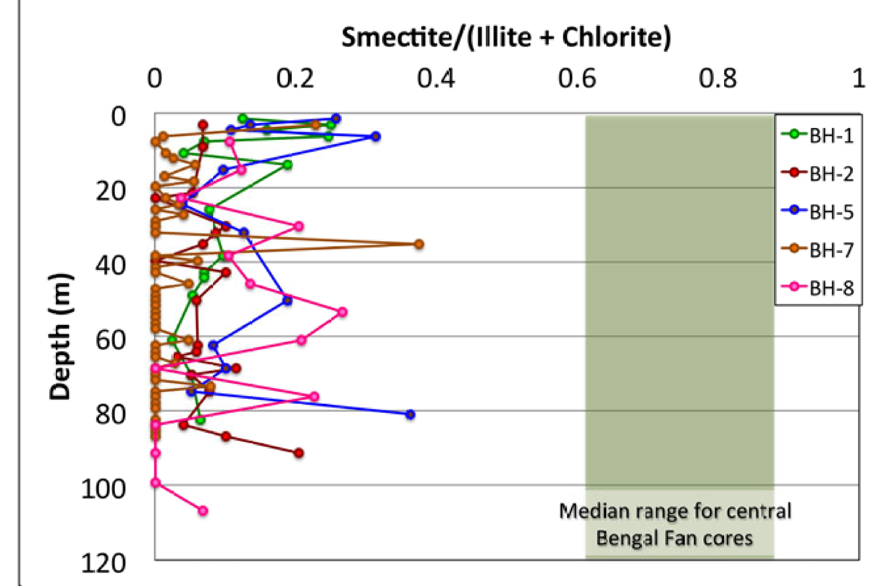






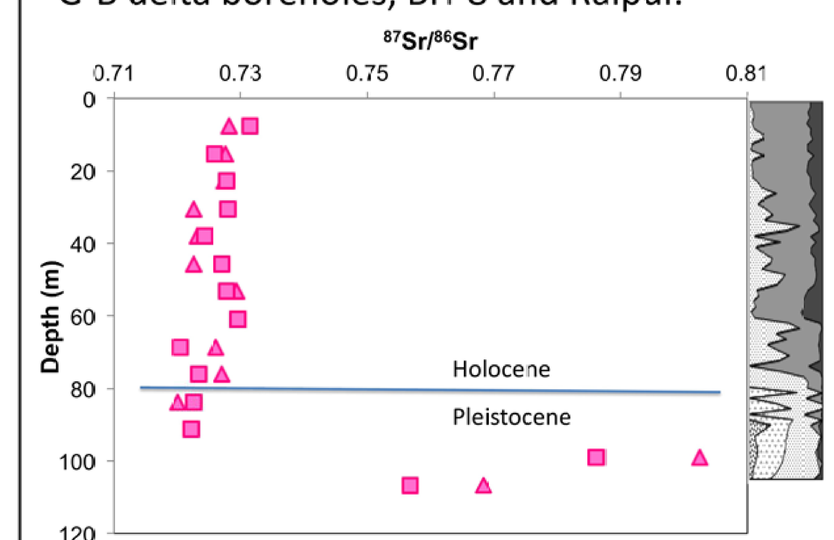
Looking at depth profiles, we can the migration and avulsion histories of the two rivers. In the Sylhet basin and parts of the central delta, the Brahmaputra has dominated Holocene sedimentation with occasional local inputs. We find evidence for Ganges sedimentation in the far Western delta and only recently in portions of the central delta. This shows the broad reach of the Brahmaputra throughout the Holocene and suggests previously unsuspected flowpaths through the delta.

