Holocene Sea-level Change in the Southwestern Baltic Sea

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Understanding past and future sea-level change in northern Europe depends on the further improvement of modelling techniques of mantle viscosity and crustal rebound. One of the limitations for such improvement has been a gap in the observational database (Lambeck et al. 1998). To overcome this limitation, this study looks at a previously neglected area of the Baltic Sea. The study presents sedimentological and geochemical data of 13 sediment cores from six lagoons in the southern Baltic Sea (Fig. 1). The results of this study provide new supporting evidence for the tentative sea-level curve proposed for the southern Baltic Sea about 20 years ago (Kliewe & Janke 1982). So far, only one attempt to test this curve has been made (Müller 2001), based on data solely restricted to the lagoonal Oder Estuary. Differences in the response of the sediments of each lagoon to sea-level change are due to complex shoreline development controlled by interaction between neotectonic and glacial-isostatic processes in the Baltic Sea region and regional deglaciation dynamics. They also reflect the different degrees of exposure of the lagoons to the open Baltic Sea and influence of river input.

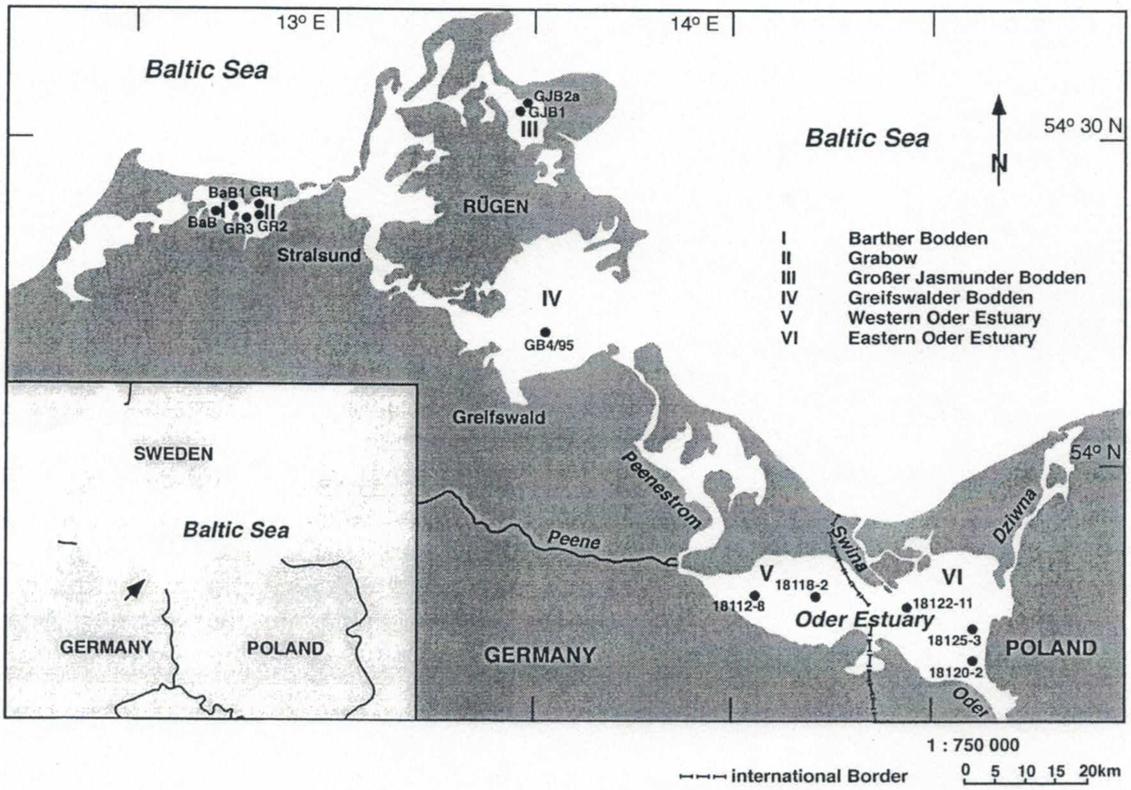

Fig. 1: Study area and sampling locations. The numbers I to VI indicate the names of the lagoons of this study as shown in the legend.

