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SHORT COMMUNICATION

Contribution to the European Pollen Database in Neotoma: a pollen diagram from the Kampe site, Quakenbrück Basin/western Lower Saxony (Germany)

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Site and collected material

The Quakenbrück Basin (ca. 20–30 m a.s.l.) with a maximum extent of 30 × 15 km^2 was shaped during the Drenthe stadial of the Saalian glaciation. The ice-tongue basin is bordered by the terminal push moraine of the Fürstenauer Berge in the southwest and Dammer Berge in the southeast. The ice advance assigned to the Rehburg Phase caused a deep vertical erosion. In the centre of the basin, the underlying Eocene sediments are located at around 110 m depth covered by Drenthian till and thick sands (Hahne et al. 1994). During the Late Saalian and the decline of MIS 6, respectively, a lake developed, which persisted throughout the Eemian (corresponding to MIS 5e) and parts of the Weichselian. This palaeolake is known as the largest lake existing in north-western Germany at that time (Hahne et al. 1994). The limnic sediments are covered by sand of (niveo)fluviatile origin, deposited during the Weichselian pleniglacial. Wildvang (1935) and Jonas (1937) did pioneer work regarding the palynological investigation of deposits assigned to the Eemian. More recently, the study of Hahne et al. (1994) revealed continuous pollen preservation covering the complete Eemian, early Weichselian, and parts of the Weichselian pleniglacial until the Ebersdorf stadial, the second stadial within the Weichselian pleniglacial.

The Kampe drill site (52° 70′ 12.49″ N, 8° 03′ 74.89″ E, 24 m a.s.l.) is situated around 6 km northeast of the city of Quakenbrück. It has been drilled in 2012 on behalf of the State Office for Mining, Energy and Geology of Lower Saxony. The core reaches down to 78 m below surface covering the whole sequence of basin sediments subject to 3D-modelling. At the base and up to 62.3 m below surface more than 15 m of Drenthian till followed by sand with gravels (62.3–54.8 m) were found. Between 54.8 and 44.9 m, the core mainly consists of sand with different admixtures of gravel, silt, and clay. From 44.9 to 31.7 m a calcareous mud was deposited covered by silty to clayey muds (31.7–22.5 m) with intercalated sand layers. These muds are overlain by (fine) (niveo)fluviatile sand with intercalations of thin clayey to silty layers (e.g. 7.8–7.55 m and 6.55–6.3 m below surface).

Chronology

One *Carex* nutlet was extracted at 7.67 m depth. Unfortunately, this nutlet did not contain enough carbon for dating purposes. Therefore, the chronology presented here is based on biostratigraphy covering the Saalian Late Glacial through the Eemian and early Weichselian to the Weichselian pleniglacial (Menke and Tynni 1984; Behre and Lade 1986).

Methods

The samples were prepared for pollen analysis following standard methods (Faegri and Iversen 1989). After the chemical treatment with 10% HCl and with 10% KOH, the

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samples were sieved followed by the treatment with cold HF overnight and acetolysis for 5 min. Finally, the samples were cleaned ultrasonically using sieves with 10 µm mesh size. Pollen grains were identified under 400× and 1,000× magnification using a light microscope (Leica) and the pollen key of Beug (2004) besides a reference pollen collection. A total of 146 samples were analysed. Except for depths below 38 m and above 22.5 m a minimum of 600 arboreal pollen grains were counted in order to achieve relatively constant percentages. The pollen sum for percentage calculations includes all terrestrial pollen, whereas aquatic pollen and all spores are excluded (their percentages were calculated based on the terrestrial pollen sum as well). Pollen nomenclature follows the EPD/Neotoma and Beug (2004) and spore nomenclature Reille (1998). The biostratigraphic subdivision of the pollen diagram (Fig. 1) is according to Menke and Tynni (1984) and Behre and Lade (1986).

