TIMESCALES OF TERRESTRIAL ORGANIC CARBON EXPORT TO THE BENGAL FAN

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The timescales of terrestrial organic carbon transport to marine sediments is a key uncertainty in the global carbon cycle. Furthermore, quantifying continental storage and transport timescales is essential to identifying distortions in terrestrial biomarker records. Soils, floodplains, and wetlands can store organic carbon for hundreds to thousands of years, while bedrock can leak fossil carbon to rivers. A fraction of organic carbon stored in continental reservoirs is ultimately deposited in marine sediments. Previous work demonstrates that terrestrial organic matter supplied by rivers to the ocean has a spectrum of ages (e.g., Kusch et al., 2010; Galy and Eglinton, 2011), but the exact age structure of terrestrial organic matter in marine sediments is not well constrained. The Bengal Fan is an ideal locality to quantify timescales of continental storage and riverine transport due to the catchment area of the Ganges-Brahmaputra river system, high sedimentation rates, and efficient organic matter preservation. Using nuclear bomb-derived carbon as a tracer, compound-specific ^{13}C and ^{14}C analyses are coupled with numerical models to place constraints on the age structure of terrestrial organic carbon deposited in the Bengal Fan and organic carbon turnover timescales in the Ganges-Brahmaputra catchment area.

Leaf-wax fatty acids were extracted from a Bengal Shelf sediment core, which was determined to span 1946 to 2003 AD according to ^{137}Cs analysis and tempestite correlations. The fatty acid $\delta^{13}C$ and carbon preference indexes are consistent with continental sources. The fatty acid $\delta^{13}C$, Al/Si ratios, $^{87}Sr/^{86}Sr$ ratios, and εNd data support a stable erosional source over the sampling interval. The bulk organic matter and the fatty acids record the ^{14}C spike, but the magnitude of the isotopic excursion is smaller and lags the atmospheric signal. These results demonstrate that fast- and slow-cycling sources contribute fatty acids to the fan complex. The slow-cycling component is depleted in radiocarbon relative to the fast-cycling component because of radioactive decay and formation primarily before nuclear weapons testing. As a result, the slow-cycling component dilutes the contribution of the ^{14}C-enriched fast-cycling component.

A two-component isotope-mixing model was constructed to quantify the ages and fractional contributions of the fast- and slow-cycling components. Rather than assigning a discrete age to each of the components, normal gaussian age distributions were used to characterize the fast- and slow-cycling components. The median (μ) and standard deviation (σ) of each distribution are varied for each simulation to test narrow age and broad age distributions centered on the deposition age or earlier. The radiocarbon composition of each component is determined by integrating over the atmospheric ^{14}C time series corresponding to the time domain of the gaussian age distribution and correcting for radioactive decay. A range of age distributions were tested where the average ages ranged from 4 to 101 years for the fast-cycling component and 199 to >50,000 years (i.e. radiocarbon dead) for the slow-cycling component. Measured fatty acid radiocarbon time series were compared to synthetic radiocarbon time series that were generated from combinations of modeled fast- and slow-cycling components.

According to the numerical modeling, a mixture of decadal organic carbon with an average age between 14 and 24 years and millennial organic carbon with an average age between 940 and 1531 years best approximates the measured leaf-wax fatty acid radiocarbon time series. The relative contribution of millennial organic carbon ranges from 60 to 90 %, with longer chain lengths having a larger millennial relative contribution. These results demonstrate that successive periods of storage in continental reservoirs, such as soils, and remobilization of sediments from the upland regions to the river delta pre-ages a majority of the terrestrial organic matter exported to the Bengal Fan.

References

Galy and Eglinton, 2011. Protracted storage of biospheric carbon in the Ganges-Brahmaputra basin. Nat. Geoscience 4, 843-847.

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