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Planktic foraminiferal dwarfism and upper water column disruption at the ETM2 in the Tethys realm

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During the long term early Paleogene warming our planet experienced several short-term (∼40–200 kyr) global warming episodes, now referred to as hyperthermals. Considerable scientific efforts have focused on understanding hyperthermals, especially the iconic Paleocene-Eocene thermal maximum (PETM, ∼56 Ma) that has even been suggested as an outstanding past analogue for understanding current and future climate change. This is because several hyperthermals were clearly associated with massive input of carbon to the ocean and atmosphere. However, the effects of these climatic perturbations on biotic communities and environments still need to be fully constrained.

Here we present an integrated geochemical (stable carbon and oxygen isotopes) and planktic foraminferal record from the Madeago section (Venetian Prealps of northeast Italy). This section deposited in a middle-lower bathyal setting of the Belluno Basin, a key area of the central-western Tethys. It contains a marly-clay unit (MU) that interrupts the prevailing carbonate sedimentation. The planktic foraminifera and calcareous nannofossil biostratigraphic framework allow us to relate the MU and associated carbon isotope excursion (CIE) to the hyperthermal Eocene Thermal Maximum 2 (ETM2, ∼ 54 Ma).

Our record on planktic foraminiferal assemblages shows significant, though transient, changes across this event, indicating abrupt episodes of environmental perturbations. Variations consist of marked increased in warm indices, surface-dweller acarininids and decline of chiloguembelinids and deeper-dweller subbotinids. The chiloguembelinids and subbotinids decline may have been a consequence of upper water-column destratification, whereby intermediate waters warmed relatively more than the surface waters. Moreover, it is known that elevated ocean temperatures enhanced the bacterial respiration rate and remineralization. This results in more efficient recycling of carbon and nutrients higher in the water column. A shallower and efficient bacterial remineralization would have contributed to an upward shift in the oxygen minimum zone while food supply at depth resulted restricted inducing shrinkage of the deeper dwelling niches in the sub-surface waters and lower thermocline. Both subbotinids and chiloguembelinids, which are recognized as eutrophic and colder taxa, thus may have suffered of reduced food supply besides the warmer temperatures.

An extraordinarily pronounced dwarfism (up to almost 50% of reduction) of planktic foraminiferal tests, both surface- and deep-water dwellers, occurred at Madeago during the ETM2. Causes explaining the reduced size in fossil organisms are manifold, and they may include collapse in primary production, changes in salinity and temperature, decrease in oxygen levels and loss of symbiotic relationship (bleaching). Whether transient bleaching could explain the morozovellid and acarinid dwarfing it cannot justify the reduced size of the asymbiotic subbotinids. Several different environmental, climatic and ecological triggers may result in the same phenotypic response and it is problematic to determine precisely the main factor responsible for the transient dwarfing in the study case.

Interestingly, our data demonstrate that biotic and environmental recovery rates were slower with respect to the carbon cycle since planktic foraminiferal disruption, included dwarfism, persisted during the CIE recovery phase. This has important repercussions in view of the current carbon-cycle anthropogenic disruption.