Re-Os isotopic characteristics of Himalayan river sediments and source rocks

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The $^{187}Os/^{188}Os$ ratio of the oceans has increased markedly during the Cenozoic Era, particularly during the past 15 My (Pegram *et al.*, 1992; Peucker-Ehrenbrink *et al.*, 1995). Some authors attribute this rise to increased weathering caused by the Himalayan collision, in analogy with similar models proposed to explain the seawater Sr isotopic record. In order to test this hypothesis we analysed sediment samples from major rivers and several tributaries in Central Nepal and Bangladesh, as well as potential source rocks in the various formations of the Himalayan Range. The Re-Os extraction techniques described by Birck *et al.* (1997) were used for bulk sample analyses, while leachates were prepared using the procedure described by Pegram *et al.* (1992).

The Himalayan range can be divided into three main units. These are, from N to S: (1) the Tethyan Sedimentary Series (TSS), composed primarily of sediments of Cambian to Eocene age; (2) the High Himalaya Crystalline series (HHC), comprising mostly highly metamorphosed paragneisses and leucogranites; and (3) the Lesser Himalaya (LH), composed mainly of less strongly metamorphosed metasediments with Sr and Nd ratios indicative of very long crustal residence ages. In all three units, several sediment samples were collected in small river basins confined to single lithologic terrains. In the LH, sediments were also collected from larger rivers and thus include contributions from the lithologic units (TSS + HHC) further upstream.

The $^{187}Os/^{188}Os$ ratios (Fig. 1) of the analysed river sediments and rocks are quite variable. Nevertheless, we can distinguish several systematic features. (1) The TSS samples are rather unradiogenic ($^{187}Os/^{188}Os$ between 0.9 and 1.1 for the sediments, 0.7 and 1.4 for the source rocks) and have concentrations varying between 20 and 106 ppt. (2) The HHC rocks have $^{187}Os/^{188}Os$ ratios between 0.9 and 2.6 and HHC sediments, with ratios of about 1.7, indicate a rather radiogenic average composition. Os concentrations of both rocks and sediments are quite low, between 7 and 50 ppt. (3) The LH is very heterogeneous. $^{187}Os/^{188}Os$ varies from 0.7 to 3.0 among the sediments derived solely from this formation and from 1.4 to 7.8 among the rocks. The concentrations are also extremely variable, ranging from less than 10 to 500 ppt. Notably, the source rock samples that have the highest Os isotopic ratios, the organic-rich metasediments, also have the highest Os concentrations. (4) River bedload from major rivers draining the whole system have $^{187}Os/^{188}Os$ ratios between 2.0 and 4.0 and their composition appears to be essentially buffered by the contribution of the Lesser Himalaya erosion. (5) Three sediments from the Indo-Gangetic Plain were analysed. The single sample from the Ganges has a $^{187}Os/^{188}Os$ ratio (2.60) consistent with those of sediments collected in one of the major Ganges tributaries at the outflow of the Himalayan range, as well as with the Ganges leachate Os isotopic ratio measured by Pegram *et al.* (1994). In contrast, 2 samples from the Brahmaputra have Os isotopic ratios of about 0.6, which is lower than any value measured among the Central Nepal samples. The reason for the non-radiogenic nature of the Brahmaputra samples (loss of radiogenic Os, mineralogical sorting, or change in the composition of the Himalayan source rocks from west to east along the chain) remains to be clarified.

The highly radiogenic character of many river sediments, including those at the outflow of the range, can be explained by the addition of a small fraction (< 5%) of organic-rich sedimentary rocks with high Os concentrations and strongly radiogenic Os isotopic ratios to less radiogenic sediments derived from the HHC or the LH formations. Sr and Nd isotopic data indicate that the LH formation does not contribute more than 35% of the sediment bedload at the outflow of the range. Despite the limited volumetric input from this formation, LH black shales may have a disproportionately large

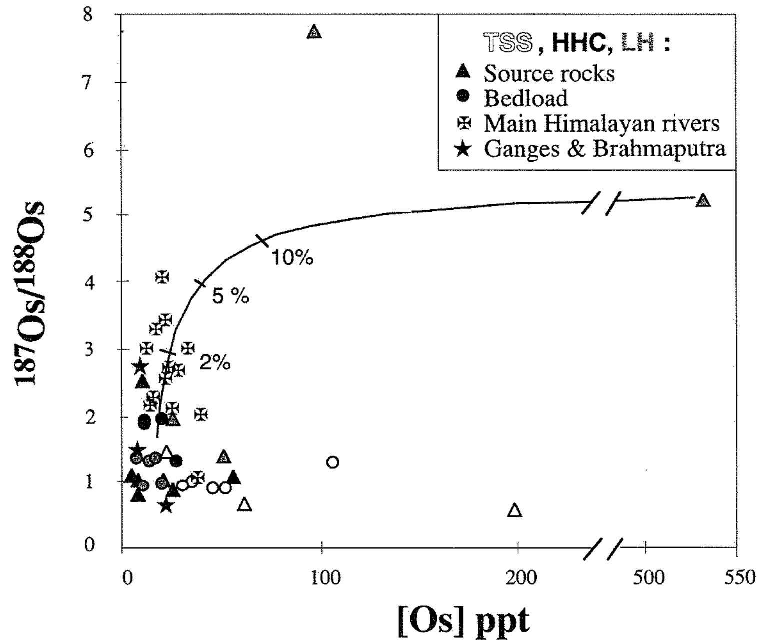

FIG. 1. Os isotopic compositions of sediment and rock samples of the Himalayan Range and Bangladesh vs their Os concentrations. Samples labelled "bedload" were taken from small rivers draining a single formation. Rock and bedload samples from the TSS are shown in white, those from the HHC are in black, and those from the LH in grey. Symbols labelled "Main Himalayan rivers" represent sediment bedload from rivers draining all three formations. Stars represent sediment bedload collected in Bangladesh from the Ganges and the Brahmaputra. The curve depicts mixing between average HHC sediment and a black shale from the LH formation.

influence on the Os isotopic composition of Himalayan-derived sediments. Simple leaching experiments suggest that the influence of such rocks on the labile Os budget may be even more important. Several rocks and sediments from each formation were leached by the technique of Pegram *et al.* (1992). The $^{187}Os/^{188}Os$ of the leachate was usually quite similar to that of the bulk rock. In most cases, a relatively small fraction (< 50%) of the bulk sample Os was released by leaching. However, essentially all of the Os contained in the two carbon-rich samples was released. Thus organic-rich samples, though volumetrically minor, may dominate the contribution of Himalayan-derived Os to the oceans and may partially explain the increase in the Os isotopic ratio of seawater over the past 15 My.

References

Birck, J.-L., Roy Barman, M. and Capmas, F. (1997) *Geostandards Newsletter* **21**, 19-27.

Pegram, W.J., Esser, B.K., Krishnaswami, S. and Turekian, K.K. (1994) *Earth Planet. Sci. Lett.* **128**, 591–9.

Pegram, W.J., Krishnaswami, S., Ravizza, G.E. and Turekian, K.K. (1992) *Earth Planet. Sci. Lett.* **113**, 569–76.

Peucker-Ehrenbrink, B., Ravizza, G. and Hofmann, A.W. (1995) *Earth Planet. Sci. Lett.* **130**, 155–67.