Reactive transport modelling of $\delta^{88/86}Sr$ in Himalayan rivers to constrain the mechanisms, magnitudes and rates of secondary calcite precipitation

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Determining the silicate mineral contribution to the dissolved load of river waters is fundamental to evaluating the impact of chemical weathering on climate. In Himalayan rivers, increases in Sr/Ca ratios have been interpreted to imply that up to 80% of Ca is precipitated as secondary calcite[1,2], further complicating deconvolution of sources to the dissolved load. Precipitation of calcite fractionates both Sr/Ca ratios and stable Sr-isotopic ratios ($^{88}Sr/^{86}Sr$ ratios) with a kinetic dependence on precipitation rate[3].

Here we present the results of dissolved $\delta^{88/86}Sr$ measurements of Himalayan river waters which span 0.05 to 0.43 ‰ coupled with Sr/Ca ratios (0.2 to 3.8 mmol/mol) and calcite saturation states.

To evaluate the controls on these Sr-systematics by the precipitation of secondary calcites we present solutions to one-dimensional reactive transport models ranging from Rayleigh fractionation to coupled dissolution-precipitation[c.f. 4]. The latter avoids the implication of very high initial water Ca concentrations implied by Rayleigh fractionation. The $\delta^{88/86}Sr$ and Sr/Ca variations may be described by two dimensionless variables, the Damköhler number, which relates the carbonate dissolution rate to the fluid transit time, and the Sr/Ca and $\delta^{88/86}Sr$ fractionation factors during the precipitation of secondary calcite. Using the empirical relationship between the $\delta^{88/86}Sr$ and Sr/Ca fractionation factors of Shalev et al., [5], we show that the Rayleigh fractionation and dissolution-precipitation models predict different trajectories in plots of water $\delta^{88/86}Sr$ versus Sr/Ca ratios and may be used to constrain the kinetics of the precipitation reactions and the residence times of waters in the weathering regimes.

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