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The Jurassic–Cretaceous boundary interval in non-marine strata of northwest Europe – New light on an old problem

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ABSTRACT

The non-marine Purbeck- and Wealden-type sediments of latest Jurassic (Tithonian) and earliest Cretaceous (Berriasian) age in northern Germany were deposited in a restricted intercontinental basin. They mark an interval of strong faunal and floral provincialism which makes correlation of the non-marine strata across northwest Europe difficult. The position of the Jurassic–Cretaceous boundary has therefore been debated for decades. Our integrated stratigraphy of four sections in northern Germany, based on palynology (spores, pollen, dinoflagellate cysts) and ostracods, provides new evidence for a precise correlation with contemporaneous strata of other non-marine basins in northwest Europe. Correlation with the marine Boreal Realm and the Tethys is achieved via the Purbeck type section in England. A stratigraphic subdivision of the non-marine Berriasian succession in Germany is possible by using seven short-lived marine flooding events, which are documented by ceratioid dinoflagellate cysts and foraminifera. Our data suggest that a first major transgression took place close to the base of the Boreal *Surites stenomphalus* ammonite Zone. This level corresponds to a contemporaneous flooding event in southern England (Scallop Beds, Purbeck Group) and in southern Sweden (Annero Formation), thereby providing an excellent marker horizon for interbasinal correlation.

1. Introduction

A Late Jurassic–Early Cretaceous global sea-level lowstand (Sneider et al., 1995; Haq, 2014) led to isolation of sedimentary basins throughout northwest Europe (Fig. 1). The biogeographic isolation triggered a distinctive faunal and floral provincialism which, in combination with the absence of marine index fossils, makes interbasinal correlation difficult. Magnetostratigraphy (Ogg et al., 1991, 1994) and sequence stratigraphy (Hoedemaeker, 1999; Hoedemaeker and Herngreen, 2003, 2004), which supplement the biostratigraphic framework, allow for correlation of the non-marine Purbeck from England and the marine sequences of the Boreal Realm and Tethys (Abbink et al., 2001; Hunt, 2004). The Purbeck Limestone Group of southern England comprises a succession of mudstones, limestones and evaporites, barren of ammonites and calpionellids, encompassing the Jurassic–Cretaceous (J–K) boundary interval (West, 1975; Westhead and Mather, 1996). The type section is located in Durlston Bay (Dorset), where Purbeckian strata are about 120 m thick. The Purbeck Limestone Group rests unconformably on marine strata (Portland Group) of late, but not latest, Tithonian age and is overlain by the non-marine Wealden Group (Fig. 2). The lithostratigraphic term “Wealden”, originally used for Lower Cretaceous non-marine deposits of southern England, is also applied to contemporaneous non-marine strata in other areas, including northern Germany. In southern England Wealden sediments were deposited throughout the late Berriasian–earliest Aptian, whereas in northern Germany the Wealden covers only the mid–late Berriasian.

The Wealden facies of northern Germany is represented by non-marine deposits that accumulated under brackish-lacustrine conditions. The first studies of the German Wealden facies described a gradual, long-term shift from freshwater conditions in the lowermost part towards a marine influenced setting in the upper part (e.g., Martin, 1961; Kemper, 1973). This long-term trend is punctuated by seven short-lived episodes of marine floodings. These are documented by the presence of dinoflagellate cysts and foraminifera, with assemblages often being dominated by few species (Martin, 1961; Strauss et al., 1993). The marine flooding events

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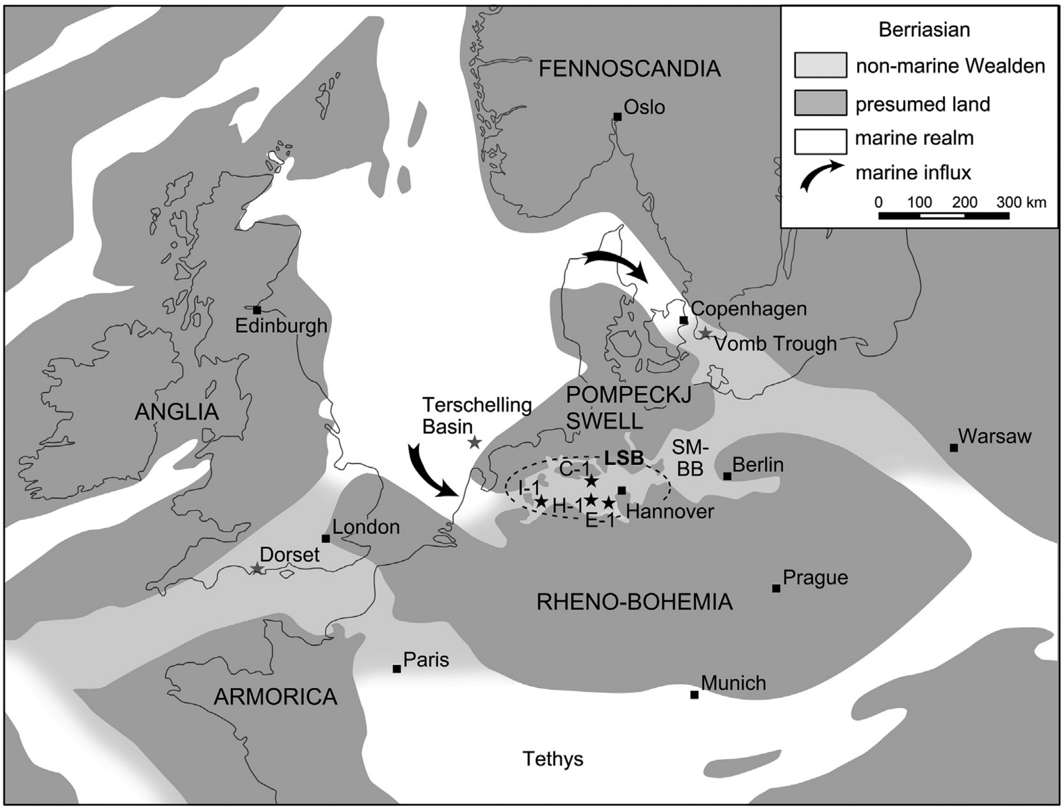

