XXXVIII International Moor Excursion

From the mountains to the sea – Lower Saxony/Germany

07.–14.09.2014

Excursion Guide

Organizers

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Lower Saxony Institute for Historical Coastal Research, Wilhelmshaven

NIhK Wilhelmshaven

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Excursion route

Accomodation

07.09.	Naturfreundehaus Bündheim, Bad Harzburg	Tel. 05322 4582
08.09.	Bundeslehranstalt Burg Warberg, Warberg	Tel. 05355 9610
09.09.	Hotel & Restaurant Prüser's Gasthof, Hellwege	Tel. 04264 9990
10.09.	Naturfreundehaus "Heinrich Frey" am Wollingster See	no phone
11./12.09.	Friesen-Hotel, Jever	Tel. 04461 4340
13.09.	Haus Tafelfreuden & Hotel Sprenz, Oldenburg	Tel. 0441 83227

Itinerary (roughly)

Sunday 07.09.2014

	Individual arrival at Hanover Central Station / Hof Cafe
16:00 –	Approx. 75 min bus drive to the Harz mountains
	Accomodation at the Naturfreundehaus Bad Harzburg
18:00 –	Welcome BBQ at the Naturfreundehaus

Monday 08.09.2014

08:30 –	Check-out and departure
08:45 –	Bogs of the Harz mountains (Radauer Born, Sonnenberger Moor)
11:45 –	Lunch
12:30 –	Departure for Schöningen
14:00 –	Paläon Center and Palaeolithic excavation in the opencast mine Schöningen
17:00 –	Departure for the memorial of the inner German border at Hötensleben
18:30 –	Accomodation and dinner at Burg Warberg

Tuesday 09.09.2014

08:00 –	Check-out and departure (long bus haul)
11:00 –	Vegetation and history of Northwest German Heathlands – Lüneburger Heide
	Lunch in the field (Toter Grund)
14:00 –	Departure for Eversen
15:30 –	Palaeolimnology of Northwest German lakes – Eversener See
17:30 –	Accomodation and dinner at Prüser's Gasthof in Hellwege
20:30 –	Evening night drink at Hermann Behling's house in Hellwege

Wednesday 10.09.2014

09:00 –	Check-out and departure
10:15 –	Palaeotopography and vegetation history of Sievern
12:00 –	Departure for Wanna
12:30 –	Lunch
13:00 –	Neolithic settlement and land-use in northwestern Germany
15:00 –	Departure for Wollingst
15:30 –	Palaeolimnology of Northwest German lakes – Wollingster See
17:30 –	Accomodation and buffet at Naturfreundehaus Wollingster See

Thursday 11.09.2014

08:30 –	Check-out and departure
09:30 –	The last growing bog at the North Sea coast – Sehestedter Außendeichsmoor
12:00 –	Departure for Neuenburg
12:30 –	Lunch
13:15 –	The historical forest “Neuenburger Urwald”
15:15 –	Departure for Jever
15:45 –	Accomodation at Friesenhotel in Jever
16:30 –	Guided tour at Jever brewery
18:30 –	Dinner at restaurant “Jever Fass”

Friday 12.09.2014

06:30 –	Early departure for Neßmersiel
07:30 –	Hike through the tidal flats to the island of Baltrum
	en-route: Settlement and Cultural History of the Wadden Sea
11:00	Crossing Baltrum from salt marshes through dunes to the beach
	Development of the East Frisian Islands
	Sea level history and submerged landscapes of the North Sea
17:15 –	Return by ferry to Neßmersiel and by bus to Jever
19:30 –	Dinner at restaurant “Jever Fass”
	Accomodation at Friesenhotel in Jever

Saturday 13.09.2014

09:00 –	Check-out and departure
09:30 –	Fuel peat cutting in Wiesmoor
10:30 –	Peat and horticulture in Wiesmoor
12:00 –	Bog renaturation at Stapeler Moor
13:00 –	Lunch
14:00 –	Departure for Bad Zwischenahn
14:30 –	Searching for early Neolithic at Lake Zwischenahner Meer
16:30 –	*Sphagnum* cultivation at Hankhauser Moor
17:30 –	Departure for Oldenburg
18:00 –	Accomodation at hotels “Tafelfreuden” and “Sprenz” in Oldenburg
19:00 –	Farewell dinner at restaurant “Tafelfreuden”

Sunday 14.09.2014

Departure

Participant list

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Facts about Lower Saxony

Lower Saxony (German: Niedersachsen) is a German state (Bundesland) situated in northwestern Germany and is second in area, with 47,624 km^2, and fourth in population (8 million) among the sixteen states of Germany. In rural areas Northern Low Saxon, a dialect of Low German, and Saterland Frisian, a variety of East Frisian, are still spoken, but the number of speakers is declining.

