

Rates of change over Oceanic Anoxic Event 2: a high-resolution $^3\text{He}_{\text{ET}}$ timescale through the Bonarelli Level, Umbria–Marche, Italy

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The concentration of extraterrestrial ^3He measured in pelagic sediments may be used as a proxy for sedimentation rate, allowing the construction of high-resolution timescales over “short” geological intervals (100s kyr), with temporal resolution in theory limited only by sampling resolution. This technique provides not only a novel method for estimating the duration of these events, but allows rates and durations to be attached to the environmental shifts indicated by changing styles of sedimentation or changing geochemical records. A $^3\text{He}_{\text{ET}}$ timescale was constructed through the Bonarelli Level, a ~1m thick interval of interbedded black and grey shales and radiolarian sands that is the sedimentary expression of Oceanic Anoxic Event 2 (~94 Ma) in Umbria–Marche, Italy¹. A new duration of the Bonarelli Level determined using a $^3\text{He}_{\text{ET}}$ timescale (478±160 kyr) is consistent with previous cyclostratigraphic estimates². A ~30 kyr slow-down in sedimentation rate was associated with the lithological shift from limestone to black shale at the base of the Bonarelli Level, reflecting the interval between an effective cessation of carbonate accumulation and an increase in biogenic silica during a biotic turnover in which carbonate-producing plankton were out-competed under higher nutrient conditions³. At the top of the Bonarelli Level a ~85kyr interval of slowly accumulating sediment was observed coincident with the final decline in total organic-carbon content, probably recording the time between the re-establishment of oxygenated marine conditions (preventing TOC preservation) and the completion of the biotic turnover that restored carbonate deposition. Once carbonate deposition was re-established post-dating the Bonarelli Level, a transient increase in accumulation rate likely reflects enhanced biogenic calcite preservation due to build-up of excess alkalinity during OAE 2. Within the Bonarelli Level itself, sedimentation and organic-carbon mass accumulation rates were far from constant, reflecting rapid changes in depositional conditions through the event. Peak OC MARs reached 0.22±0.09 g/cm²/kyr, with estimated primary productivity (60–110 gC/m²/yr) comparable to that of Mediterranean sapropels⁴.

1. Schlanger and Jenkyns, 1976. *Geologie en Mijnbouw*.
2. Batenburg et al., 2016. *Past Discuss*.
3. Erba, 2004. *Marine Micropaleontology*.
4. Menzel et al., 2002. *Marine Geology*.