Several lakes existed in the area of the present Greifswalder and Oder lagoon during the late last glacial period, with sand being the predominant sediment (Fig. 2). These late glacial deposits were recognized in four of the five cores from the Oder lagoon. The composition of the sand in the Oder lagoon has been described as being similar to glacial deposits on land, indicating a high contribution from local material (Gingele & Leipe, 1997). This suggests high rates of erosion, possibly associated with the chaotic flow of meltwater in the area. Core 18112 from the western basin of the Oder lagoon contains an almost complete section from the Allerød stade (II) where fine sands alternate with peat. Sediments from this core show an increase in water level at this time due to a change in climate from cool and dry to more humid warm conditions.

A hiatus up to 7800 yr B.P. is found in both the western and eastern basins of the Oder lagoon as reflected in cores 18118 and 18120. This hiatus appears to be due to erosion related to the low sea level during the Ancylus regression period (9200-9000 yr B.P.). This regression has been associated with the drainage of the Ancylus-Lake via the Darss Sill area between the present landmasses of Germany to the south and southern Sweden and Denmark to the north (Björck, 1995). The regression period, which was followed by temporary terrestrial stages in large basins of the study area, lasted for almost a millenium, from about 8700-7900 yr B.P. (Kliewe, 1995). In the Greifswalder Bodden lagoon it is reflected by the growth of peat (Fig. 2).

Between 7800 and 6000 yr B.P., lakes clearly existed in both basins of the Oder lagoon, and are also evident in the Greifswalder Bodden and Großer Jasmunder Bodden lagoons. In the Oder lagoon, cores 18118 and 18120 show this lacustrine period, which started in the eastern basin of the lagoon (core 18120), at least in the Older Atlantic stade (VI), and continued far into the Younger Atlantic stade (VII). Although a marine transgression obviously did not occur in the study area, the lake stages reflect the rising water level at the time. Higher sea level in the area is linked to the onset of the Litorina transgression in the Baltic Sea region about 7900 yr B.P. The sea level rose quickly up to 5700 yr B.P. during the first main stage of the Litorina transgression (Kliewe, 1995). The lake stage in the eastern Oder lagoon (Fig. 2 & Fig. 3) appears to partially tie-in with the Main Litorina Regression stage (MLR). Peats found on top of the lake sequence in the Oder lagoon core 18120 before the onset of mud sedimentation about 5500 yr B.P. support a previously suspected regression stage after the first main stage of the Litorina transgression (Kliewe & Janke, 1982).

The lacustrine phase in the study area was followed by the Litorina transgression, characterized by three main stages. The first of these affected the area of the southern Baltic Sea around 7000 yr B.P. (Kliewe & Janke, 1982). However, the sediments of the Oder lagoon reflect only the second main stage of Litorina transgression in that mud sediments occur around 5500 yr B.P. in both basins of the lagoon (Fig. 2). The onset of the second main stage is evident in the transgressive sands found on top of the lacustrine/peat sequence in core 18120 from the eastern basin. In contrast, in the Greifswalder Bodden lagoon adjacent to the northwest of the Oder lagoon and in the Großer Jasmunder Bodden lagoon in the north of the study area, the influence of the Litorina transgression can be seen around 6500 and 7000 yr B.P.