Lower Saxony borders on (from north and clockwise) the North Sea, the states of Schleswig-Holstein, Hamburg, Mecklenburg-Vorpommern, Brandenburg, Saxony-Anhalt, Thuringia, Hesse and North Rhine-Westphalia, and the Netherlands. Furthermore, the Free Hanseatic City of Bremen forms two enclaves within Lower Saxony, one being the city of Bremen, the other, its seaport city of Bremerhaven. In fact, Lower Saxony borders more neighbours than any other single Bundesland. The state's principal cities include the state capital Hanover, Brunswick, Lüneburg, Osnabrück, Oldenburg, Hildesheim, Wolfenbüttel, Wolfsburg and Göttingen.

The northwestern area of Lower Saxony, which lies on the coast of the North Sea, is called East Frisia and the seven East Frisian Islands offshore are popular with tourists. In the extreme west of Lower Saxony is the Emsland, a traditionally poor and sparsely populated area, once dominated by inaccessible swamps. The northern half of Lower Saxony, also known as the North German Plains, is almost invariably flat except for the gentle hills around the Bremen geestland. Towards the south and southwest lie the northern parts of the German Central Uplands: the Weser Uplands and the Harz mountains. Between these two lie the Lower Saxon Hills, a range of low ridges. Thus, Lower Saxony is the only Bundesland that encompasses both maritime and mountainous areas.

The region in the northeast is called the Lüneburg Heath (Lüneburger Heide), the largest heathland area of Germany and in medieval times wealthy due to salt mining and salt trade, as well as to a lesser degree the exploitation of its peat bogs up until about the 1960s. To the north, the Elbe river separates Lower Saxony from Hamburg, Schleswig-Holstein, Mecklenburg-Western Pomerania and Brandenburg. The banks just south of the Elbe are known as Altes Land (Old Country). Due to its gentle local climate and fertile soil it is the state's largest area of fruit farming, its chief produce being apples.

Most of the state's territory was part of the historic Kingdom of Hanover; the state of Lower Saxony has adopted the coat of arms and other symbols of the former kingdom. It was created by the merger of the State of Hanover with several smaller states in 1946.

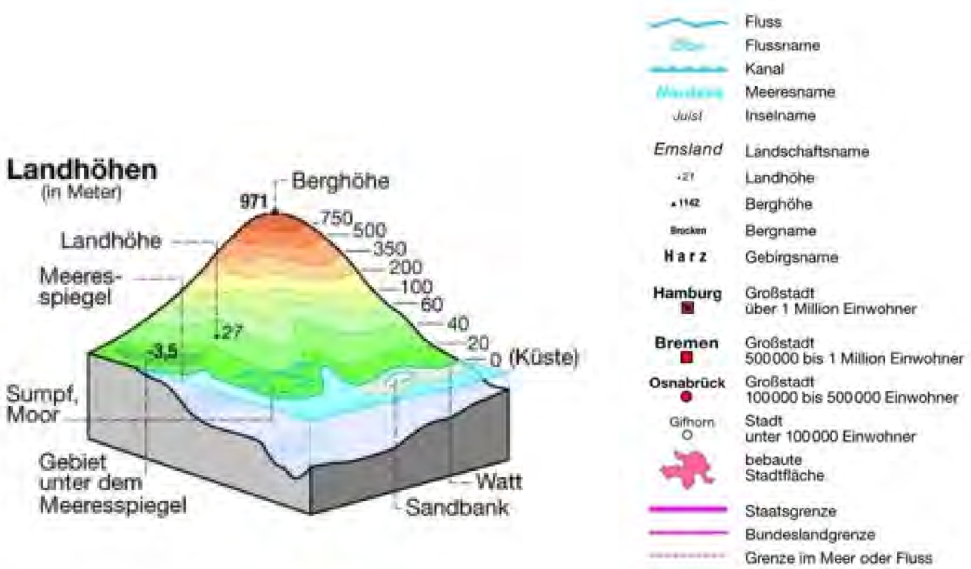
Lower Saxony falls climatically into the north temperate zone of central Europe that is affected by prevailing westerlies and is located in a transition zone between the maritime climate of Western Europe and the continental climate of Eastern Europe. This transition is clearly noticeable within the state: whilst the northwest experiences an Atlantic (North Sea coastal) to Sub-Atlantic climate, with comparatively low variations in temperature during the course of the year and a surplus water budget, the climate towards the southeast is increasingly affected by the continent. This is shown by greater temperature variations between summer and winter and in lower and more variable amounts of precipitation across the year. This sub-continental effect is most sharply seen in the Wendland, in the Weser Uplands (Hamelin to Göttingen) and in the area of Helmstedt. The highest levels of precipitation are experienced in the Harz because the Lower Saxon part forms the windward side of this mountain range against which orographic rain falls. The average annual temperature is 8 °C (7.5 °C in the Altes Land and 8.5 °C in the district of Cloppenburg).

