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Orbital control on the timing of oceanic anoxia in the Late Cretaceous

Sietske Batenburg (1), David De Vleeschouwer (2), Mario Sprovieri (3), Frederik Hilgen (4), Andrew Gale (5), Brad Singer (6), Christian Koeberl (7), Rodolfo Cocioni (8), Philippe Claeys (9), and Alessandro Montanari (10)

(1) Institute of Geosciences, Goethe-University Frankfurt, Germany, (2) MARUM, Center for Marine Environmental Sciences, Universität Bremen, Germany, (3) Istituto per l'Ambiente Marino Costiero, Consiglio Nazionale delle Ricerche, Campobello di Mazara, Italy, (4) Department of Earth Sciences, Utrecht University, The Netherlands, (5) School of Earth and Environmental Sciences, University of Portsmouth, United Kingdom., (6) Department of Geoscience, University of Wisconsin-Madison, USA, (7) Department of Lithospheric Research, University of Vienna and Natural History Museum Vienna, Austria, (8) Dipartimento di Scienze della Terra, della Vita e dell'Ambiente, Università degli Studi "Carlo Bo", Urbino, Italy., (9) Earth System Sciences, Vrije Universiteit Brussel, Belgium, (10) Osservatorio Geologico di Coldigioco, Frontale di Apiro, Italy

The oceans of the Cenomanian-Turonian transition, at the height of the Cretaceous greenhouse, were abruptly disturbed by a period of oceanic anoxia. This led to the brief but widespread deposition of black organic-rich shales in the world's oceans, such as the Livello Bonarelli in the Umbria-Marche Basin (Italy). However, the origin and exact timing of the onset of oceanic anoxia are debated.

We present a 6-Myr-long astronomically-tuned timescale across the Cenomanian-Turonian Oceanic Anoxic Event 2 (OAE2), obtained from the Furlo and Bottaccione sections in the Umbria-Marche Basin. The cyclic climatic imprint on lithological, geophysical and stable isotope records allows us to decipher the relationship between orbital forcing and the Late Cretaceous carbon cycle. The deposition of black shales and cherts, as well as the onset of oceanic anoxia, is related to maxima in the 405-thousand year cycle of eccentricity modulated precession. In this study, we also present a new radioisotopic Ar/Ar age for the Thatcher bentonite occurring within the mid-Cenomanian carbon isotope event in the Western Interior of the USA. We correlate our astrochronology from the Umbria-Marche Basin to this new and recent radioisotopic ages, and we come to an unprecedented age control for European successions. The most likely tuned age for the Livello Bonarelli base is 94.22 Ma, however a 405-kyr older age cannot be excluded due to increasing uncertainties in stratigraphic correlation, radioisotopic dating, and orbital configuration. Although volcanism was probably the ultimate driver of OAE2, the cyclicity of the Umbria-Marche successions reveals that the exact timing of carbon cycle perturbations in the Late Cretaceous was determined by orbital periodicities.