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Transport of particulate organic carbon in the Amazon River: insights from river sediment depth-profiles

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Burial of terrestrial organic carbon (OC) in marine sediments is a major sink of atmospheric CO_2 on geological timescales. The flux of riverine particulate OC (POC) burial is dependent on (1) its lability regarding oxidation processes during transport within rivers and in the oceans (2) its readiness to sink and to be buried in sediments once delivered to the oceans. Although sediment grain size can affect both these aspects, the importance of grain size on POC content, source and physical properties in river sediment remains largely unexplored on large tropical rivers, loci of high primary productivity and important particulate OC flux to the oceans.

Here we examine POC content and isotopic composition (δ^{13}C, Δ^{14}C) of river sediments from the large tributaries of the Amazon Basin (Brazil), sampled at various depths in the river channel, and complemented by bed sediment grab-samples. This sampling method allows to access the whole range of sediments transported by the river in terms of grain size, mineralogy and chemistry.

POC content increases drastically in the river channel (typically from 0.01% to 1.5%) from bed sediment to suspended sediment sampled at the channel surface. This increase of POC is related to an increase of the Al/Si ratio of the sediment, which serves as a proxy for grain size distribution and clay content (finer grain size and higher clay content at high Al/Si ratio). Normalized POC concentrations (e.g. POC/Th) indicate that dilution by quartz or other minerals has a major effect on POC content throughout the grain size range of sediment. Furthermore, surface specific area (SSA), albeit correlated with Al/Si in the Solimões and the Madeira rivers, is weakly correlated with POC content. This observation suggests that SSA does not exert an overwhelming control on OC content in Amazon River sediments, and that an additional control by mineralogy (i.e. the assemblage of clay minerals) or transport of OC as free particles are needed to explain the observed patterns, as previously shown on the Ganga-Brahmaputra system [1].

δ^{13}C values range from -29.0‰ to -27.6‰ in the Solimões suspended load and from -28.3‰ to -26.5‰ in the Madeira River. Bed sediment display on average higher δ^{13}C (between -27.2‰ and -26.0‰). δ^{13}C of bed sediment in the Madeira River is well explained by a mixture between fossil, or petrogenic OC derived from Andean bedrock, and biospheric OC harvested from current ecosystems of the Amazon Basin. A mixing equation is used to determine the isotope composition of the biospheric pool, averaged over the whole water column. Comparison of this average δ^{13}C value with the grain size-dependent values for individual samples allows to discuss the sources of POC in large tributaries of the central Amazon River.

Δ^{14}C values of sediments collected along depth-profiles decrease drastically with depth of sampling. A binary mixing model yields values for: (1) the absolute concentration of petrogenic OC and, (2) the age of biospheric OC. The result indicates a significant contribution of petrogenic OC to the riverine OC exported by the Amazon River, most of which is degraded during transport within the river system [2]. Furthermore, biospheric OC exported by Rivers in the Amazon basin is significantly pre-aged. In the Amazon mainstem near mouth, at Óbidos, biospheric OC is on average 1.2 kyrs old, constituting an estimate of the average age of biospheric OC in the basin.

[1] Galy et al., Geochim. Cosmochim. Acta, 2008

[2] Bouchez et al., Geology, 2010