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BIO- AND LITHOSTRATIGRAPHICAL INVESTIGATIONS OF EEMIAN FLUVIOLACUSTRINE SEDIMENTS AND TILLS FROM THE LOWER PEENE VALLEY (NE GERMANY)

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Abstract. Corresponding biostratigraphical and lithological evidences permit to conclude that the drilled Eemian sediment was formed predominantly in fluviolacustrine facies in stagnant river lakes. The mollusc faunas investigated, therefore, is also of supra-regional significance and contains many mollusc species of the interglacial fluviolacustrine type. The stratigraphical classification of the sands as of the Eemian Interglacial age can be confirmed, finally, by the presence of *Theodoxus fluviatilis*. Moreover, the findings of *Marstoniopsis scholzi* were unknown so far from the Pleistocene in Germany. A constant pollen composition suggests a very short time of sedimentation during the Eemian namely from pollen zone 4 (*cf.* Erd, 1973) up to the beginning of pollen zone 5. The increasing rates of amphibole show an initial interglacial weathering impact. The surrounding morainic plateaus are covered only by a single Weichselian till (Mecklenburgian phase, qW3), which in the lower Peene valley directly overlays the Eemian fluvial deposits. A till of the younger Saalian (Warthian, qS2) underlays the fluviatile Eemian sands and the lowest till is classified as the lower Saalian glaciation (Drenthian, qS1). The Eemian fluvial sediments in the modern lower Peene valley argue for the existence of a pre-Weichselian river valley.

Key words: till, heavy minerals, pollen analysis, fluviolacustrine facies, fresh-water molluscs, *Marstoniopsis scholzi*, *Theodoxus fluviatilis*, Eemian Interglacial.

Abstrakt. Badania biostratygraficzne i litologiczne wykazały, że odwiercone osady interglacjału eemskiego powstały w jeziorze przepływowym występującym w dolinie rzecznej. Przeanalizowana fauna mięczaków ma znaczenie ponadregionalne i zawiera wiele gatunków charakterystycznych dla interglacjalnych warunków rzeczno-jeziornych. Na korelację piasków z interglacjałem eemskim wskazuje obecność gatunku *Theodoxus fluviatilis*. Stwierdzono obecność *Marstoniopsis scholzi*, który dotychczas nie był znany z osadów plejstoceńskich w Niemczech. Mało zróżnicowane spektrum pyłkowe dowodzi szybkiej sedymentacji w interglacjale eemskim podczas 4. i na początku 5. poziomu pyłkowego (por. Erd, 1973). Zwiększająca się zawartość amfibolu w osadach wskazuje na wietrzenie w pierwszej części interglacjału. Otaczająca wysoczyzna polodowcowa jest pokryta jednym pokładem gliny lodowcowej (faza meklemburska, qW3), która w dolnym odcinku doliny Peene bezpośrednio przykrywa eemskie osady rzeczne. Glina lodowcowa młodszego stadiału zlodowacenia Soławy (Warthian, qS2) podściela eemskie piaski rzeczne, natomiast niżej występująca glina lodowcowa została zakwalifikowana do starszego stadiału zlodowacenia Soławy (Drenthian, qS1). Eemskie osady rzeczne współczesnego dolnego odcinka doliny Peene wskazują na istnienie doliny rzecznej starszej od ostatniego zlodowacenia.

Słowa kluczowe: glina lodowcowa, minerały ciężkie, analiza pyłkowa, facje rzeczno-jeziorne, mięczaki słodkowodne, *Marstoniopsis scholzi*, *Theodoxus fluviatilis*, interglacjał eemski.

INTRODUCTION

This publication provides a general overview of bio- and lithostratigraphical investigations of 14 engineering drillings in the valley of the Peene River near Stolpe village, 10 km E of Anklam (Fig. 1, Mecklenburg–Western Pomerania). The results were based on faunistic investigations (Meng, 2008), pollen analysis (Strahl, 2009), analysis of heavy minerals

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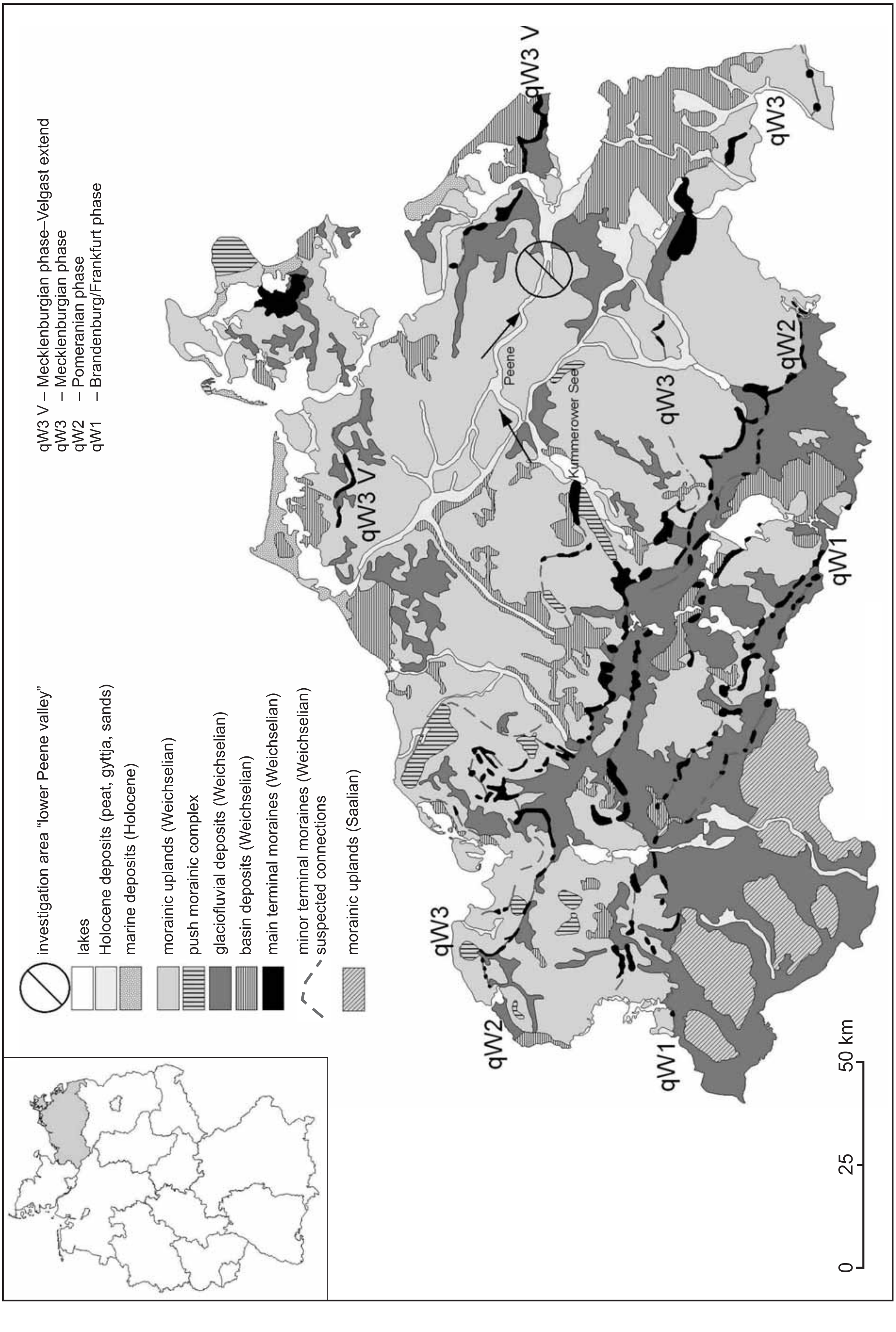

