The $^{187}Os/^{188}Os$ record of Himalayan palaeorivers: Himalayan tectonics and ocean chemistry

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Significant debate exists on the role of the uplift and unroofing of the Himalayan mountain range on the chemical evolution of seawater, atmospheric CO_2 consumption and climate change. Weathering of silicate minerals as the Himalayas were uplifted would consume significant quantities of atmospheric CO_2, possibly sufficient to cool the earth's atmosphere (Raymo and Ruddiman, 1992). Variations in the $^{87}Sr/^{86}Sr$ record of the oceans has thus been used as proxy for the extent of silicate weathering of the high Himalayas during uplift, due to the large volumes of sediment carried by Himalayan river systems (e.g. Edmond, 1992). However recently, Quade *et al.*, (1997) has suggested that the source of Sr measured in Himalayan rivers are from carbonates (which do not consume CO_2 during weathering) from the foothills and lesser Himalaya. Therefore, the marine Sr record may not be a proxy for greater Himalayan unroofing, silicate weathering, CO_2 consumption or change in global climate.

Seawater $^{187}Os/^{188}Os$ ratios have undergone a rapid rise over the past 15 Ma (e.g. Ravizza, 1993). Currently debate exists as to whether this increase can be attributed in part to the increase in continental erosion due to Himalayan uplift, in analogy with the marine Sr isotopic record. The evolution of the osmium isotopic ratio of seawater provides another means of deciphering the relative contributions of continental weathering to the chemical evolution of seawater. ^{87}Sr and ^{187}Os are radiogenic daughter products of ^{87}Rb and ^{187}Re, respectively. Changes in the isotopic ratios of Os and Sr are therefore dependent on time and the amount of the parent isotope present, however Re and Os are hosted by different minerals than Rb and Sr. Thus combining the Os and Sr isotopic records, which are distinct geochemical and mineralogic systems, we can constrain the geologic process(es) that affect ocean chemistry and atmospheric CO_2 consumption.

Quade *et al*, (1997) focused on carbonates from palaeosoils of rivers draining the Himalayas and western Nepal. The palaeosoils form in floodplains

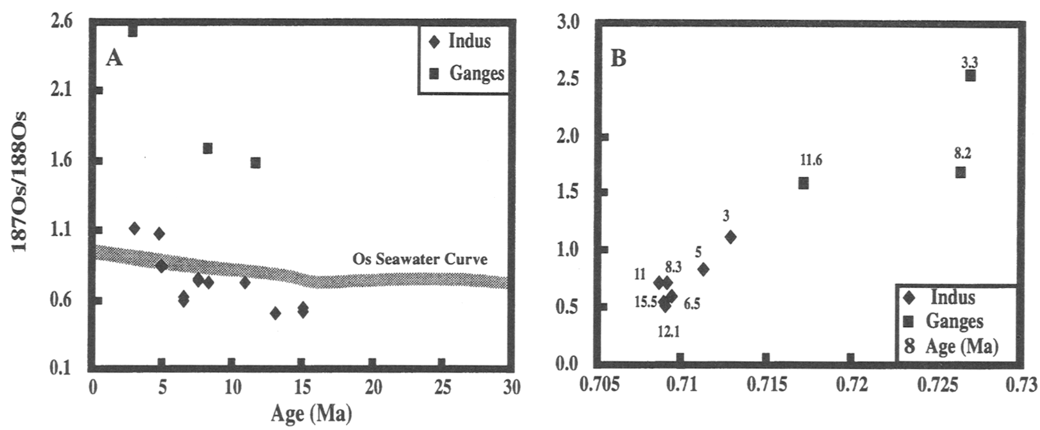

FIG. 1. A) Os isotopic values *vs* age for Mn nodules in palaeosoils from the Ganges and Indus Rivers. Os isotopic curve for seawater from Ravizza (1993). B) Os *vs* Sr isotopic ratios for palaeosoils from the Ganges and Indus rivers. Sr values are from Quade *et al.*, (1997). Numbers next to symbols are the ages of the samples in million years. Note possible correlation of Sr and Os from 6–3 Ma in the Indus and from 11–3 Ma in the Ganges palaeosoils, which may reflect the different unroofing histories of the two drainage systems.

leached by local rainwater, these soils also contain layers of Fe- and Mn-rich nodules. Because Os behaves in a similar manner to Mn, these palaeosoil layers are ideal candidates to determine the Os composition of waters entering the adjacent river through time and the source of the sediments in the floodplain. We have undertaken preliminary measurements on palaeosoils from several different stratigraphic sections from both Indus and Ganges drainage systems.

Re and Os concentrations range from 50 to 500 ppt and 15 to 500 ppt, respectively. Re/Os ratios vary from 1–30 and ^{187}Os growth from the time of sediment deposition only accounts for 0.01 to 1.5% in the initial isotopic ratio. Little variation is observed between Fe-oxide rich matrix and Mn nodules or samples that were treated with an acetic acid leach prior to analysis. These data can be used to suggest that the Os is homogenized and Re removed (thus stopping the isotopic clock) during formation of the palaeosoils. The preliminary data suggest that the Os isotopic ratios of the Ganges river are significantly elevated and may in part explain the rapid rise in seawater Os isotopic ratios at ~ 15 Ma. However, the $^{187}Os/^{188}Os$ isotopic record of the Indus river is lower than that of seawater through most of the Neogene (Fig. 1a). In addition, there appears to be a correlation of the Os and Sr isotopic records in the Indus drainage after 6 Ma and in the Ganges after 11 Ma (Fig. 1b), which may reflect the uplift, unroofing and exposure at different times.

The rapid growth of ^{187}Os and the preliminary data from the Himalayan palaeosoils point toward the potential use of the Re-Os system to address major questions regarding tectonic reconstruction, history of foreland basins and to help unravel the connections between mountain building, ocean chemistry and environmental changes.

References

Quade, J., Roe, L., DeCelles, P.G. and Ojha, T. (1997) *Science*, **276** 1828–31.

Ravizza, G.(1993) *Earth Planet. Sci. Lett.*, **118**, 335–48.

Raymo, M.E. and Ruddiman, W.F. (1992) *Nature* **359**, 117–21.

Edmond, J.M. (1992) *Science*, **258**, 1594–7.