Geophysical Research Abstracts
Vol. 12, EGU2010-11493, 2010
EGU General Assembly 2010

Marine carbon cycling following end Cretaceous extinction

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Knowing how the transport of particulate organic carbon and associated nutrients into the ocean interior is controlled, is a prerequisite to reliable predictions of future changes in marine carbon cycling as the circulation and carbonate chemistry of the oceans are perturbed. Multiple mechanisms for particulate organic carbon transport have been proposed, most commonly based on sediment trap observations. Yet these observations primarily provide evidence for correlations between fluxes rather than being able to pin-point any particular mechanism. Despite this, global models tend to adopt one or other mechanism (e.g., ballasting) without independent justification. The geological record may help, as the evolution of pelagic ecosystems through the Phanerozoic has seen the emergence of animals (faecal pellets) and silicification and calcification of planktic organisms (ballasting), with evolutionary innovation fundamentally altering the nature of the oceanic biological pump. Moreover, catastrophic and transitory events, in which pelagic ecosystems were temporary disrupted, altering and biological pumping mechanisms, produced a tell-tale marine geochemical signature than may help elucidate the working of the biological pump.

Here we focus on the bolide impact at the Cretaceous-Palaeogene boundary as it induced an enigmatic 'collapse' in surface-to-deep carbon isotope (d13C) gradients, previously interpreted as representing a complete cessation of biological productivity and/or carbon pumping. Contemporaneous with this was a pronounced extinction of planktic calcifiers, resulting in an order of magnitude reduction in carbonate burial in deep-sea sediments. On face value, no (or little) carbonate ballasting and only a minor possible importance for dust together with ceased organic carbon transport to depth, is consistent with the existence of a dominant (carbonate) mineral ballasting mechanism prior to the event. However, a collapsed surface-to-deep d13C gradient does not imply a cessation of the biological pump as the solubility pump impacts a counter gradient. Using an Earth system model we show that a weakening in organic matter transport to depth of no more than 60-70% is needed to explain the isotopic observations. A corollary is that a minimum 30-40% of sinking organic matter reaching the deep sea does not depend on carbonate mineral ballasting.