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Belemnites from the lower middle Cenomanian of Hoppenstedt, northern Germany: significance and integrated correlation

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ABSTRACT

The belemnite species *Praeactinocamax primus* (Arkhangelsky, 1912) and *Belemnocamax boweri* Crick, 1910 are described from the Cenomanian of the abandoned limestone quarry section of Hoppenstedt (Sachsen-Anhalt, northern Germany). They co-occur in the upper part of a prominent tripartite bioclastic limestone bed associated with the ammonite *Acanthoceras rhotomagense*, indicating the *primus* Event of the lower middle Cenomanian *A. rhotomagense* ammonite Zone. An integrated stratigraphical calibration including carbon stable isotope correlation to southern England suggests that the belemnite event horizon at Hoppenstedt occupies exactly the same chronostratigraphical position as elsewhere, highlighting the strictly isochronous character of the *primus* Event across northwestern Europe. Furthermore, stratigraphical gaps in the Hoppenstedt succession are evaluated.

1. Introduction

A characteristic feature of Cenomanian epicontinental shelf sediments in northwestern Europe is the occurrence of widespread palaeontological events, i.e., beds or thin intervals of strata that are characterized by either "exotic" or acmes of common faunal elements (Ernst et al., 1983). Among those "bioevents" are several belemnite events (see Christensen, 1990; Christensen et al., 1992; Mitchell, 2005; Wilmsen et al., 2007), the most important being the early Cenomanian *Neohibolites ultimus/Aucellina* Event, the middle Cenomanian *Praeactinocamax primus* Event, and the late Cenomanian *Praeactinocamax plenus* Event. Their importance in stratigraphical calibration has been recognized and they are widely used as correlation tools (e.g., Ernst et al., 1983, 1996; Gale and Christensen, 1996; Mitchell, 2005; Wilmsen et al., 2007). Here, we document and describe belemnites from the lower middle Cenomanian of Hoppenstedt, northern Germany. Furthermore, we provide a carbon stable isotope curve of the interval in order to calibrate the stratigraphical position of the belemnite horizon, and discuss the stratigraphical significance of the occurrence.

2. Locality and geological setting

The abandoned limestone quarry "Kalkwerk Nordharz" is situated 4 km west of Osterwiek at the northern margin of Hoppenstedt (Fig. 1, TK 25 Vienenburg, no. 4029, R: 4408000, H: 5763350). The beds dip at c. 30–40° SSW at the southern limb of the northwest/southeast-trending Fallstein anticline and are exposed on an eastern, western, and northern quarry wall (where the oldest beds crop out). The section exposes a c. 80 m thick succession ranging from the upper lower Cenomanian (*Mantelliceras dixoni* Zone) up to the lower Coniacian. The entire succession was described by Tröger (1969), Horna et al. (1994), and Horna (1996) using an integrated stratigraphical approach, whereas Wilmsen (2004) and Wilmsen and Wood (2004) focused on the Cenomanian part.

Cenomanian sediments of marine origin are widely distributed in northwestern Europe. Deposition took place in a wide epicontinental shelf sea covering most of northwestern Europe at a palaeo-latitude of c. 40°N (see Fig. 1). The predominant lithologies in northern Germany are inner-neritic "greensands" (glauconitic sandstones) and (silty) marls, hemipelagic fossiliferous marl-limestone alternations ("Pläner"), and pelagic calcareous nannofossil limestones, broadly reflecting the proximal–distal arrangement of inner, mid- and outer shelf facies belts (see Wilmsen et al., 2005, for a synopsis).

The Hoppenstedt section is located in the western Subhercynian Basin (SHB, Tröger, 1995; a proximal part of the northern German

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shelf), comprising the area between the Harz Mountains and the Flechtingen High. During the late early to early middle Cenomanian, it was a site of fossiliferous mid-shelf marl-limestone deposition. Biostratigraphy of this interval (Fig. 1) is based mainly on macrofossils (inoceramid bivalves and ammonites). The logged stratigraphical interval comprises the upper part of the *Mantelliceras dixoni, Cunningtoniceras inerme* and lower *Acanthoceras rhotomagense* ammonite (standard) zones. The corresponding inoceramid bivalve zones are those of *Inoceramus virgatus* (upper part) and *Inoceramus schoendorfi*. The investigated interval contains the *arlesiensis* Bed (a *Cunningtoniceras inerme* zonal Anglo-Paris Basin marker bed containing the calcitic bivalve *Lyropecten arlesiensis*; see Mitchell et al., 1996) and the *Praeactinocamax primus* Event, an important interbasinal belemnite marker bed of early *Acanthoceras rhotomagense* zonal age (see Ernst et al., 1983; Christensen, 1990; Paul et al., 1994; Mitchell, 2005; Wilmsen et al., 2007). In a sequence stratigraphical interpretation, the interval under consideration comprises the late highstand of a 3rd-order depositional sequence (DS Ce III, late *Mantelliceras dixoni* Zone), sequence boundary (SB) Ce III (latest *Mantelliceras dixoni* Zone), and the lower part of the following sequence (DS Ce IV, latest *Mantelliceras dixoni* to *Acanthoceras rhotomagense* Zone; see Robaszynski et al., 1998 and Wilmsen, 2003 for details).

