

The last global extinction of deep-sea foraminifera during the mid-Pleistocene Climate Transition

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The deep-ocean floor is considered to be the most stable habitat on Earth. It is one of the three highest biodiversity ecosystems on Earth, alongside coral reefs and tropical rain forests, but it is the only one that can offer insights into the evolution of its biota through an excellent fossil record. Benthic foraminifera (Protista) are the main constituents (more than 50 %) of the total eukaryotic biomass at water depths deeper than 1000 m, thus their fossil record can provide us with evidence about how the sea-floor biota has evolved in response to changes in the deep-sea and globally. During the mid-Pleistocene Climate Transition (MPT, 1.2-0.6 Ma) the last and most recent period of enhanced extinction of cosmopolitan bathyal and abyssal foraminifera has occurred worldwide. Our global study on 22 well-dated deep-sea core sites bathed in various watermasses in different parts of the world's oceans has documented the disappearance of nearly 100 species of deep-sea fauna since the late Pliocene. In the late Pliocene major changes in sources, circulation and character of global deep water started to be significant, and culminated in the major changes of the MPT. Over several hundred thousand years during the MPT, species progressively pulled out from the deeper waters (deeper than 3000 m) followed later from intermediate water depths (600-3000 m), particularly in glacials, and they survived the longest at locations furthest downstream from the production area of intermediate water. We have suggested that increased dissolved oxygen in colder bathyal and abyssal water formed during glacials in association with change in Earth's climate may be responsible, but would this have been truly global and permanent to have prevented recolonisation from refugia? Unlike the well-known previous catastrophic extinction events occurring in oxygen-depleted warmer deep-sea environments at the Paleocene-Eocene Thermal Maximum (lost ca. 50 % of the deep-sea foraminiferal diversity), this youngest severe decline and extinction event influenced only three foraminiferal families (ca. 20 % of the diversity) that were characterised by elongate test morphology with specialised nature of the apertures (e.g., cribrate, necked with a single tooth, crenulate, hooded with two peg-like teeth, or small and circular). These morphologies may provide a clue to the cause of their extinctions, because these morphologies were likely related to a microhabitat and a particular kind of feeding to capture a specific food source, to which the extinct foraminifera had become highly adapted.