Interpretation

The base of the pollen diagram (44.9–39.2 m) is characterised by the dominance of reworked arboreal taxa, especially 'Tertiary' elements, such as *Nyssa*, *Sciadopytis*, *Sequoia*-type, and *Taxodium*-type. Therefore, it is assigned to the Saalian Late Glacial (Pollen zone A sensu Menke and Tynni 1984) reflecting a treeless environment with sparse growing heliophilous taxa (e.g. Poaceae, *Artemisia*, Amaranthaceae, and *Thalictrum*). The subsequent zone B (39.2–38 m) shows *Hippophaë* values between 2 and 6% pointing to the presence of *Hippophaë* shrub stands. The increase of heliophilous taxa, like Poaceae, *Artemisia*, Chenopodiaceae, *Helianthemum*, and *Thalictrum*, also indicates more favourable climatic conditions resulting in a denser vegetation cover. Consequently, the proportions of redeposited arboreal taxa are decreasing. During zone C (38–37.7 m) shrub stands still play an important role, however, the *Betula* values are increasing and a short expansion of *Pinus* is witnessed. This subdivision of the Saalian Late Glacial has also been confirmed by Hermsdorf and Strahl (2008). The Eemian interglacial with its rather uniform vegetation development all over Central Europe (see Behre and van der Knaap 2023), begins with a distinct increase of the *Betula* values reflecting the spread of open *Betula* woodland (Pollen zone E I; 37.7–37.1 m) followed by the rise of the *Pinus* curve indicating the presence of *Pinus*-*Betula* woodlands (Zone E II; 37.1–35.9 m), in which *Ulmus* and (with some delay) *Quercus* immigrated. The subsequent zone E III (35.9–34.9 m) is characterised by deciduous mixed woodlands dominated by *Quercus* and accompanied by *Pinus*. During this zone, the comparably high *Betula* values are referable to local *Betula* stands in a silted-up area of the former lake, because such high *Betula* proportions were not registered in the pollen record Quakenbrück GE 2 (Hahne et al. 1994; a re-digitized version of the pollen diagram is shown in Stojakowits and Mayr 2022) situated close to the centre of the former lake. The same applies for the high *Alnus* values at the beginning of zone E VI. Samples showing dominance of *Corylus* correspond to zone E IVa (34.9–34.7 m), the time of prevailing deciduous mixed woodlands with an understorey rich in *Corylu*s. Zone E IVb (34.7–34.5 m) as well as zone E IVa has a very low resolution. Therefore, the maxima of *Tilia* and *Taxus*, characteristic for this zone, are truncated. Pollen spectra dominated by *Carpinus* and accompanied by increasing *Picea* proportions correspond to zone E V (34.5–32 m). May be, the earliest part of this zone has also a low resolution. From 32 to 28.7 m the pollen assemblages with initially dominating *Alnus* and increasing values of *Pinus*, *Picea* and *Abies*, characterise the lowermost part of zone E VI. In the course of this zone, the curves of deciduous trees, especially *Alnus*, *Quercus*, and *Carpinus*, decrease and *Pinus* becomes dominant accompanied by pretty constant *Betula* and *Picea* proportions. Noteworthy is the early spread of Ericales depending on the soil conditions. Slightly increasing values of herbs indicate a first opening of the woodlands. From 31.3 m onwards, the samples again contain many reworked arboreal taxa. Additionally, above 31.2 m sand layers are intercalated in the core. The subsequent zone E VII (28.7–26.7 m), the last pollen zone of the Eemian, with prevailing open *Pinus* woodland and the general acidification of the soil (a phenomenon well-known in the north German lowlands, e.g. Behre 1989; Caspers et al. 2002) is characterised by comparably high *Betula* values in the middle part. Such a subdivision of the outgoing Eemian into three pollen subzones (*Pinus* dominated, *Betula* dominated and *Pinus* dominated again) is known from Poland (Kupryjanowicz et al. 2016) and much more less pronounced from eastern Germany close to the Polish border (Novenko et al. 2008) generally interpreted as sign of the environment instability.

As shown by Menke and Tynni (1984) and Behre and Lade (1986), the dominance of Ericales and *Pinus* in conjunction with continuously increasing *Artemisia* values marks the onset of the first stadial of the early Weichselian (Zone WF I; 26.7–22.5 m), the Herning stadial. Additionally, the core contains a sand layer closely above the Eemian-Weichselian transition. The pollen spectra of the Herning stadial indicate a steppe-like tundra vegetation with small patches of dwarf shrub stands. Again, many reworked arboreal pollen grains were registered. Based on the pollen spectra, the Herning stadial may be subdivided into two pollen subzones, a preceding subzone WF Ia dominated by *Calluna* and poor in Poaceae followed by subzone WF Ib, rich in Poaceae, *Artemisia* and other herbs. The subsequent Brørup interstadial