Fig. 1. General geomorphological map of Mecklenburg-Vorpommern (after Bremer, 2000)

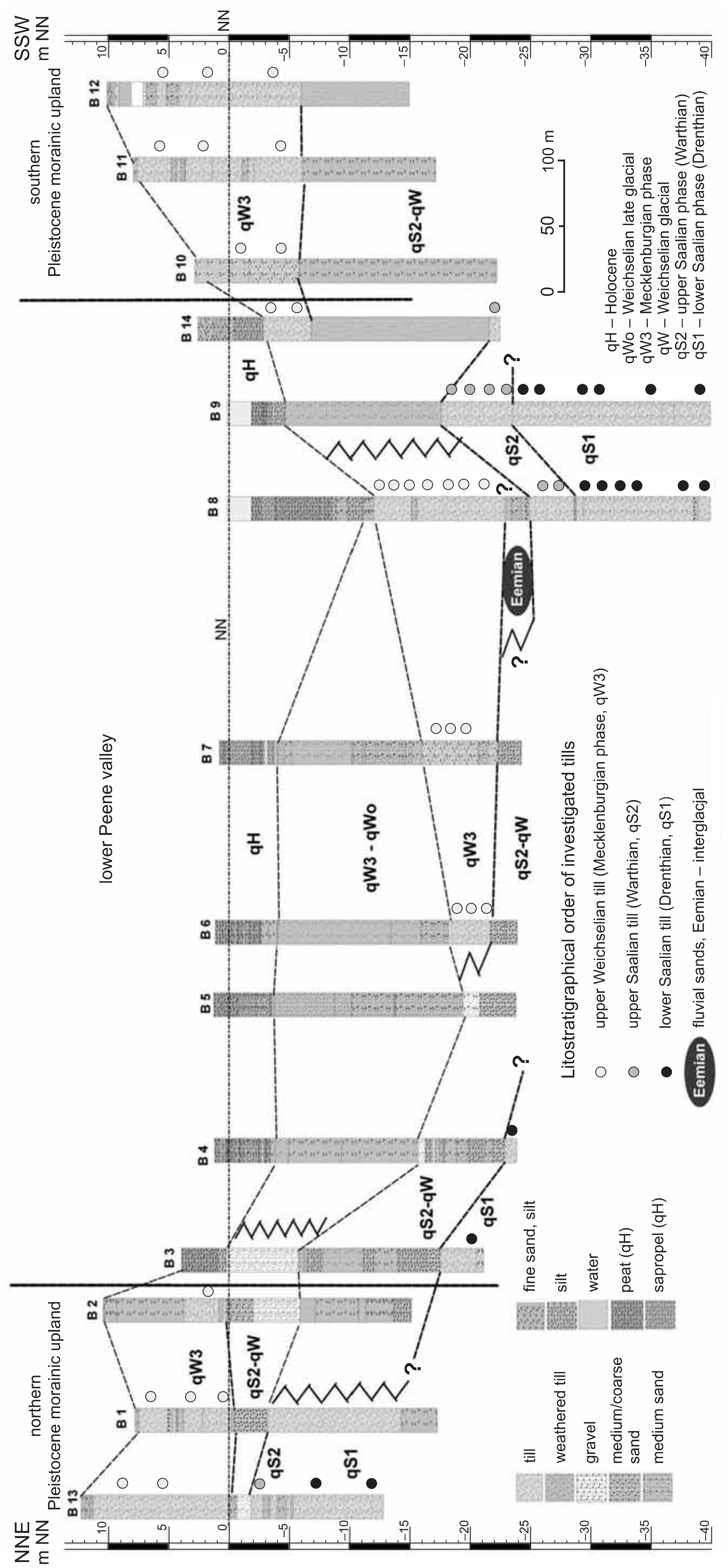

Fig. 2. Cross-section of the lower Peene valley with lithostratigraphical classification of tills

(Thieke, 2008) and lithostratigraphical classification of tills with pebble-counting method (Börner, Müller, 2008).

The modern Peene River flows through the largest fen landscape in Germany. The length of the Peene River amounts to 143 km, with steady calm flow and a very low flow level of 24 cm/km. The catchment area extends to 5,110 km^2 and the modern discharge is calculated to 20.6 m^3/s.