Fig. 1. Palaeogeographic map for the Berriasian of northwest Europe showing the positions of the four studied sections in the Lower Saxony Basin, the Purbeck type section in Dorset, the Terschelling Basin in the Netherlands and the Vomb Trough in Sweden. Modified after Schott et al. (1967/69), Ziegler (1982, 1990) and Mutterlose (1992). I-1: well Isterberg 1001. C-1: well "core-1". H-1: well 1/08 Husen. E-1: well Eulenflucht-1. LSB: Lower Saxony Basin. SM-BB: Südmecklenburg-Brandenburg Basin.

presumably entered the basin from the west via the Netherlands (Fig. 1; Elstner and Mutterlose, 1996).

For the evaporitic facies of the upper Münder Formation (joOM 5–6, also named OM 5–6, **O**ber **M**alm 5–6) and the overlying non-marine facies of the Bückeberg Group (Wealden 1–6) a biostratigraphic framework has been established for northern Germany based on ostracods of the genus *Cypridea* (Wolburg, 1949, 1959; Elstner and Mutterlose, 1996). Previous studies correlated the Berriasian deposits from Germany (upper Münder Formation, Bückeberg Group) with Purbeckian strata from England by using ostracods (e.g., Bischoff and Wolburg, 1963; Anderson, 1967, 1973; Wienholz, 1968; Anderson and Bazley, 1971; Kemper, 1973; Wimbledon and Hunt, 1983; Allen and Wimbledon, 1991) and sporomorph suites (Döring, 1965; Burger, 1966; Norris, 1969; Dörhöfer and Norris, 1977; Hunt, 1985; Herngreen et al., 1988). The stratigraphic ranges of some ostracod species are identical in both countries, allowing correlation (Fig. 2). Other species have different taxonomic definitions in Germany and England, their stratigraphic information is therefore limited. The ranges of various species further differ, possibly because of different ecological conditions in Germany and England at a given time (Anderson and Hughes, 1964; Elstner and Mutterlose, 1996).

New palynological and micropalaeontological data were obtained from two cores positioned in the central part of northern Germany. These findings are compared with published observations from the Isterberg 1001 well located about 150 km further west (Strauss et al., 1993). The objective of this multidisciplinary analysis is to create a basin-wide palynostratigraphic reference scale for northern Germany, based on ostracods, spores, pollen and dinoflagellate cysts. Palynomarkers are used for intra- and interbasinal correlation and complement the existing ostracod zonation scheme.

2. Geological setting

The non-marine Purbeck- and Wealden-type sediments, cropping out in northern Germany, were deposited in two small, isolated basins. The Lower Saxony Basin (LSB) and the Südmecklenburg-Brandenburg Basin (SM-BB; Schott et al., 1967/69) were the main depocentres, characterised by differential subsidence. The LSB was bordered in the south by Rheno-Bohemia and in the north by the Pompeckj Swell (e.g., Kockel et al., 1994; Gramann et al., 1997).

The global regression in the Late Jurassic (Sneider et al., 1995; Haq, 2014) caused the isolation of both basins (Ziegler, 1982, 1990; Mutterlose, 1992), leading to the precipitation of the evaporitic sequences of the upper Münder Formation (lower Berriasian). The upper Münder Formation can be subdivided into the OM 5, formerly the Katzberg Member and the OM 6, formerly the Serpulit Member. These marly sequences include oolites, serpulites and stromatolitic limestones. The overlying Bückeberg Group of mid–late Berriasian age (Kemper, 1973; Erbacher et al., 2014) is represented by non-marine deposits of the Wealden facies, which accumulated under a brackish-lacustrine regime. The Wealden facies is characterised by steadily increasing marine conditions (Martin, 1961; Strauss et al., 1993), suggesting the existence of a seaway to the Boreal Realm. In the earliest Valanginian the LSB became fully marine, documented by ammonite-bearing strata (Kemper, 1971; Mutterlose and Bornemann, 2000; Mutterlose et al., 2014).

The stratigraphic position of the lithological units discussed here is summarised in Fig. 2. In the central part of the LSB (Fig. 3) up to 700 m of bituminous claystones of Berriasian age (Schott et al., 1967/69; Mutterlose and Bornemann, 2000) represent potential