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The isotopic composition of particulate organic carbon in mountain rivers: The role of fossil organic carbon

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Erosion of particulate organic carbon (POC) from the continents and its delivery to the oceans by rivers is an important component of the global carbon cycle. Rivers draining tectonically active regions are thought to play a significant role in this transfer because of the link between the erosion of POC and clastic sediment. These rivers have very high sediment yields and the highest measured POC yields. Coastal regions that receive large volumes of sediment tend to have high offshore accumulation rates and in these settings the efficiency of organic carbon burial can be high. If the POC is derived from the terrestrial biosphere then its deposition and preservation represents a sink of atmospheric carbon dioxide. In the geological record, its burial can provide a record of the past composition of terrestrial organic matter from which changes in the size and composition of global carbon reservoirs can be inferred with the help of stable carbon isotopes.

A growing body of work suggests that a significant proportion of the POC in high yielding rivers draining mountain belts is not sourced direct from the terrestrial biosphere, and instead derived from sedimentary bedrock. In these settings erosion removes material from hillslopes and channels which contains fossil organic carbon that has not undergone complete oxidation upon exhumation. If this fossil POC is re-buried in depositional environments it has no net impact on atmospheric carbon dioxide at that time. In addition, if one assumes all organic carbon present in a sedimentary deposit was contemporaneous (non-fossil POC) at the time of burial then there may be bias in using its composition to reconstruct the geochemistry of past environments. For example, at present if a proportion of fossil POC exists in an accumulation of sediment then its stable isotopic composition may vary over more than 5 permil solely dependant upon the age of the rocks exposed at the surface.

We present a detailed characterisation of POC in the mountain rivers that drain the Central Range, Taiwan. We investigate the range in the stable carbon isotopes, nitrogen to organic carbon ratio and the stable nitrogen isotopes of river suspended sediment, with an aim to determine the processes influencing their variability. We observe considerable heterogeneity in the carbon isotopic composition of fossil organic matter contained in bedrocks and river bed materials. Based on observations from our data, we present an end member mixing model that accounts for a variable fossil POC composition while quantifying the proportion of riverine POC derived from fossil sources and that from the terrestrial biosphere (non-fossil sources). Radiocarbon is used as an independent constraint upon which to test the model. We find that fossil POC dominates the suspended load sediment and induces a $\sim$5 permil range in the stable carbon isotopes of riverine POC in Taiwan. We proceed to examine the implications of incomplete oxidation of fossil organic carbon in this landscape on the compositional variability of POC exported to the ocean from Taiwan and discuss its wider implications for the sedimentary record.