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Factors affecting the short-term fate of organic carbon in marine sediments: evidence from stable isotope enrichment studies

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Deliberately enriched levels of uncommon stable isotopes can be powerful tools, allowing the tracking of natural chemicals and processes in the environment. In this presentation a series of experiments from the Pakistan margin are described in which organic matter with enriched levels of ^{13}C was used as a tracer for C-cycling in marine sediments. The results of these experiments will be compared with other such experiments from a wide range of marine settings, allowing suggestions to be made about the likely pattern of sedimentary C-cycling in unstudied regions.

^{13}C tracing experiments all share the same structure, in which algal detritus containing a greatly enriched level of ^{13}C ($\sim$15-80 % compared to the natural 1.1 %) is added to the sediment water interface (either in cores or in situ). Following incubation for days to weeks, sediment samples are sectioned, and the sediment, fauna and porewaters are separated. Analysis of these different components for their ^{13}C contents then allows quantification of carbon uptake by metazoan macrofauna, foraminifera and bacteria, as well as total community respiration, and physical mixing of the sediment.

^{13}C tracing experiments conducted across the Pakistan margin oxygen minimum zone, together with those conducted in a range of other marine settings, reveal that the impact of biological activities on benthic C-cycling varies markedly among sites exhibiting different seafloor conditions. Variations in site environmental conditions are proposed to explain the considerable variations observed in C-processing patterns. Three categories of C-processing pattern are identified: (1) Respiration dominated, where respiration accounts for $>75\%$ of biological C-processing, and uptake by metazoan macrofauna, foraminifera and bacteria are relatively minor processes. These sites tend to be cold and deep, with relatively low inputs of organic carbon and relatively low-biomass metazoan macrofaunal communities; (2) Active faunal uptake, where respiration accounts for $<75\%$, and metazoan macrofaunal, foraminiferal and bacterial uptake each account for 10-25% of biological C-processing. This type is further split into metazoan macrofaunal- and foraminiferal-dominated situations, dictated by oxygen availability; and (3) Metazoan macrofaunal uptake dominated, characterised by metazoan macrofaunal uptake accounting for $\sim 50\%$ of biological C-processing, due to unusually large biomasses of the phytodetritus-consuming animals