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Cenomanian and Turonian (Upper Cretaceous) Belemnitellid Provinces, Palaeotemperatures and palaeoceanographic Implications

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Introduction

After continuous belemnite records during the early Cretaceous (and lowermost Cenomanian), belemnites were very scarce in the European shelf seas and the Western Interior Seaway (USA) as a result of increasing palaeotemperatures during the Cenomanian/Turonian (thermal maximum in the early/mid-Turonian). In this interval, belemnites (Belemnitellidae) are exclusively restricted to three event-bed like occurrences in Europe. On the other hand, belemnitellids were very common on the Russian platform and their geographic distribution – also of the partly scattered occurrences – permit a clear differentiation into distinct palaeobiogeographic units (i.e. subprovinces) within the North Temperate Realm into a North European Province (NEP) (with the Central European Subprovince, CES, the Central Russian Subprovince, CRS and the North American Province (NAP; Christensen 1976).

Geological context of the belemnite events

In the Cenomanian/Turonian of (western) Europe three short-termed immigration pulses are recognized (i: Mid-Cenomanian *primus* Event; ii: Late Cenomanian *plenus* Event; iii: Late Turonian Cooling Phase III of Voigt & Wiese 2000), which are complex events characterized by short-termed climate cooling (as indicated by $\delta^{18}0$ evidence; Voigt & Wiese 2000, Voigt et al. 2004), a relatively rapid sea level fall (Gale et al. 2002) and a brief incursion of belemnites together with other cool-water fauna (Jefferies 1962, Gale & Christensen 1996).

Migration paths

The incursion of *Praeactinocamax primus* (Middle Cenomanian) and *P. plenus* (Upper Cenomanian) happened from the Russian platform (Košťák et al. 2004). New systematic work on Turonian belemnitellids from the US Western Interior and Bohemia show both faunas to be conspecific/closely allied (Košťák 2004). No similarities with belemnitellids from the Russian platform ca be recognized. A strict palaeobiogeographic occurred between the western European and the Russian shelf seas in the Turonian-Lower Coniacian, justifying the discrimination of an isolated biogeographic unit (East European Province). Consequently, immigration of belemnites into Europe must have happened from the US, indicating a short term inversion of palaeocurrent systems during late Turonian times (this has also been discussed for ammonites; Wiese & Voigt 2002).

Discussion and perspectives

Three belemnite incursion events into the European shelf seas are associated by short-termed regressive/transgressive events and climate cooling in the Cenomanian and Turonian. As the taxa in question show preference to shallow shelf facies, migration most likely was triggered by the interaction of regression, a resulting connection of wide shelf areas and a spread of cooler waters, permitting unhindered migration of belemnitellids following the cold waters in favourable water depths. For the Cenomanian events, cooling has long been suggested on faunal data (Jefferies 1962, Gale & Christensen 1996), verified by stable isotope analyses (Voigt et al. 2004), and for the Upper Turonian, cooling has been elaborated both by faunal and isotopes evidences (Wiese & Voigt 2002). Both fauna and isotope data give the same palaeotemperature trend, although faunal data cannot be used to calculate absolute temperature values. However, the severe differences in migration direction in the Cenomanian and Turonian can, at the moment, only be recognized by macrofaunal data. Consequently, a synthesis of both data sets contribute to a much better fine-tuning and understanding of palaeoceanographic reconstructions of the interval in question.

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