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Timing environmental perturbations across the Cretaceous – Paleogene boundary in the Boreal Realm (N. Denmark)

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The Cretaceous-Paleogene boundary (K-PgB) interval of Denmark has been the subject of numerous contributions for understanding this mass extinction, focusing essentially on the famous coastal exposures of Stevns Klint (Sjælland). Although less popular, exposures of the K-PgB are also known in northern Jutland (NW Denmark) and have been the subject of a few contributions on their macro- and microfaunal content. Through an integrated study of the section of Nye Kløv (biostratigraphy and high-resolution stable isotope stratigraphy), we show here that the KPgB interval in northern Jutland presents the double advantage of (1) being continuous across the latest Maastrichtian to early Paleogene (contrary to Stevns Klint sections that bear several discontinuities such as prominent hardgrounds) and (2) bearing well-preserved macro- and microfossil assemblages, and isotopic trends in carbon and oxygen. Bulk carbonate oxygen isotopes delineate with great precision temperatures trends across the KPgB interval with cyclic oscillations that faithfully reproduce trends of the La2010b astronomical solution, hence allowing for an astronomical calibration of the section. The orbital calibration of the KPgB in Nye Kløv points to an age of 66.01 Ma. Our study delineates a Deccan warming optimum at 66.25 Ma corresponding to the deposition of the Kjølby Gaard marl, a distinct marly layer that can be traced throughout the North Sea. A clear shift toward the end-Maastrichtian cooling follows the Deccan warming at 66.1 Ma and precedes a last pulse of warming immediately below the boundary at 66.02 Ma. The earliest Danian is characterized by lower temperatures up until 65.88 Ma, after which temperatures resume to the same range as those of the Deccan warming, albeit with strong oscillations that reflect pacing by the short-eccentricity. This shift toward much warmer temperatures is associated with a first negative excursion in carbon isotopes. A second marked negative excursion in carbon isotopes occurs at 65.65 Ma and taken all-together, the overall warm interval comprising these two carbon isotope excursions reflects the local expression of the Dan-C2 hyperthermal event. Orbital calibration of the Nye Kløv section also allowed us to determine the timing of the recovery in the benthic community in the Boreal Chalk Sea, marked by an increase in skeletal fragments and brachiopod diversity, which occurred at 65.8 Ma, hence in conjunction with the Dan-C2 event.