Entirely, the study area in northeast Germany is dominated by landforms and sediments formed during the Weichselian Glaciation. During the Weichselian, the pleniglacial period began with the first main ice advance of the Brandenburg/Frankfurt phase (qW1) and the stepwise deglaciation was interrupted by at least two substantial ice readvances of the Pomeranian (qW2) and the Mecklenburgian phases (qW3). The deglaciation processes produced a mosaic of morainic and glaciofluvial landforms, that were dissected by ice marginal valleys like the generally eastbound valley of the modern Peene River (*cf.* Fig. 1). In the study area the surface of flat and undulating morainic uplands is situated between 10–25 m a.s.l. and is mostly covered by Weichselian tills (Fig. 2). With the deglaciation of the youngest Weichselian ice sheet of the Mecklenburgian phase (qW3) the lower Peene valley was a part of the meltwater drainage system of an ice-dammed lake basin (so-called "Haffstausee") which, during Late Weichselian, extended in SE–NW-direction. Furthermore, the Peene marginal valley acted as a proglacial drainage system of the last ice sheet terminal zone of the "Velgast Extent" (qW3V) and the adjacent outwash plains. The main ice-marginal drainage system ran throughout the lower Peene valley *via* the Trebel/Recknitz valley ("Grenztal") in NW-direction, into the lower basin of the Western Baltic (Keilhack, 1899; Janke, 1978). With a phase of fluvial erosion the reversal of flow direction from W to E in Peene valley began during the Late Pleniglacial (Janke, 2002). In the drillings at lowlands in the Peene valley, up to 10 m thick layers of coarse sand and gravel, locally directly above the Weichselian till, suggest the higher energy discharge during the Late Weichselian glacial period. The postglacial landscape transformation changed the originally highly disorganized pattern of channels and depressions into the present more hierarchical hydrographical network. The calm discharge since the Atlantic Period is presented by medium and fine grained sands at >15 m b.s.l. and by organic gyttja deposits which are covered up to max. 3 m a.s.l. by the Holocene peat (Fig. 2). The Holocene Peene River development is characterized by frequently aggradational (accumulation) river stretches and at the Stolpe transect, the valley bogs are typical rheophilous mires with max. 8 m in thickness. The postglacial evolution of fluvial systems of rheophilous mires is recorded in the accumulation of organic deposits as gyttja and peats. This younger development is directly connected with eustatic sea level rise during the Littorina transgression since the Atlantic Period (Börner *et al.*, 2008).

LITHOSTRATIGRAPHY OF TILLS

The lithostratigraphical classification of tills (Börner, Müller, 2008) used a marginal modified pebble-counting method of till clasts 4–10 mm (TGL 25 232, 1980). In the Peene drill cores the gravel analysis of 53 samples focused on three types of tills with different compositions of till gravel spectra (Fig. 2). In this regional study only the uppermost Weichselian till layer contains higher percentages of Paleozoic shales (PS) and partly dolomites (D). This more "Baltic" gravel composition is clearly different if compared with the tills of the Weichselian Brandenburg/Frankfurt phase (qW1) which includes in this region higher rates of nordic crystallines (NK), Paleozoic shales (PS) and sandstones (Rühberg, 1987). The "Baltic" gravel clast associations of the uppermost Weichselian tills were described in the western region of the lower Oder river by Rühberg and Krienke (1977), who classified this upper Weichselian till as the youngest Weichselian ice advance, so called the Mecklenburgian phase (qW3). A till gravel composition of the Mecklenburgian tills of the Stolpe sections are very similar to the clast association of the upper Saalian tills (Fig. 3). In three drillings at the lower Peene valley this youngest Weichselian till was detected at depth of 10–23 m b.s.l. In the drilling B8 this more than 10 m thick qW3-till directly overlays the fluvial Eemian deposits at 23 m b.s.l. (Fig. 2).

In four drillings at the southern morainic uplands (B14, B10, B11, B12) the max. 13 m thick qW3 till is underlain by fine-grained silty sands <6 m b.s.l. Close to the Peene valley these fine-grained basin deposits separate the Weichselian till from a till with a clast association of the younger Saalian ice-advance (Warthian, qS2). In comparison to the underlying Saalian till (qS1), the max. 8 m thick "Baltic"-till of the Warthian age includes just small contents of Paleozoic shales and sandstones. A revision of the lithostratigraphical classification of tills in the surrounding Stolpe-Anklam region shows similar stratigraphical results: only one layer of the Weichselian till with "Baltic" till clast associations, typical for the tills of the Mecklenburgian phase (Börner, Müller, 2002).

In the Peene drilling project the lowest till was ascribed to the lower Saalian Glaciation (qS1, Drenthian). In the typical till clast spectrum of this Drenthian-till, rates of nordic crystallines (NK >47%) clearly dominate and in all qS1-samples the low rates of Paleozoic limestones (PK ±26%) are conspicuous. In Mecklenburg-Vorpommern the conventional subdivision of the Saalian into "Drenthian and "Warthian" subphases has been confirmed by results of numerous of drillings and investigations of gravel composition (Rühberg, 1999).