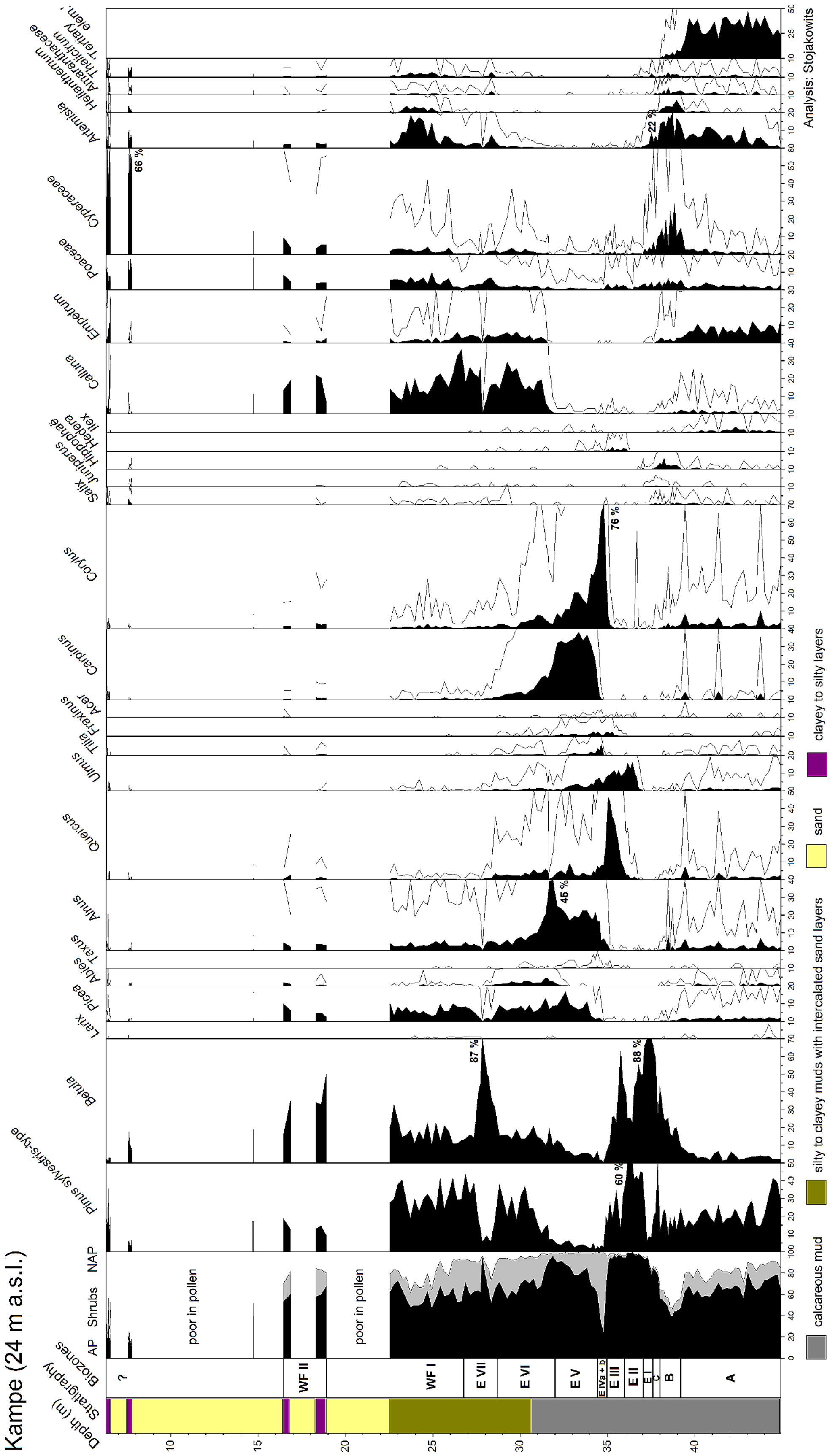

Fig. 1 Percentage pollen diagram of the Kampe drill site; white curves are 10x exaggerated

