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A budget of the Himalayan orogenesis on the Global Carbon Cycle

C. France-Lanord (1), V. Galy (2), L. A. D. Derry (3), M. J. Evans (4), and M. Lupker (1)

(1) CRPG-CNRS, Vandoeuvre-les-Nancy, France (cfl@crpg.cnrs-nancy.fr), (2) Woods Hole Oceanographic Institution, (3) Cornell Univ. Ithaca, NY USA, (4) Wheaton College, Chemistry Dep. Norton, MA USA

The India-Asia collision induces major topographic and drainage evolutions at continental scale. As a consequence, dynamics of processes which control the carbon cycle are strongly modified. The development of the Himalayan basin generates major erosion fluxes that, through silicate weathering and organic carbon burial, tend to consume atmospheric CO2. Conversely, several processes tend to release CO2 to the atmosphere. This includes processes poorly documented such as CO2 degassing due to metamorphism of carbonated formations or oxidation of fossil organic carbon during erosion. In this synthesis we review the major processes involved and the present quantification that can be measured on the modern Himalayan basin or deduced from sedimentary archives.

Both silicate weathering and organic carbon burial can be quantified using sediments, however mineralogical sorting effects during transport exert a primary control on these parameters. The study of modern river sediments help to constrain these effects. Tracers of weathering intensity and total organic carbon content are well correlated to the Al/Si ratio. Normalisation to Al/Si ratio of sediments therefore allows inter-comparison of detrital sediments and quantitative approach. In the Himalayan basin, the transfer of organic carbon appears remarkable as the dynamics of the process is such that the exported organic matter is effectively buried in sediments of the Bengal fan [1]. For the past record of erosion, the comparison of Bengal Fan sediments in different locations of the fan reveals large variability that are primarily controlled by transport processes within the turbiditic system. Based on the modern and past budgets, the burial of organic carbon appears dominant over the CO2 uptake by silicate weathering. Unknowns remain on the efficiency of the silicate weathering, as most silicates in Himalaya are alkaline which does not favours long term CO2 uptake through further carbonate precipitation.

The Himalayan orogenesis also acts as a source of CO2 to the atmosphere. Erosion exposes to oxidation fossil organic carbon. While this process exists it is difficult to determine it's importance. Comparison of Himalayan source rocks and modern river sediment using 14C show that 70 to 50 % of the carbon initially present in the Himalayan rocks is oxydised to the atmosphere during the erosion cycle [2]. Another significant source is related to metamorphic decarbonation. Himalayan hot springs present in the most deeply incised valleys along the MCT reveal that significant release of metamorphic CO2 occurs. Dissolved Ge/Si ratios in the hot springs are among the highest reported (50-800 μmol/mol), and are 10-200 time those of the rivers. This allows to estimate the flux of these hot springs [3]. On the Central Nepal drainage, hydrothermal alteration contributes to more than 10% of the annual flux of silicate alkalinity. Evidences of direct degassing of CO2 have also been observed on some sites leading to significantly higher CO2 fluxes to the atmosphere [4].

While our knowledge remains insufficient on these processes, sedimentary records can be used to scale the relative importance of silicate weathering and organic carbon burial. Over the Neogene, a key issue is then to reconstruct past fluxes of erosion. This requires the combination of sedimentary record, geochemical proxies, and sediment accumulation volumes. Future drilling in the peri-Himalayan fans should provide better constrains in this scope.

[1] V. Galy et al., Nature, 450: 407-410.
[2] V. Galy et al., Science, 322: 943-945.
[3] M. Evans et al. 2008, G3 doi:10.1029/2007GC001796
[4] F. Perrier et al. 2008, EPSL doi:10.1016/j.epsl.2008.12.008