SMALL ORGANISMS ON THE SEA FLOOR: UNDERSTANDING PATHWAYS OF CARBON IN THE OCEANS

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The deep ocean appears hostile to life: dark, cold, and very little food, but it is home to diverse, though little known, life forms. Food is derived from photosynthesizing algae in surface waters that settle down through the water column to the deep ocean floor. Many organisms consume this material on its way down, and less than 1% of the algae from the surface waters actually reach the sea floor. Biological oceanographers have established that there is a strong linkage (bentho-pelagic coupling) between food-producers in sun-lit surface waters and the abundance and species composition of deep-sea bottom animals (benthos), such as the unicellular benthic foraminifera.

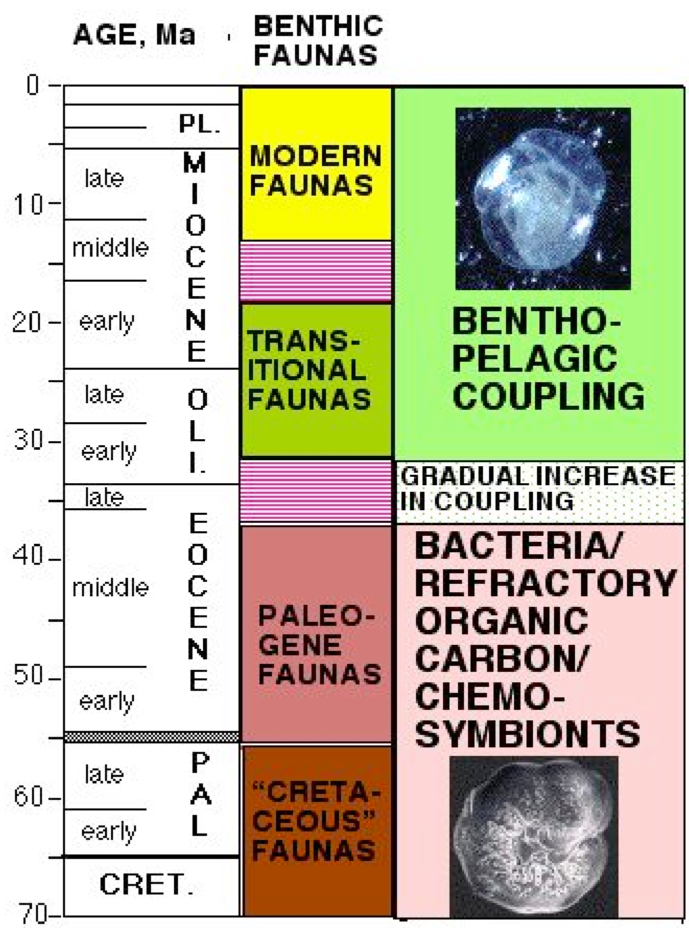
ODP has provided information on whether such coupling was important during "Greenhouse World"– times (between 50 – 70 million years ago), when deep-water temperatures averaged 8 - 12°C and metabolic rates of benthos were thus much higher. If oceanic surface productivity had been similar to today's, bottom-dwelling faunas would have appeared to be inhabiting an environment with low nutrient levels at these higher rates of living. Against this expectation, the Greenhouse Ocean bottom species look like present faunas that live at high nutrient levels, even though floral, faunal and geochemical data suggest that Greenhouse World surface productivity was lower than today's productivity.

In another twist, deep-sea benthic foraminifera did not show significant extinction levels at the Cretaceous/Tertiary boundary (65 million years ago), when surface productivity collapsed. It thus looks as if the bottom-dwelling foraminifera living in the Greenhouse World were not analogous to present faunas. Common recent deep-ocean species appeared during the establishment of the Antarctic ice sheet (~33.5 Ma), and have no morphological counterparts in older sediments. Species groups common in the Greenhouse World declined after the establishment of ice sheets, and became extinct in the last few millions of years; they have no Recent morphological counterparts (Hayward, 2001).

The Greenhouse World faunas are thus not true analogs of faunas in the present, cold deep-oceans, where phytodetritus (algal material from the surface waters) is deposited in little-altered, fresh form to the sea floor and used by opportunistic species. The lack of evidence for strong bentho-pelagic coupling in warm oceans might be explained by the existence of different processes of carbon transfer from surface to deep oceans than in cold oceans, or by a greater importance of primary productivity of food on the ocean floor itself, by chemosynthetic bacteria, i.e. organisms not dependant on sunlight.

We do not know which (if any) of these possible answers is correct, but Recent and future ODP drilling (e.g., Shatsky Rise, Paleogene transect, Walvis Ridge, Demerara Rise) can be expected to increase our understanding of the non-analog worlds of the past and help gain improved insight in the transfer of organic carbon from the surface to the deep ocean, a process of major importance for understanding the fate of atmospheric carbon dioxide (CO_2.)

Figure: Speculative overview of structural changes in deep-sea faunas over the last 70 million years.



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