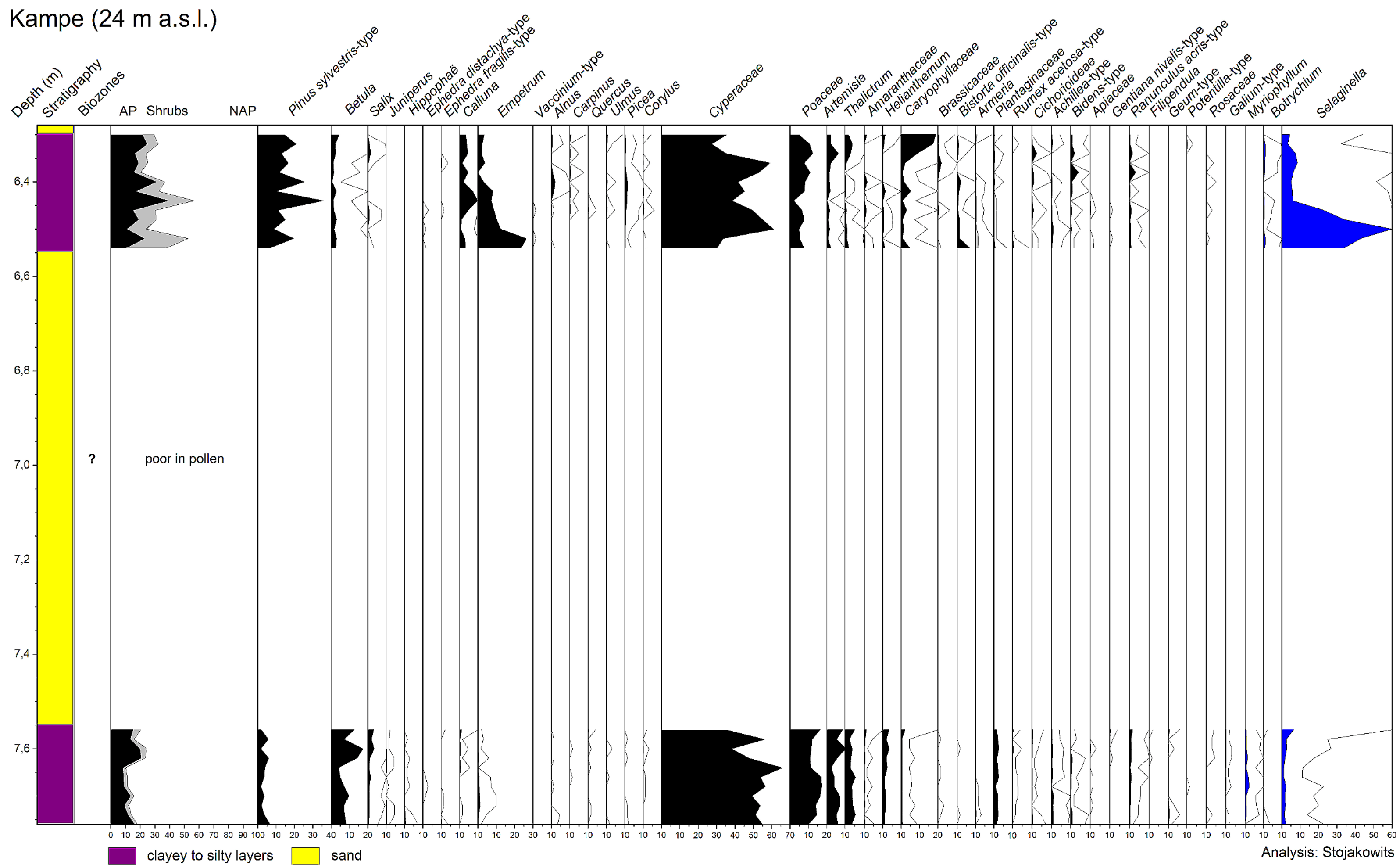

Fig. 2 Percentage pollen diagram of the uppermost section of the Kampe drill site (7.76–6.3 m); curves in blue represent taxa excluded from the pollen sum. Note that the pollen-bearing samples between 7.8–7.55 m and 6.55–6.3 m depth consist of clayey to silty layers intercalated in the prevailing sand

(Zone WF II; 18.9–16.4 m) is incomplete being just a part of the *Betula* period with lots of redeposited arboreal pollen, whereas the subsequent *Pinus* period is lacking. Finds of aquatic taxa, like *Pediastrum* and *Potamogeton* (not shown in the pollen diagram), indicate limnic conditions until 22.5 m depth. This is in accordance with the change in stratigraphy from lacustrine to (niveo)fluviatile sedimentation at this depth. The pollen assemblages of the pollen-bearing samples above 8 m depth can be related to either the early Weichselian (= Rederstall stadial) or the Weichselian pleniglacial. If the Weichselian pleniglacial is represented, then the following interpretation would be possible. Between 7.8 and 7.65 m depth, stadial conditions with dominating Cyperaceae (the local presence is witnessed by one *Carex* nutlet extracted at 7.67 m) and around 7.6 m interstadial conditions, even though very weak, are indicated (Fig. 2). The *Betula* peak (over 17%) together with the slightly elevated values of *Salix*, *Juniperus*, and *Hippophaë* point to a short spread of dwarf shrub stands at climatically favourable sites as response to improved climatic conditions. However, the pollen assemblages are dominated by Cyperaceae and other heliophilous taxa like Poaceae, *Artemisia, Thalictrum* and *Helianthemum*. Based on the fact, that above a depth of 19.2 m the Weichselian pleniglacial is represented, it is very unlikely that this interstadial found here being a time-equivalent of the Oerel interstadial described by Behre and Lade (1986). Furthermore, *Selaginella* is lacking in the Oerel interstadial (Behre 1989), whereas it is continuously present in this section of the Kampe pollen profile. A correlation with the Moershoofd complex can also be excluded due to the higher *Betula* values occurring in the Kampe record compared to other records (e.g. Zagwijn 1974; Kolstrup and Wijmstra 1977). Therefore, one of the remaining Glinde (Behre and Lade 1986), Hengelo, and Denekamp interstadials (e.g. Zagwijn 1974; Kolstrup and Wijmstra 1977) should correlate with this interstadial. Last but not least, between 6.55 and 6.3 m another stadial generally dominated by Cyperaceae with high proportions of *Selaginella* and *Empetrum* in the lower part was found, whereas in the upper part higher Caryophyllaceae values occur.

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