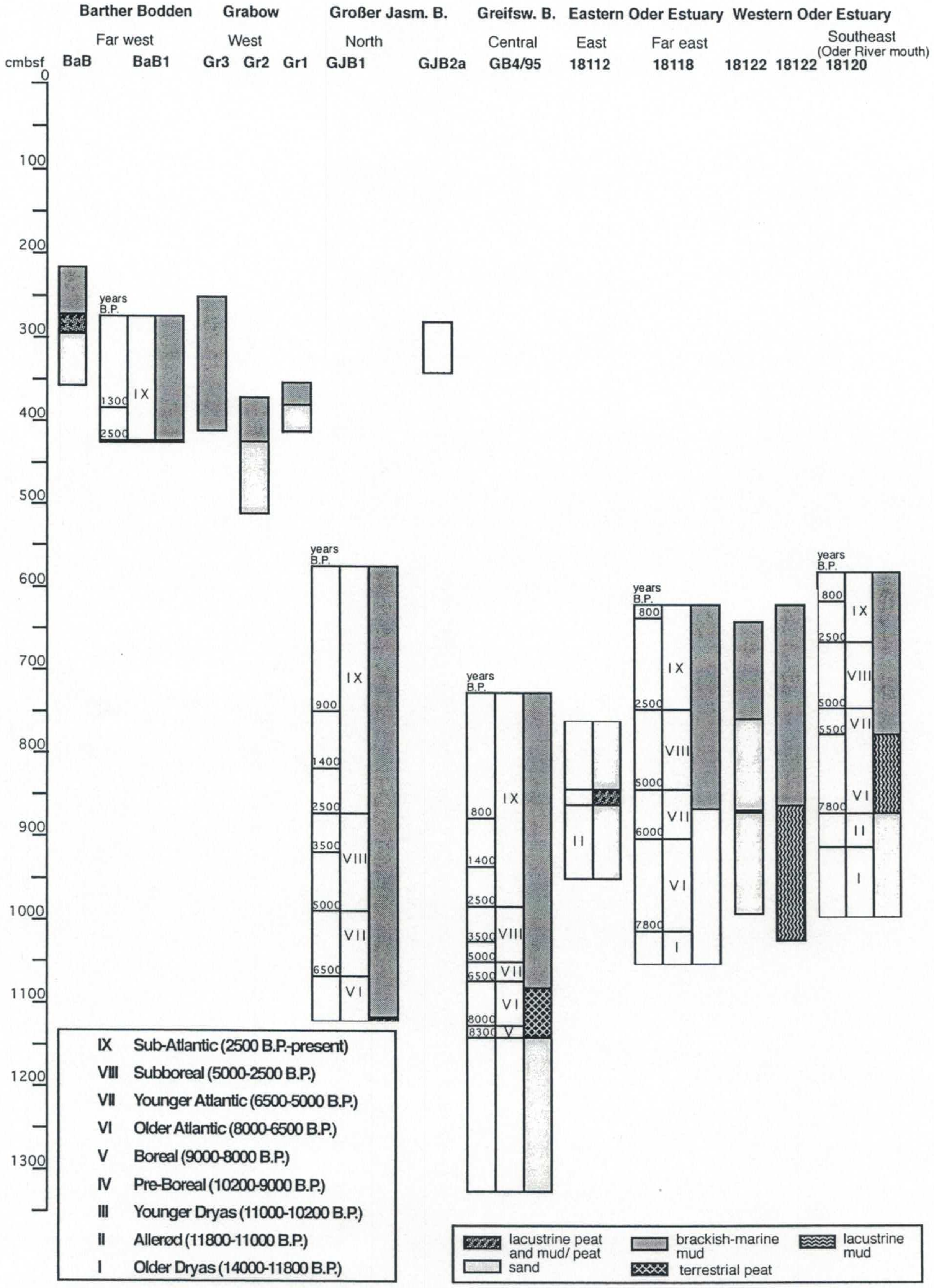

Fig. 2: Sediment sequences for all cores of this study. The age models for some cores are shown to the left of the sediment sequences.

repectively, more than a thousand years earlier than in the Oder lagoon. Autochthonous productivity started during the optimum of the first main stage of the Litorina Transgression (L1o) in both the Greifswalder Bodden and Großer Jasmunder Bodden lagoons (Fig. 3).

The findings given above strongly support the suggestion that the onset of the Litorina transgression varies regionally in the southern Baltic Sea area (Kliewe & Janke, 1982), with the northernmost lagoons being affected earlier. Such variation must be due to differences in post-glacial isostatic rebound in the Baltic Sea area, the position of the lagoon bodies to the Baltic Sea and the pre-existing relief.

The brackish-marine to brackish muds of this study show a decreasing fraction of sand toward the present. This indicates a rapid increase in quiescence of the inner shores of the Oder lagoon due to the closure of barrier islands. The lake stage in the eastern Oder lagoon around 4000 to 2000 BP (Fig. 2) appears to tie-in with the Late Litorina Regression (LLR). This lake was characterized by high autochthonous productivity (Fig. 3).

