The ETM2 in the Tethys Realm: Extreme Planktic Foraminiferal Dwarfism

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Pronounced warming in the geological record negatively impacts ecosystems. To show the impact on different parts of the marine calcareous plankton, we present an integrated record, from two Tethyan sections, Madeago and Terche (northeastern Italy), of the planktic foraminiferal and calcareous nannofossils response to the Eocene Thermal Maximum 2 hyperthermal (ETM2, ~54 Ma). The main result of our study is the striking planktic foraminiferal dwarfism (up to ~40% decrease in test-size compared to pre-event values) recorded at the ETM2 impacting both surface and deeper dwelling species. To a lesser extent, calcareous nannofossils exhibited a size reduction as documented by an increase of ‘small placoliths’.

Causes to explain the dwarfism can be manifold. Enhanced metabolic rate in response to warming requires more food to support growth, thus a strategy to optimize resource uptake is to enlarge surface area/volume ratio by reducing the cell mass and therefore the test-size. Deoxygenation is not likely a driver as the dwarfing occurred in both mixed layer than deeper dwelling taxa, which oxygen limitation typically limited to the thermocline. Our foraminiferal size data from Site 1263 (Atlantic Ocean) and Site 1209 (Pacific Ocean) highlight that the pronounced dwarfism is restricted to the Tethyan area. We record local increase in productivity in our sections not observed in the open ocean sites. This could have limited the growth of symbiont bearing taxa, as in modern ocean the size of symbiont bearing taxa decreases towards to shore due to increases in productivity reducing light availability. Reduced symbiosis though cannot be the only factors as it cannot explain the dwarfing of the deep-dweller taxa in our Tethyan sections. The warming at our site is similar to open ocean sections and cannot explain this different response. Therefore, we hypothesise that local drivers could have acted additively to warming such as the input of biolimiting/toxic metals from the volcanic emissions of the Veneto Volcanic Province, which was active during the ETM2. We find the smallest size in close temporal association with peaks in magmatic derived Hg/Th-Hg/Rb recorded just before and at the ETM2 which cannot be brought into our sections through weathering. The lack of dwarfisms associated with Hg peak above the ETM2 at Terche, when warming would have ended, suggests that the volcanic input by itself was not sufficient to cause dwarfism. We speculate that volcanism could have acted synergistically causing the uniqueness of dwarfism in the global context of warming. The size reduction lasted several thousand years thus implying long term impacts of such additive drivers.