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The early Barremian warm pulse and the late Barremian cooling: a high resolution geochemical record of the Boreal Realm

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A high resolution geochemical study of seven Barremian (lower Cretaceous) sections in NW Europe documents warming and cooling periods throughout the investigated interval. A total of 289 belemnite guards from localities in NE England and NW Germany were analysed for their trace elements (Mg, Sr, Fe and Mn) and their stable isotope composition (13C, 18O) in order to reconstruct the palaeotemperature record and to better understand different palaeotemperature proxies (18O, Mg/Ca). The material has been collected bed-by-bed from bio- and lithostratigraphically well studied outcrops with a palaeolatitude of 36-38°N.
The carbon isotope curve of the Barremian is described by a long term (5my) increase from 1‰ in the early Barremian to 3‰ in the late Barremian. This long term trend is thought to reflect the global signal of the carbon budget of the Barremian oceans. Superimposed on this signature is a short termed peak ($\sim$ 105kyrs) of 2.5‰ in the late early Barremian Aulacoteuthis zone. This “Aulacoteuthis peak”, which goes along with the widespread deposition of TOC rich mudstones, was caused by increased productivity. It is seen as a regional signal related to warm-humid conditions and palaeoceanographically a quasi lagoonal setting. 13C shifts of 1.5‰ from specimens collected from one horizon may reflect high resolution seasonal changes of run-off and nutrient supply.
The oxygen isotope signature clearly shows similar palaeotemperature variations of the approx. 5my lasting Barremian for all sections investigated. The climatic evolution allows to recognize three different phases. An earliest Barremian cool phase (Praeoxyteuthis pugio zone) is characterized by 18O values of - 1.2‰ to 0.3‰ (16°C to 10°C) with most data plotting around - 0.2‰ (12°C). This “P. pugio cool phase”, which extends into the underlying Hauterivian, is followed by a distinctive warming event in the late early Barremian Aulacoteuthis zone. This “Aulacoteuthis warm pulse”, which supplied 18O data of - 2‰ to - 1‰ (20°C to 16°C), is a relatively short termed peak lasting $\sim$ 500kyrs and went along with widespread anoxic conditions of bottom waters. These resulted in the deposition of TOC rich laminated mudstones. This warm pulse recorded the highest T°C throughout the entire Valanginian-Barremian in the Boreal Realm. A third climatic interval, the “late Barremian cooling phase” marks the Oxyteuthis brunsvicensis, Oxyteuthis germanica and Oxyteuthis depressa zones. The 18O data steadily increase to values of 0‰ (12°C) in the latest Barremian.
The Mg/Ca-proxy data clearly parallel the trend of the 18O signature. The “P. pugio cool phase” of 13-15°C is followed by the “Aulacoteuthis warm pulse” with temperatures up to 25°C. The overlying Upper Barremian zones show the “late Barremian cooling phase” with temperatures around 15°C. Temperature differences of more than 2°C between the 18O and the Mg/Ca data have been observed for 48% of the studied belemnite material. These differences may either reflect the natural variation of an unfiltered high resolution record and/or salinity fluctuations, in a palaeoceanographically restricted setting where alternating seasons of raised and lowered salinities were controlled by variations of the run-off. Warm periods (early late Barremian) went along with warmer 18O temperature values or alternatively a higher salinity, cool periods (late Barremian) with cooler 18O temperatures or a lowered salinity.