3. Material and methods

For stratigraphical and sedimentological analyses, we measured the section bed-by-bed, analyzed the microfacies using a hand lens and several thin-sections, and collected macrofossils largely *in situ* (based on their adherent matrix, loose specimens can also usually be safely attributed to individual beds or thin bedsets). The palaeontological part of the study is based on material from the lower *Acanthoceras rhotomagense* Zone *primus* Event, which is currently stored in the collection of one of the authors (MR). Eight plaster casts of the figured specimens are stored in the collections of the Palaeontological Institute of Würzburg University (repository PIW2005 V). The fossils were cleaned, mechanically prepared and treated with magnesium oxide prior to photography. For descriptive terms and measurements of the belemnite guard see Fig. 2.

For carbon and oxygen stable isotope analyses, the section was sampled at decimetric intervals. The bulk rock samples were powdered and the powders were reacted with 100% phosphoric acid (density >1.9, Wachter and Hayes, 1985) at 75 °C using a Kiel III online carbonate preparation line connected to a ThermoFinnigan 252 mass spectrometer. All values are reported in per mil relative to V-PDB by assigning a $\delta^{13}C$ value of +1.95‰ and a $\delta^{18}O$ value of −2.20‰ to NBS19. Reproducibility was checked by replicate

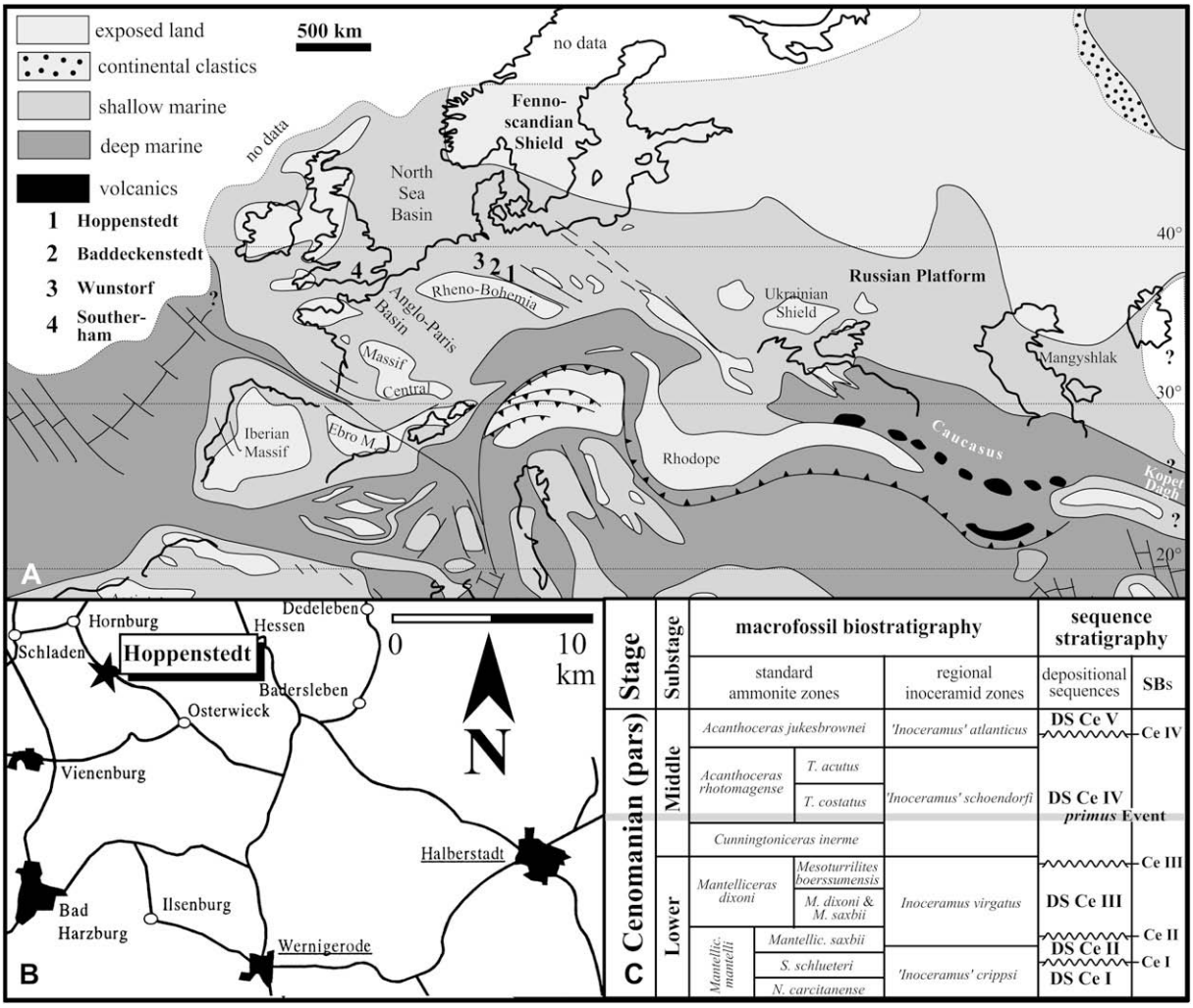

Fig. 1. Palaeogeographic and stratigraphical framework. A, Palaeogeography of the Cenomanian in the western Tethyan Realm (modified after Philip and Floquet, 2000). The positions of the sections mentioned in the text are indicated by numbers. B, Locality map of the Hoppenstedt quarry. C, Integrated stratigraphical subdivision of the lower and middle Cenomanian in northwestern Europe. The position of the *Praeactinocamax primus* Event is highlighted.