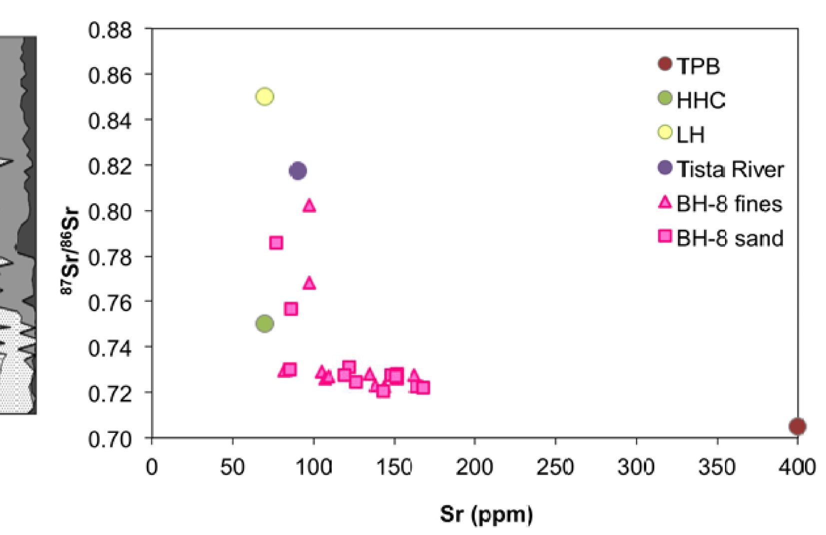
Source-to-Sink



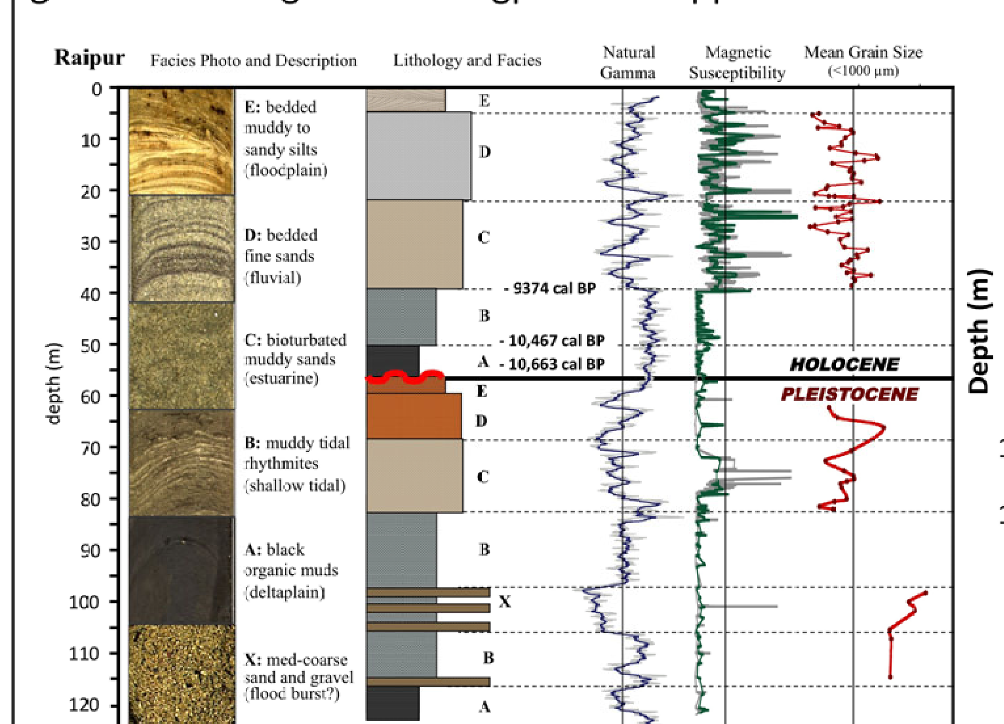
Relatively low smectite content of Holocene delta sediments shows that even the finest grained sediments do not carry significant weathering signatures. Variations in Bengal Fan clay mineralogy have been attributed to variations in weathering in catchment and floodplain regions. Lack of these weathered signatures on the delta indicates a partitioning of weathered signatures between on- and off-shore. depocenters

Bengal Fan studies suggest that the Himalayan erosional regime has remained stable for ~12 Ma. However, shorter-term broad-scale provenance variations are recorded on the delta that could aid in the interpretation of more recent and proximal fan deposits. In addition, the thick deltaic sequences are able to record more detailed source-to-sink processes such as glacial lake damming and possible flood bursts. Evidence for this is seen in two eastern G-B delta boreholes, BH-8 and Raipur.

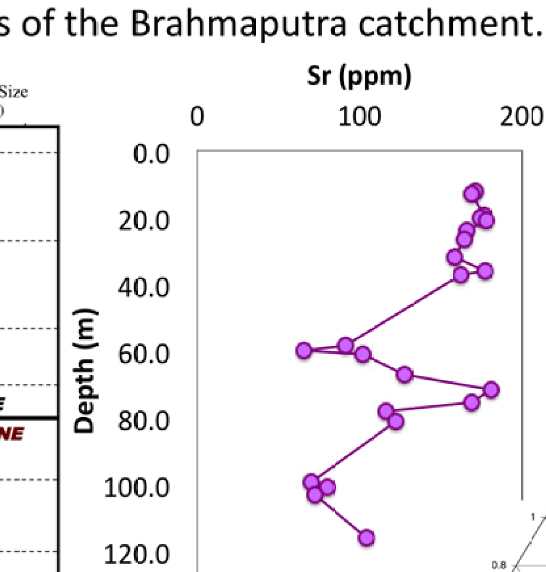


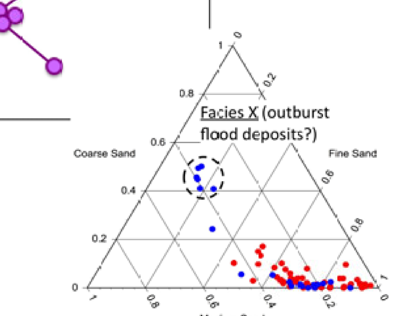


A significant provenance shift is noted a the base of BH-8 in the Sylhet Basin. These sediments of Late Pleistocene origin are distinctly coarser grained and much more radiogenic than any other throughout the rest of the borehole. The geochemistry suggests a sudden dramatic increase in Lesser Himalayan sedimentation, possibly derived directly from the Tista River, with a concurrent decrease in Tibetan sediments. The most likely explanation for this is glacial damming of the Tsangpo in the upper reaches of the Brahmaputra catchment.



Pate, Goodbred, and Khan, 2009





A similar event is captured in the Raipur borehole, downstream of BH-8 in the southeastern delta. At ~100m depth, Sr concentrations dip to 70ppm in a coarse-grained deposit, characteristic of Lesser Himalayan (Tista) sediments. The model for Tsangpo megafloods resulting from the release of glacial dams has been put forth my Montgomery et al. (2004) but this is the first evidence for these glacial lake dams in the downstream sedimentary record.

References

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