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Another Source of Radiogenic Os in the Himalayas: the Lesser Himalaya Carbonates

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The Himalayan Range is composed of three main formations. From N to S, these are: (1) The Tethyan Sedimentary Series (TSS), composed of Phanerozoic sediments, is characterized by non-radiogenic bedrocks and bedloads with $^{187}Os/^{188}Os$ = 0.6-1.9 and [Os] = 20-200 ppt. (2) The High Himalayan Crystallines (HHC), highly metamorphosed paragneisses and leucogranites, are the principal source of eroded material of the Range. Bedrocks have $^{187}Os/^{188}Os$ = 0.8-1.6, while bedload ratios = 1.1-1.8. (3) The LH formation consists of metasediments with ε_{Nd} values indicative of long crustal residence. $^{187}Os/^{188}Os$ = 0.7-3.0 in the bedloads and 0.9-15 in the bedrocks. The Os concentration also varies widely, from 7 to 3200 ppt. The highest Os isotope ratios are associated with the highest [Os], and are derived from black shales containing 6 to 10 wt% of black carbon. (Os data from Pierson-Wickmann et al., 2000).

Mass balance calculations based on isotopic composition and Os concentration indicate that 5% of LH black shales must be mixed with High Himalayan silicates to explain the $^{187}Os/^{188}Os$ of sediments. However this is inconsistent with the low proportions of black shale in the Lesser Himalaya and with the low organic carbon contents of these sediments. This suggests that another source of radiogenic Os may be present in the source rocks. A rough correlation between Os concentration and carbonate contents in the sediments suggested that this source may be composed of carbonates. The whole rock analysis of LH carbonates from both mines and outcrops, displays a wide range of $^{187}Os/^{188}Os$ ratios, from 0.4 to 193, with greatly variable Os concentration, from 9 to 188 ppt. The carbonates from the mines are the least radiogenic and least concentrated in Os ($^{187}Os/^{188}Os$ = 0.4 - 0.8, [Os] = 9 - 22 ppt). Carbonates from outcrops are moderately to highly radiogenic ($^{187}Os/^{188}Os$ =3-193) and often more concentrated (10 - 188 ppt). Many have ^{187}Os contents comparable to those of LH black shales.

The very high Os isotopic ratios of the carbonates in outcrop cannot be explained by simple in situ radioactive decay of ^{187}Re. In addition, marbles which are radiogenic in Os are also radiogenic in Sr. The highly radiogenic Sr ratios, which cannot be explained by *in situ* radioactive decay of ^{87}Rb, result from redistribution of ^{87}Sr during Himalayan metamorphism (Deniel, 1985). A similar process may explain the very high $^{187}Os/^{188}Os$ ratios. This suggestion is supported by observation that mine carbonates containing evidence of hydrothermal circulation in the form of phlogopite have higher Os isotopic ratios. One such sample, found in the proximity of a black shale, has a $^{187}Os/^{188}Os$ ratio of 11.6. Thus black shales may be the ultimate source of the radiogenic Os found in many of the LH carbonates.

The addition of radiogenic LH carbonates in the observed proportions (2 - 4%) as well as a small amount of black shale (0.5 - 1%) can explain Os isotopic ratios observed in sediments sampled at the range outflow and in the Ganga. As carbonates can be easily dissolved these rocks may be an important source of radiogenic Os in river water.

Pierson-Wickmann A-C, Reisberg L & France-Lanord C, *Earth Planet. Sci. Lett.*, **176**, 203-218, (2000).
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