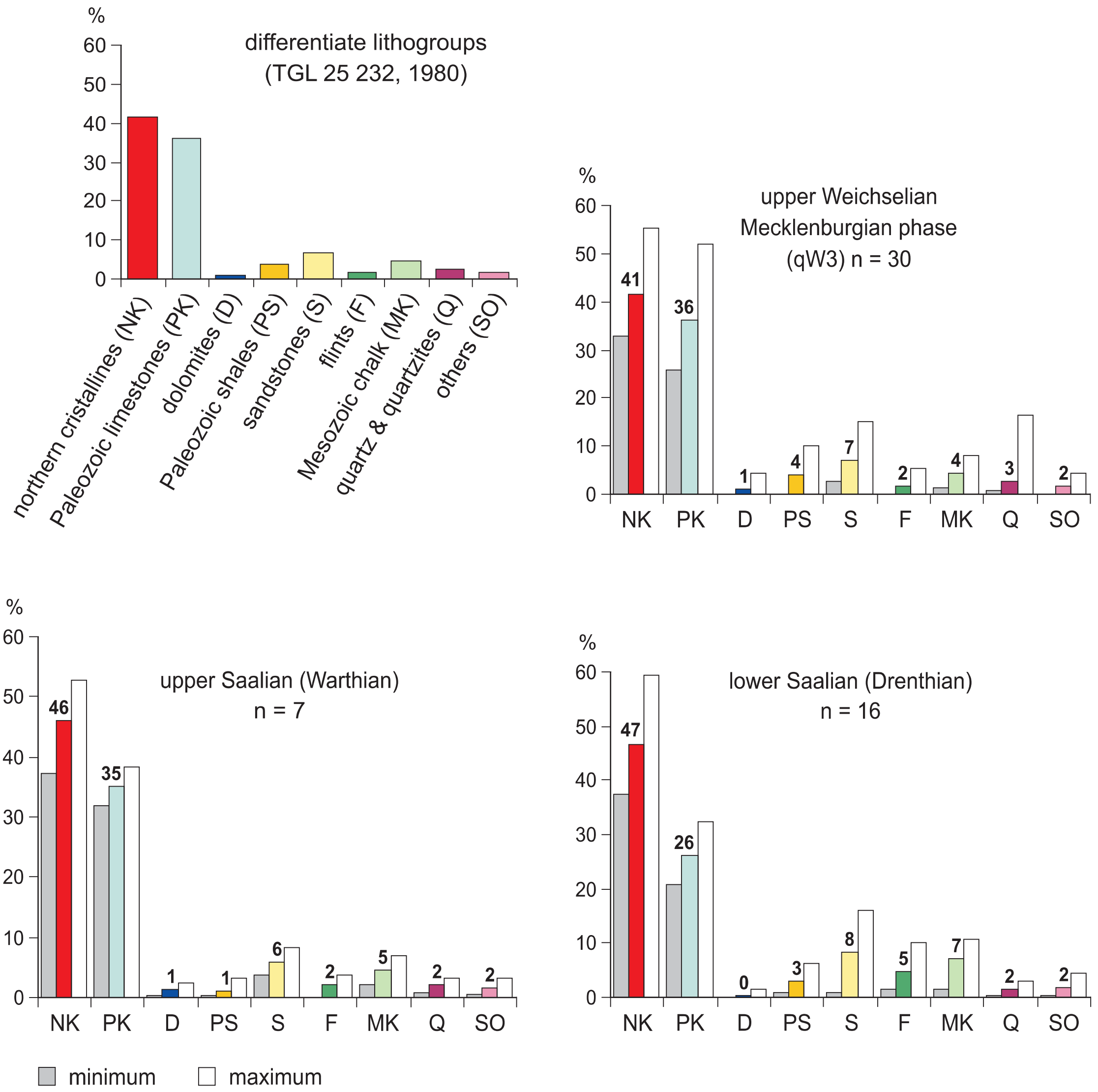

Fig. 3. Results of till clast contents (4–10 mm) from drill core samples of the lower Peene valley

SEDIMENTOLOGY AND HEAVY MINERAL COMPOSITION OF EEMIAN FLUVIAL SANDS

Heavy minerals of four sand samples from the depth range of 23–25 m in the floodplain of the Peene River drilling B8 were analysed. The sandy-silty intercalation between the underlying younger Saalian (Warthian) qS2-till and the overlying Weichselian till is interesting in a twofold manner. This layer was biostratigraphically (*cf.* this publ, chapter molluscs, Meng, 2008) clearly determined as an Eemian sediment. In the northeastern part of Germany the Eemian deposits are mostly of organic composition (peat, organic silts) and sandy-silty Eemian sediments are very rare (Brose *et al.*, 2006).

The investigated samples concern a fining upward sediment sequence, which is characterized by coarse sand at the basis and fine grained silty sands on the upper part of this Eemian sequence. By means of a dry sieving a moderate to a very bad sorting (1.4–2.0 after Trask, 1932), respectively, a middle to a very bad sorting ration (Q 3/Q 1 = 2.0–4.3 after Füchtbauer, 1988) was established. Considering the biostratigraphic (*cf.* chapter mollucs this publ.) and granulometric analysis are assumed calmy fluviolacustrine conditions of deposition.

In order to study heavy minerals and their frequency distribution in the Eemian part of the section the fractions 100–200 µm and 63–100 µm were separated by tetrabromethane in a separation funnel after Sindowski (1938). At least 300 transparent mineral grains, each on gelatine specimen holders, were determined by polarization microscopical studies. The mean value of frequency of the essential heavy minerals of both fractions is presented in Figure 4.

