Chemical erosion in the Himalayas-Tibet for the past 4 million years studied by Pb and Nd isotopic stratigraphy

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A record of the ^{143}Nd/^{144}Nd ratio of Northern Indian Ocean seawater has been obtained for the past 4 Ma using a new method of differential dissolution on marine sediments. We studied ODP Sites 758 and 757 both located on the Ninetyeast Ridge. At Site 758, the ε_{Nd} and δ^{18}O curves fluctuate in conjunction during the glacial-interglacial periods. The largest variation occurred during the last 20 kyrs where ε_{Nd} varies from -7.5 at Last Glacial Maximum to -10.5 during the Holocene, whereas the amplitude of the variation of the seawater signal is less than 1 ε_{Nd} unit 2.5 Ma ago. The correlation between maxima and minima of ε_{Nd} and δ^{18}O is excellent (r=0.95). However, a detailed comparison of the two signals show that ε_{Nd} and δ^{18}O vary simultaneously during warming while ε_{Nd} is delayed with respect to δ^{18}O during cooling.

The southern ODP Site 757 shows little variations in Nd isotopic ratio. We thus interpret the ε_{Nd} fluctuations at Site 758 as being linked to the erosion regime in the Himalayas-Tibet rather than to variations in the intensity of the deep ocean conveyor belt which flows from the South to this area. A simple quantitative model assuming that seawater Nd is a mixture of Nd that was chemically eroded in the Himalaya-Tibet with Nd coming from Indonesian island arcs indicates that chemical erosion in the Himalaya-Tibet was 2 to 4 times more intense during interglacial than during glacial periods.

We have shown by chemical tests that the same technique of partial dissolution can be also applied for lead isotopes. At Site 758, the lead isotopes ratios fluctuate following glacial interglacial alternance, but within a very small range. Indeed, ^{206}Pb/^{204}Pb, ^{207}Pb/^{204}Pb, ^{208}Pb/^{204}Pb varies from 18.9 to 19.0, 17.73 to 17.77, 39.23 to 39.42 respectively. These variations are extremely well correlated suggesting a binary mixture. We suggest that the two component are the Trans-Himalaya-Belt and the High-Himalaya-Chain.

These results gives strong constrains on the enhancement of monsoon rainfall during Interglacials but also on the glacier occurrence in the Himalaya-Tibet highlands during glacials periods.

References

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Assimilation beneath Mid-Ocean Ridges: Cl and H_2O constraints

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Many submarine basalts have assimilated hydrothermally influenced material before they erupt. High Cl and Cl/K in mid-ocean ridge basalts (MORB), submarine ocean island basalts (OIB) and submarine back-arc basin basalts (BABB) are often correlated with Mg#, and suggest that altered rock or brine is involved. It is possible to constrain the H_2O/Cl of the assimilated material if it is assumed that mantle derived H_2O/Ce ratios are fairly constant at 180 – 250 for Pacific MORB and many Pacific OIB sources, and that mantle-derived Cl/K is fairly low; $\leq$0.06 in MORB and OIB. (Robust values for low-Cl MORB and OIB). The maximum H_2O/Cl ratio in assimilated material can be determined by subtracting Cl from basalt analyses to obtain mantle Cl/K values, and subtracting H_2O up to the amount where H_2O/Ce constraints are violated. This exercise works best using samples that have very high Cl/K >0.30, such that the mantle contribution is relatively small and the uncertainty on the mantle contribution to Cl is negligible. For samples from the Galapagos Spreading Center (GSC) 86°-92°W, many glasses have <0.4Cl/K<0.6. The maximum H_2O/Cl content that does not violate H_2O/Ce constraints is H_2O/Cl = 1.0. If low-Cl/K samples from the nearby Galapagos Platform can be used to more tightly constrain the mantle H_2O/Ce, then the best fit is obtained with H_2O/Cl=0: e.g., halite addition. The requirement of a very dense brine or halite means that assimilation involves rocks at very high temperatures, consistent with assimilation of a narrow magma-hydrothermal transition zone.