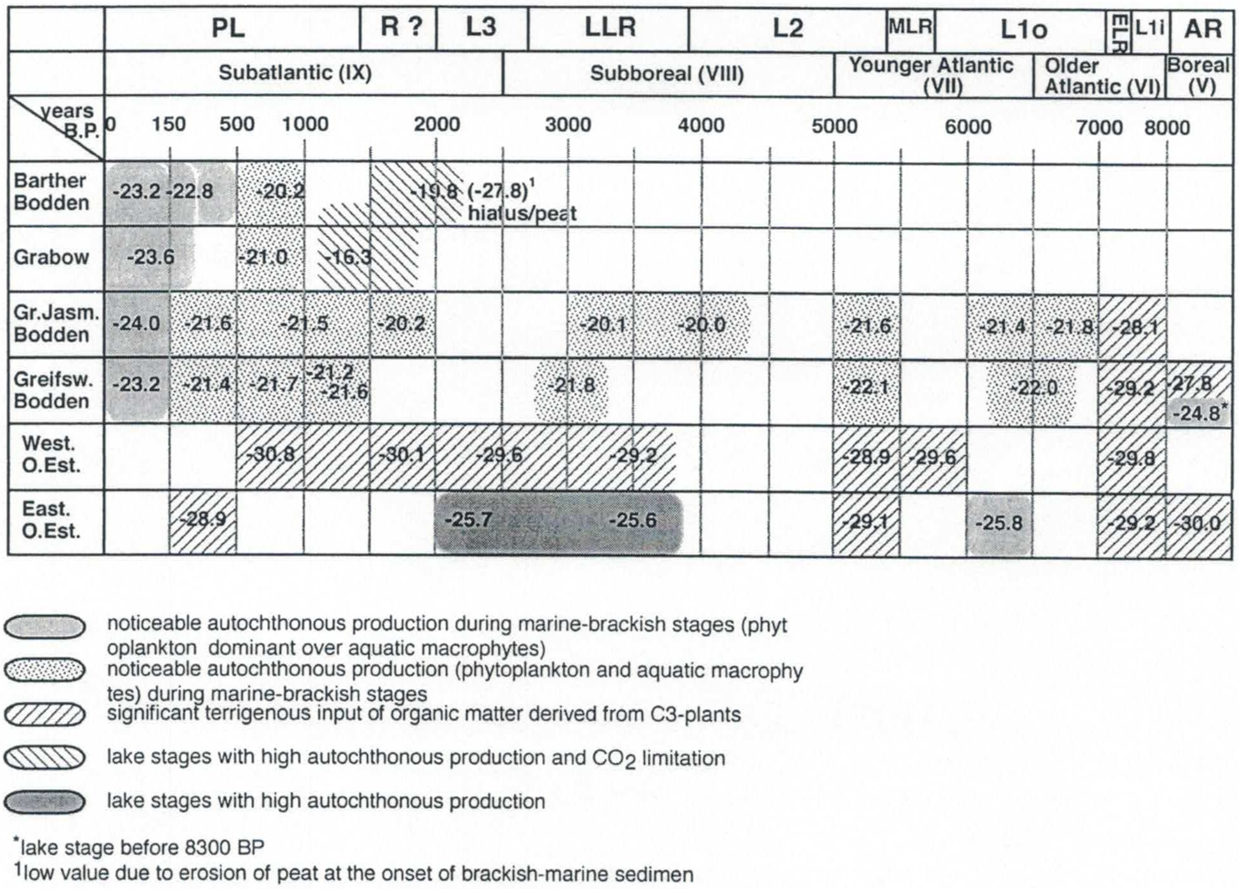

Fig. 3: Variations in the $\delta^{13}C$ isotope values over time in the lagoons of the study area. Boundary values representing marine organic matter and terrigenous organic matter such as land plants, shore plants, peat and soils were derived from measurements of organic matter sources in the study area and fully discussed in Müller and Mathesius (1999) and Müller and Voss (1999).

It has been shown that the outer coast sand spits in the southern Baltic Sea region were closed to form barrier islands in the Subboreal regression period from 4000 to 3000 yr B.P. (Kliewe & Janke, 1982, 1991). Subsequently, contact between sea and coastal lagoons diminished further owing to the growth of sand spits and barrier islands, a process which continues to the present (Kliewe & Janke, 1991). Locally, i.e. in the Barther Bodden lagoon, the onset of brackish-marine mud sedimentation can be seen rather late, e.g. 2500 BP in the northeastern part of the Barther Bodden lagoon (core BaB1) (Fig. 2). Autochthonous productivity did not become noticeable before 1500 BP at the earliest (Fig. 3), which suggests that these two lagoons were closed off from the Baltic Sea rather late compared with the other lagoons.

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