Landscapes of Lower Saxony

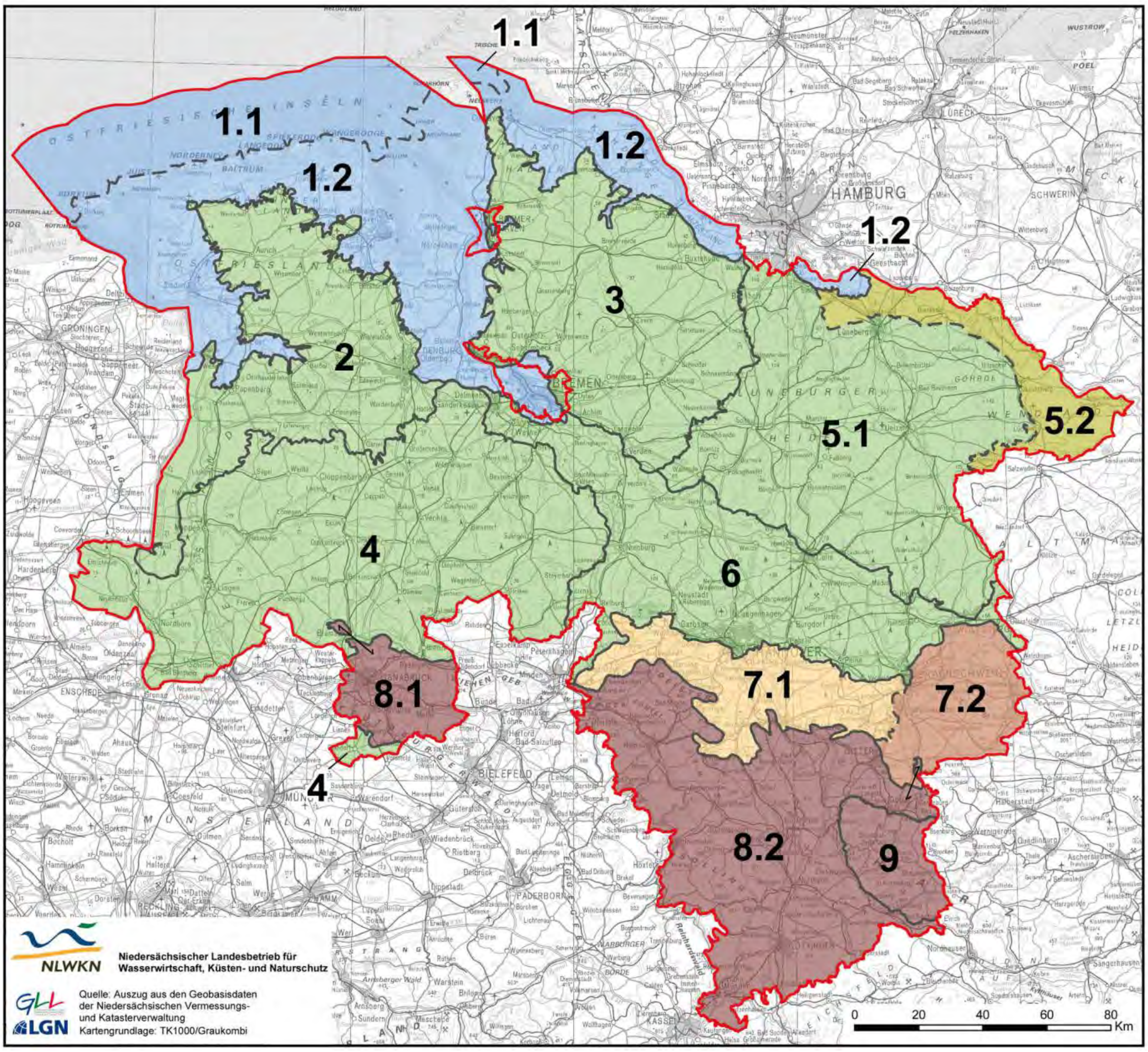
with excursion stops

1	Bogs of the Harz mountains
2	Schöningen spears
3	Totengrund in the Lüneburg Heath
4	Lake Eversen
5	Palaeolandscape at Sievern
6	Neolithic sites at Wanna and Flögeln
7	Lake Wollingst
8	The „swimming“ bog of Sehestedt
9	The historical forest of Neuenburg
10	Baltrum Island
11	Peat exploitation at Wiesmoor
12	Bog regeneration at Stapeler Moor
13	Stone Age sites at Zwischenahner Meer
14	Paludiculture at Hankhauser Moor

