Integrated stratigraphy and cyclostratigraphy reveal astronomical pacing of flint beds in type-Maastrichtian chalk (Upper Cretaceous, Europe)

Jarno Huygh*[1,2], Matthias Sinnesael[3], Pim Kaskes[2], Johan Vellekoop[4,5], John W. M. Jagt[6], and Philippe Claeys[2]

[1]Université de Liège, Sedimentary Petrology, 4000 Liège, Belgium – Belgium
[2]Vrije Universiteit Brussel, Analytical and Geo-Chemistry, 1050 Brussels, Belgium – Belgium
[3]Sorbonne Université, CNRS, 75014, Paris, France – PSL, IMCEE, Observatoir de Paris, Paris, France – France
[4]Katholieke Universiteit Leuven, Department of Earth and Environmental Sciences, 3000 Leuven, Belgium – Belgium
[5]Royal Belgian Institute for Natural Sciences, OD Earth and History of Life, 1000 Brussels, Belgium – Belgium
[6]Natuurhistorisch Museum Maastricht, 6211 Maastricht, The Netherlands – Netherlands

Abstract

Northwestern Europe is the scene of many Upper Cretaceous chalk deposits, often containing interbedded flint nodules and bands. Yet, it remains unclear whether the pacing of these often seemingly rhythmically distributed flints is astronomically controlled. For this reason, we investigated a Maastrichtian chalk succession near Hallembaye (BE) in the type-area around Maastricht (NL). The Hallembaye section is characterized by a gradual change in lithology, which varies from greyish chalk with rare occurrences of flint nodules towards more pure, whitish chalk with clearly expressed flint bands. Powdered chalk samples were analyzed using micro-X-Ray Fluorescence to determine the concentration of major and trace elements. To quantify the distribution of flints in function of the stratigraphic height, 'Flint Scores (FS)' were attributed. Using an integrated stratigraphic approach, we applied cyclostratigraphy to assess a potential astronomical imprint in the FS and chalk elemental composition. Short-scale fluctuations superimposed on a gradually decreasing trend are observed in Ti/Al, a diagenesis-resistant proxy reflecting changes in the composition of detrital influx or the provenance thereof. Time-series and spectral analyses of the Ti/Al signal reveal a dominant 40 kyr obliquity component with its 173 kyr modulation, as well as a weaker precession-eccentricity signal. In addition, analyses performed on the FS strongly indicate astronomical pacing of the flint beds. The FS record is tuned using the stable 173 kyr obliquity modulation and 405 kyr long eccentricity cycles, yielding a high-resolution age model in absolute time. This age model is complementary to a floating astrochronology obtained after tuning the Ti/Al signal to the identified 40 kyr obliquity imprint. Even though the exact mechanism(s) behind the formation and astronomical pacing of flints remain to be constrained, evidence points towards a link to variations in the influx of detrital material (clays).

*Speaker

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