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The Campanian - Maastrichtian (Late Cretaceous) climate transition linked to a global carbon cycle perturbation

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The Late Cretaceous was a period of long-term climate cooling succeeding the extreme warmth of the mid-Cretaceous greenhouse world. The cooling is mainly considered as a result of changes in ocean circulation due to plate movements resulting in progressive deep-water exchange between the deep oceanic basins and a parallel drop in atmospheric carbon dioxide concentrations. In Campanian – Maastrichtian times, pronounced climate cooling is documented between 71 - 69 Ma, when distinct changes in foraminiferal oxygen and carbon isotope data at a global scale indicate substantial deep-water cooling and reduced rates of organic carbon burial. The causal mechanisms of this cooling period, however, are poorly understood to date. While some authors suggest mainly oceanographic changes, others supposed an ephemeral glaciation related to a eustatic sea-level fall. Mainly, the relative timing of oceanic oxygen and carbon isotope changes to eustatic sea-level changes is not proven yet. Likewise, the influence of plate tectonic changes as the opening of gateways or the subduction of mid-ocean ridges and/or of orbital forcing is poorly understood. A principle objection beside the sparse available data is the low temporal resolution of biostratigraphic zonations.
Here, we present carbon isotope stratigraphies from Campanian-Maastrichtian Boundary sites in the Boreal and Tethyan shelf seas of Europe and from Shatsky Rise in the tropical Pacific in order to improve the resolution of stratigraphic correlation. Prominent features at that time are two negative carbon isotope excursions (CIEs) in the late Campanian and earliest Maastrichtian, which are well documented in the Lägerdorf-Kronsmoor section in N-Germany and the Campanian-Maastrichtian Boundary Stratotype at Tercis in SW France. These new carbon isotope records correlate well with the carbon isotope reference curve from the English Chalk (Jarvis et al., 2002, 2006).
The new carbon isotope record at Site 305 in the tropical Pacific shows the prominent negative CIE in the early Maastrichtian, which perfectly resembles the carbon isotope data of planktonic and benthic foraminifers (Barrera and Savin, 1999). Numerous stratigraphic details, represented only by single points in the foraminiferal record, are clearly resolved in the bulk-carbonate carbon isotope signal. Of special importance are several positive excursions, which are superimposed on the CIE. These detailed carbon isotope features can be correlated to the shelf-sea carbon isotope curves of Europe (Lägerdorf-Kronsmoor) in a surprisingly good precision supported by calcareous nannoplankton stratigraphy (Lees & Bown 2005). The possibility to correlate small-scale carbon isotope variations proves their robustness as significant signals. The carbon isotope variations seem to reflect minor changes in the global carbon cycle, possibly triggered by orbital forcing.
The negative CIEs in the Campanian-Maastrichtian lasted about 0.8-1 million years and are associated with major regressions on epicontinental shelves. Intensified ventilation of the ^{12}C enriched deep-water reservoir, lowering of the CCD and increased rates of terrestrial and marine organic matter oxidation during the sea-level fall could have caused an increase of ^{12}C in the inorganic carbon reservoir. The associated change in the slope of seawater strontium isotopes possibly suggests an increased continental weathering flux as result of long-term (first order) sea-level fall and widespread continental shelf exposure. Activation of silicate weathering could have triggered enhanced atmospheric CO_2 reduction, which again became a positive feedback for ongoing climate cooling at the end of the Cretaceous greenhouse climate.