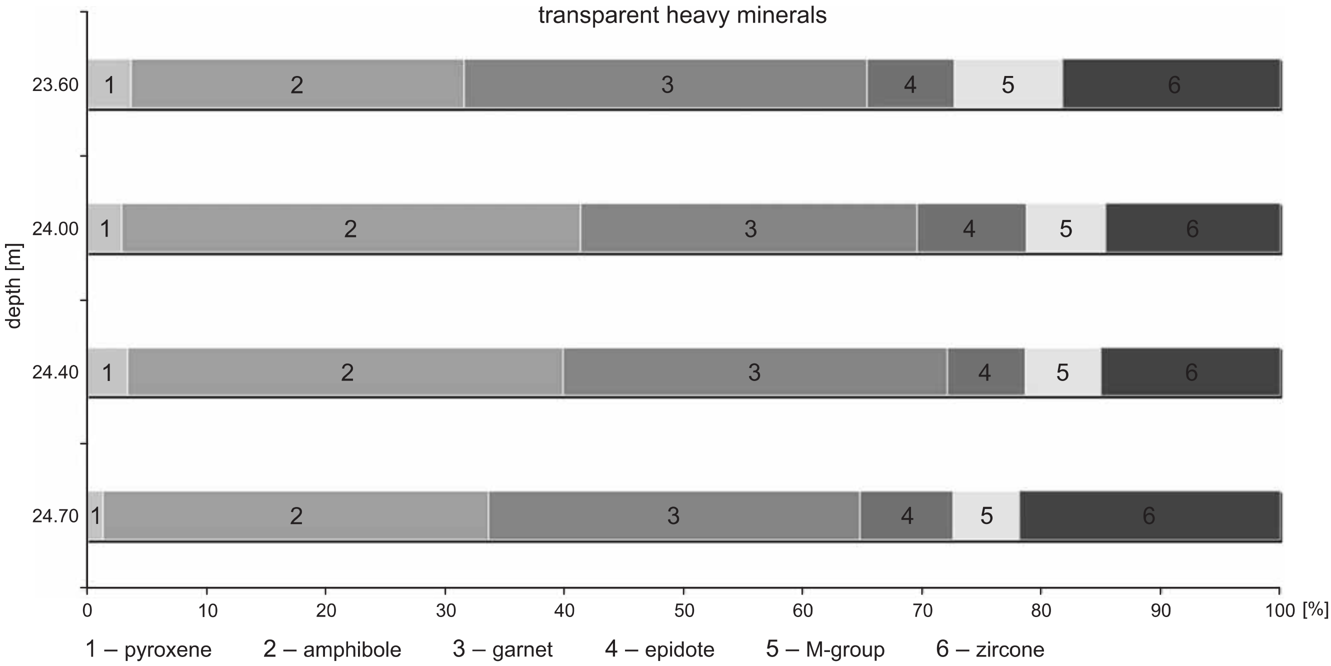

Fig. 4. Frequency distribution of the transparent heavy minerals and their relative content from the Eemian part of the drilling section B8

M-group: andalusite, apatite, topaz, tourmaline, rutile, cyanite, staurolite, sillimanite

According to a stratigraphic position of the sandy intercalation, the lowest sample (24.7–24.9 m) carries some features showing the mineral mode of the Saalian glacial deposits with almost similar contents of amphibole (32%), garnet (31%) and zircon (22%). In opposite to this, two samples from a middle part of the profile (24.0–24.6 m) shows a slowly increased content of the instable minerals: pyroxene (3%) and amphibole (36–38%), with simultaneous decrease of the stable zircon (15%). These relative fluctuations may be interpreted as an indication for intensified soil weathering originating from a climatic change and resulting in a reinforced decay of amphiboliferous crystalline boulders. Some traces of glauconite (<1%) were found there, but concerning the malacological results they are probably not indicating a short marine-brackish ingression.

Obviously, in the studied profile only the beginning of the interglacial weathering process has been conserved, because the contents in decreasing amphibole (28%) as well as in increasing garnet (34%) and zircon (18%) in the upper sample (23.6–23.8 m) suggest a glaciofluvial environment. Figure 4 shows insignificant variations of the relative content of heavy minerals around 1%. Just as slow is the varying content of opaque heavy minerals (35–42%, sulphides, oxides, not plotted here) confirming relative calm and constant sedimentation conditions.

The sum of the lithological evidences characterizes the Eemian sediment sequence as an incomplete interglacial profile. Presumably, it was deposited in a flat but extended fluviolacustrine accumulation area with a low energetic hydrological regime (stagnant river lakes) and cut off from or at least under reduced fluvial erosion. Similar depositional conditions were observed during the Late Elsterian until the Early Saalian Glacial "Berliner Elbelauf" (so called Berlin course of the river Elbe) (Strahl, Thieke, 2002), respectively at the occurrence of the Eemian of Strausberg (30 km E Berlin) (Müller *et al.*, 2008).

PALAEOZOOLOGY

MOLLUSCS

The sands sampled from the drilling B8 in the Peene meadows at a depth of about 23–25 m contained many specimens of mollusc faunas of interglacial fluviolacustrine type (Table 1). Evidence was found of a total of 30 fresh-water species (2855 specimens from 8 samples). There was a complete lack of terrestrial specimens. The fluviatile conditions were demonstrated especially by the occurrence of *Unio crassus*, *Theodoxus fluviatilis* (Fig. 5), *Pisidium amnicum* and *Pisidium supinum.*

Overall, however, the dominant species of these faunas, namely *Bithynia tentaculata*, *Valvata piscinalis* (Fig. 5) and *Sphaerium corneum,* point to a conclusion about gently flow-

Table 1

Molluscs (absolute numbers of specimens, frg: fragments), mammals and fish

Samples / **Mollusca**	1/1	1/2	1/3	2/1	2/2	2/3	2/4	2/5
Theodoxus fluviatilis (Linnaeus, 1758)	3	2			1	3	4	3
Viviparus contectus (Millet, 1813)			1					
Marstoniopsis scholzi (A. Schmidt, 1856)	1	9	1					5
Bithynia tentaculata (Linnaeus, 1758)	70	97	105	72	55	203	234	828
Bithynia leachii (Sheppard, 1823)		2	4				1	4
Valvata cristata O. F. Müller, 1774		10	1	1			5	8
Valvata piscinalis (O. F. Müller, 1774)	2	45	26	10	17	12	14	50
Acroloxus lacustris (Linnaeus, 1758)								4
Lymnaea stagnalis (Linnaeus, 1758)					1		1	2
Radix auricularia (Linnaeus, 1758)	2	1	1	1		1		8
Radix cf. *balthica* (Linnaeus, 1758)				1				3
Radix sp.	frg	1	frg			frg	1	frg
Myxas glutinosa (O. F. Müller, 1774)								1
Lymnaeidae					frg		frg	frg
Gyraulus crista (Linnaeus, 1758)								3
Planorbarius corneus (Linnaeus, 1758)	2	1	2			1		4
Unio tumidus Philippson, 1788								3
Unio crassus Philippson, 1788		1		2	1	5	3	9
Unio sp.	frg	frg	frg	frg	frg	frg	frg	frg
Anodonta anatina (Linnaeus, 1758)								1
Anodonta sp.			frg	1				frg
Pseudanodonta complanata (Rossmässler, 1835)								1
Sphaerium corneum (Linnaeus, 1758)	15	42	38	20	10	40	70	524
Pisidium amnicum (O. F. Müller, 1774)	2	1	1		2	2	3	11
Pisidium henslowanum (Sheppard, 1825)		4			3	1	3	20
Pisidium cf. *henslowanum* (Sheppard, 1825)	1					3		
Pisidium supinum Schmidt, 1851						1		20
Pisidium milium Held, 1836			1				1	1
Pisidium subtruncatum Malm, 1855		1						3
Pisidium nitidum Jenyns, 1832		2				1		3
Pisidium casertanum (Poli, 1791)							1	
Pisidium casertanum ponderosum (Stelfox, 1918)	2	1				2		6
Pisidium moitessierianum Paladhile, 1866			1					
Species: 30	**12**	**16**	**14**	**8**	**9**	**14**	**14**	**28**
Shells: 2855	**102**	**221**	**185**	**110**	**92**	**277**	**343**	**1525**
Pisces								
Perca fluviatilis Linnaeus, 1758	X							X
Rutilus rutilus (Linnaeus, 1758)		X	X		X	X	X	X
Scardinius erythrophthalmus (Linnaeus, 1758)						X		
Salmoniformis					X			
Esox lucius Linnaeus, 1758						X		X
Mammalia								
Apodemus sp.								X

Samples: 1/1: 24.65–25.00 m; 1/2: 24.35–24.60 m; 1/3: 24.00–24.35 m; 2/1: 23.90–24.00 m; 2/2: 23.70–23.90 m; 2/3: 23.50–23.70 m; 2/4: 23.30–23.50 m; 2/5: 23.00–23.30 m

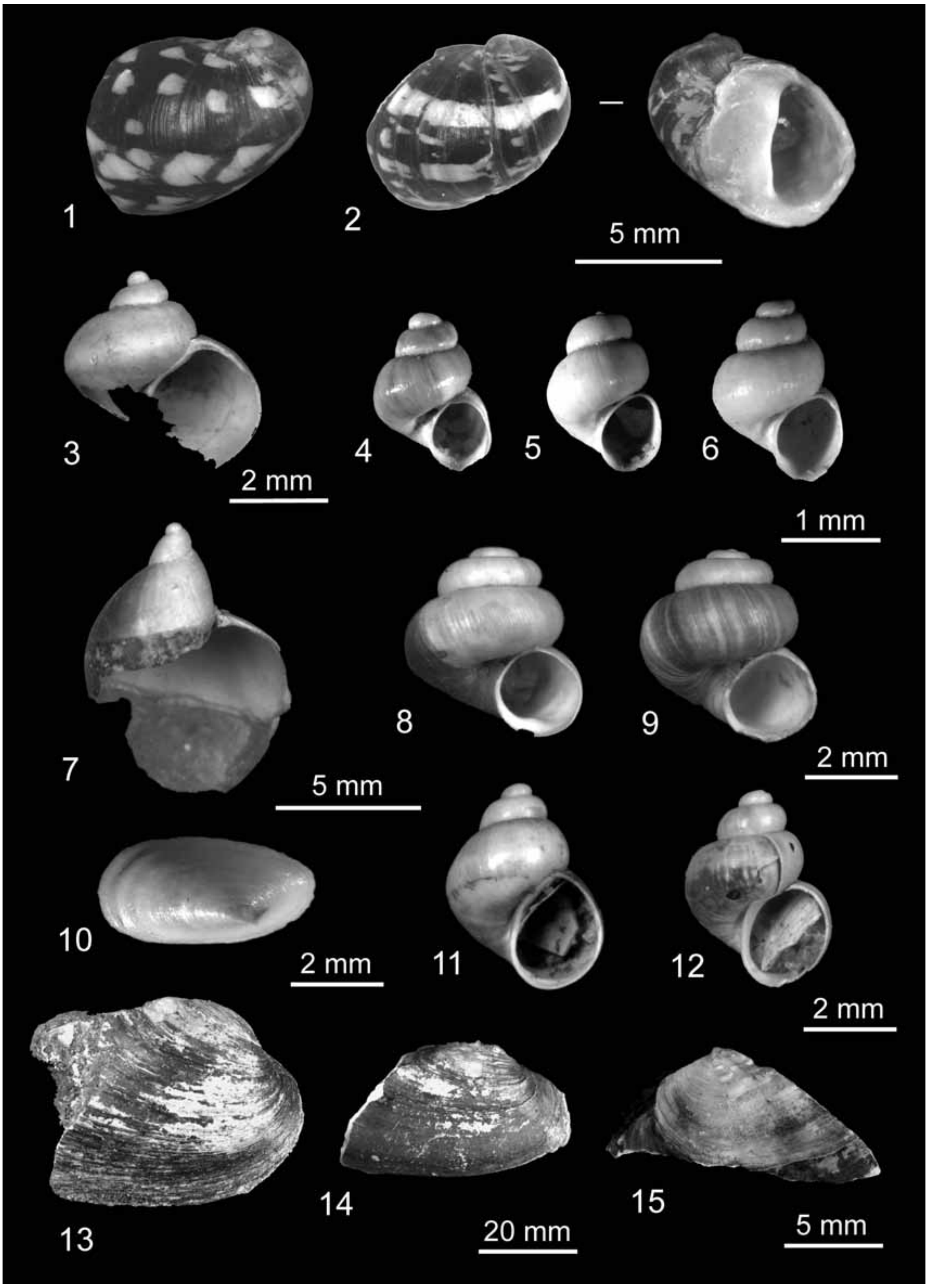

Fig. 5. Eemian mollusc faunas of the Peene drilling B8

1, **2** – *Theodoxus fluviatilis* (sample 2/3, 2/5), **3** – *Viviparus contectus* (sample 1/3), **4**, **5**, **6** – *Marstoniopsis scholzi* (sample 1/3, 1/2, 2/5), **7** – *Radix auricularia* (sample 1/3), **8**, **9** – *Valvata piscinalis* (sample 1/2), **10** – *Acroloxus lacustris* (sample 2/5), **11** – *Bithynia tentaculata* (sample 2/4), **12** – *Bithynia leachii* (sample 1/3), **13** – *Unio crassus* (sample 2/5), **14** – *Unio tumidus* (sample 2/5), **15** – *Pseudanodonta complanata* (sample 2/5) ing water. Further indications of this are provided, for example, by *Viviparus contectus, Acroloxus lacustris* and *Radix auricularia* (Fig. 5) or *Planorbarius corneus*. The associations observed well correlate with the modern faunas of the Peene River (Zettler, 1998).

The stratigraphical classification of the sands as of the Eemian Interglacial can be confirmed, finally, by the presence of *Theodoxus fluviatilis*. This interglacial index species had previously been known since the Eemian only (e.g. Bibus, Rähle, 2003). Fluviolacustrine formations of the Eemian as a whole have only rarely been reported, so therefore, occurrences of *T. fluviatilis* are also extremely rare. Evidence of this species has been found, for example, in the Neckar region of southern Germany (*op. cit.*) and in marine Eemian deposits with limnic influence from Offenbüttel in northern Germany (Jaeckel, 1963; Hinsch, 1985). Similar conditions can be assumed for *Viviparus contectus*, since no reliable proofs of earlier (pre-Eemian) occurrences of this species have been presented either (Fig. 5). Hence, the Holsteinian Interglacial in comparison with the Eemian is still characterised by the species *Theodoxus serratiliniformis* and *Viviparus diluvianus* which were already extinct in the middle Pleistocene.

The findings of *Marstoniopsis scholzi* (Fig. 5, synomym of *M. insubrica*?) are also noteworthy because this species was evidently unknown previously from the Pleistocene in Germany, although it had been reported, for example from Denmark (*cf.* Glöer, 2002).

Falniowski and Wilke (2001) have put forward the view that the *M. scholzi* found mainly in the Baltic region constitutes a synonym of the southern alpine *M. insubrica* (Küster, 1853). But the assessment of the palaeo-zoogeographical relationships remains problematic because, for example, *Marstoniopsis* has so far not been found from the Pleistocene in the central German region despite the high concentration of investigations.

Although, today, the level of the Peene River meadows is very low (0.1 m a.s.l.), and despite the closeness to the coast of these findings, in the evidence from the mollusc faunas of the Peene region near Stolpe, it was surprising to find no marine or brackish influences for the period of the Eemian transgression in the Baltic region (Eemian optimum, see above).

Because of the general rarity of fluviatile faunas from the Eemian and in view of this first evidence of Pleistocene *Marstiniopsis scholzi* in Germany, these faunas are of supra-regional significance.

FISH

Isolated fish remains were also found (Table 1). The vast majority comprised teeth and fish scales. The faunas found include *Esox lucius, Perca fluviatilis, Rutilus rutilus* and *Scardinius erythrophthalmus* which also points to quite gentle flow speeds in the aqueous habitat. On the other hand, evidence of a representative of the Salmoniformis confirms the fluviatile conditions. These faunas show interglacial characteristics.

MAMMALS

Just occasionally, remnants of small mammals were found (Table 1). It was possible to identify a molar of the wood mouse *Apodemus* sp. This can be interpreted as a further indication of interglacial conditions.

PALYNOLOGICAL RESULTS

From lenses of organic silts 12 samples were taken, but only three samples could be used for a statistical analysis (Table 2). The 3 samples with statistics show a constant composition of tree pollen flora with pine, hazel, oak, alder, birch, lime and seldom elm, ash, hornbeam, spruce and very seldom fir and ivy. The very low herbaceous pollen content is dominated by grasses and sedges. Inside open water occurred water and cow lily, less frequently watermilfoil, the water fern *Salvinia* (absent glochidae as an evidence for *Azolla filiculoides* suggest a non pre-Eemian age of the sediments) and algae (*Pediastrum boryanum, P. kawraiskyi*, various diatoms) – Table 3. Swampy areas respectively reeds were settled by ferns, horsetail, bulrush and sphagnum. May be due to a continuous fluviatile input always pre-Quaternary sporomorphs are present with indeed high but decreasing rates up to the top of the sediment horizon. The examined sediments do not repre-sent a sequence of a constant fluviolacustrine sedimentation during the Eemian Interglacial. The pollen analysis assumed a very short time of sedimentation during the Eemian, pollen zone 4 after Erd (1973, time of deciduous mixed forests with oak and hazel) up to the beginning of the pollen zone 5 (time of main prevalence of hazel, yew and lime). A Holocene age can be definitely excluded, probably also a Holsteinian age, mainly due to high content of hazel and to less of spruce.

Table 2

Quantitative pollen-analytical results of the samples 1, 2 and 9 in the drilling B8 – AP, NAP, swamp- and aquatic plants, ferns, moss

Taxa / Sample / Depht in m b.s.l. / Ident-No.	9 23.37 100083874	2 24.03 100083881	1 24.41 100083883
AP in %			
Salix sp.	0.3	–	0.4
Betula sp.	18.4	10.4	9.9
Pinus sp.	33.2	26.5	30.6
Ulmus sp.	0.9	1.8	0.8
Quercus sp.	6.2	7.1	11.9
Corylus sp.	14.5	18.8	9.9
Alnus sp.	4.7	11.9	13.1
Tilia sp.	1.5	0.3	1.6
Fraxinus sp.	0.9	0.3	1.2
Carpinus sp.	–	0.9	1.2
Picea sp.	0.9	2.4	1.6
Abies sp.	–	0.3	0.8
Hedera sp.	–	–	0.4
Fagus sp.	–	0.6	–
Σ BP in %	**81.6**	**81.2**	**83.3**
NAP in %			
Poaceae	11.9	11.6	7.1
Cyperaceae	3.3	3.9	3.6
Calluna sp.	–	0.3	0.8
Ericaceae p.p.	0.3	0.6	0.8
Artemisia sp.	0.6	0.9	0.8
Chenopodiaceae	0.3	–	0.4
Tubuliflorae	–	–	1.2
Liguliflorae	–	0.3	0.4
Cruciferae	–	0.6	–
Umbelliferae	0.3	–	–

Taxa / Sample / Depht in m b.s.l. / Ident-No.	9 23.37 100083874	2 24.03 100083881	1 24.41 100083883
Rosaceae p.p.	0.6	0.6	0.4
Filipendula sp.	0.6	–	1.2
Fabaceae	0.3	–	–
Σ NAP in %	**18.4**	**18.8**	**16.7**
Σ (AP + NAP)	**337**	**336**	**252**
Swamp- and waterplants, ferns, moss in %			
Ceratophyllum, leaf prickles	0.9	–	–
Myriophyllum spicatum	0.3	–	–
Nuphar sp.	0.3	–	–
Nymphaea sp.	0.6	–	–
Nymphaeaceae, statoblasts	4.5	2.1	7.9
Salvinia natans?, massulae debris	0.3	–	0.4
Typha-Sparganium-type	2.7	0.9	1.6
Typha latifolia	1.2	–	0.4
Ranunculus acer-type	0.3	–	–
Equisetum sp.	0.3	2.4	1.2
Lycopodium compl.-clavatum-type	–	0.3	–
Lycopodium annotinum	0.3	–	–
Lycopodium sp.	–	–	0.8
Osmunda sp.	–	–	0.8
Pteridium aquilinum	0.6	0.3	0.4
Polypodium vulgare	0.3	–	–
Monoletes without perispore	7.7	6.8	8.3
Sphagnum	0.3	1.5	1.2
Spores of fungi and moss	–	–	+
Antheridien	–	0.3	–

Table 3

Quantitative pollen-analytical results of the samples 1, 2 and 9 of the drilling B8 – algae, plankton, pre-Quaternary sporomorphs

Taxa / Sample / Depht in m b.s.l. / Ident-No.	9 23.37 100083874	2 24.03 100083881	1 24.41 100083883
Algae, plankton and microremains in %			
Pediastrum boryanum	5.0	3.0	3.2
Pediastrum kawraiskyi	1.2	3.6	5.6
Botryococcus sp.	+	+	+
Diatomaphyceae, pennate	0.3	0.6	0.4
Diatomaphyceae, cyclic	–	0.3	–
Cyanophyceae	–	–	+
Ovoidites sp.	–	1.2	0.4
Spirogyra sp.	0.3	–	–
Sponge needles	++	++	+
Cladocera, debris	0.3	–	–
Turbellaria, debris	0.3	1.2	–
Filinia sp.	–	0.3	–
Chironomidae	0.3	–	–
Varia	1.5	1.2	2.0

Taxa / Sample / Depht in m b.s.l. / Ident-No.	9 23.37 100083874	2 24.03 100083881	1 24.41 100083883
Pre-Quaternary sporomorphs (Tertiary and older) in %			
Taxodiaceae-Cupressaceae-group	3.9	13.7	23.8
Sciadopytis sp.	0.3	1.2	3.6
Myrica sp.	0.3	–	–
Carya sp.	–	–	0.4
Liquidambar sp.	–	0.3	0.4
Ilex sp. (redeposited)	–	–	0.4
Tricolporates	–	2.1	1.2
Tricolpates	0.9	–	–
Triletes	0.3	1.5	2.0
Stereisporites	–	–	0.4
Dinocysts	2.4	12.8	18.2
Wood, cell remains	–	0.3	–

CONCLUSIONS

The Eemian sands contained many species of mollusc faunas of the interglacial fluviolacustrine type. The fluviatile conditions were demonstrated especially by the occurrence of *Unio crassus*, *Theodoxus fluviatilis*, *Pisidium amnicum* and *Pisidium supinum*. The stratigraphical classification of the sands as of the Eemian Interglacial can be confirmed, finally, by the presence of *Theodoxus fluviatilis*. The findings of *Marstoniopsis scholzi* (synomym of *M. insubrica*?) are also noteworthy, because this species was evidently unknown previously from the Pleistocene in Germany.

Sedimentological and especially heavy mineral studies were carried out on a 2 m thick sandy-silty layer of the Eemian age. On the basis of the ratio increase above all of amphibole, an initial interglacial weathering impact was proved by an accelerated decay of amphiboliferous nordic crystalline rocks. Corresponding biostratigraphical and lithological evidences permit to conclude that the drilled Eemian sediment succession predominantly represents a fluviolacustrine facies and was formed under stagnant river lake depositional conditions.

The results of palynological investigations assume a very short time of sedimentation during the Eemian, namely from the pollen zone 4 after Erd (1973, time of deciduous mixed forests with oak and hazel) up to the beginning of the pollen zone 5 (time of main prevalence of hazel, yew and lime) at 125 ka BP (*cf.* beginning of the Eemian Stage in Europe at 127.2 ka, Brauer *et al*., 2007; Litt, Gibbard, 2008).

The surrounding, flat or undulating morainic plateaus are covered by a single Weichselian till of the Mecklenburgian phase (qW3). In the Peene valley the till of the Mecklenburgian phase overlies the Eemian fluvial deposits directly above –23 m b.s.l. A maximum 8 m thick till of the younger Saalian (Warthian, qS2) underlies the fluvial Eemian sands. The lowest till was classified into the lower Saalian Glaciation (Drenthian, qS1). The Eemian fluvial sediments in the recent Peene valley argue a existence of a pre-Weichselian river valley depression, which could be closely connected to the north with marine Eemian deposits at –30 m b.s.l. at NW Usedom island (*cf.* Müller, 2004).

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