Physical geography of Lower Saxony



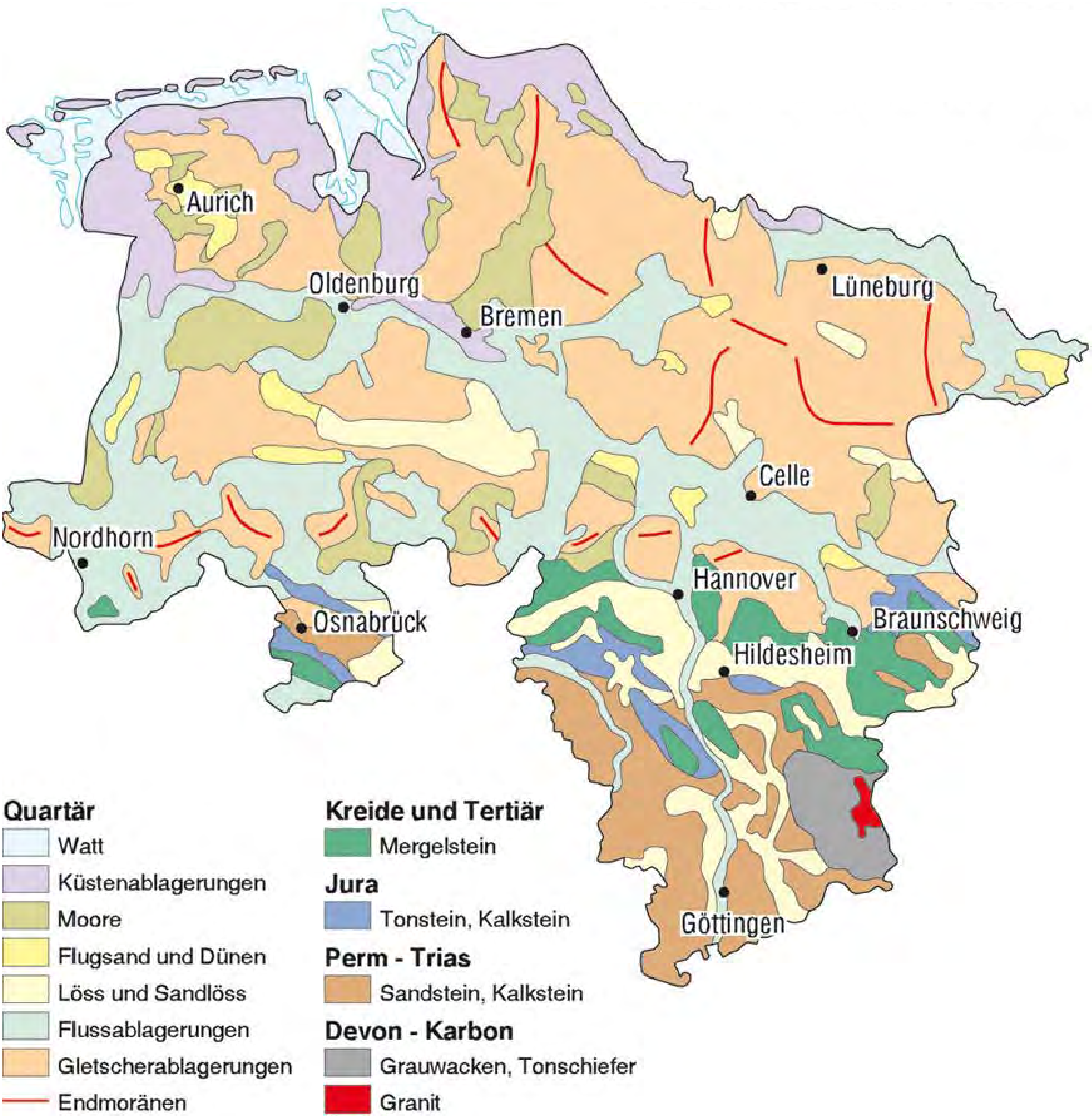
Natural regions of Lower Saxony



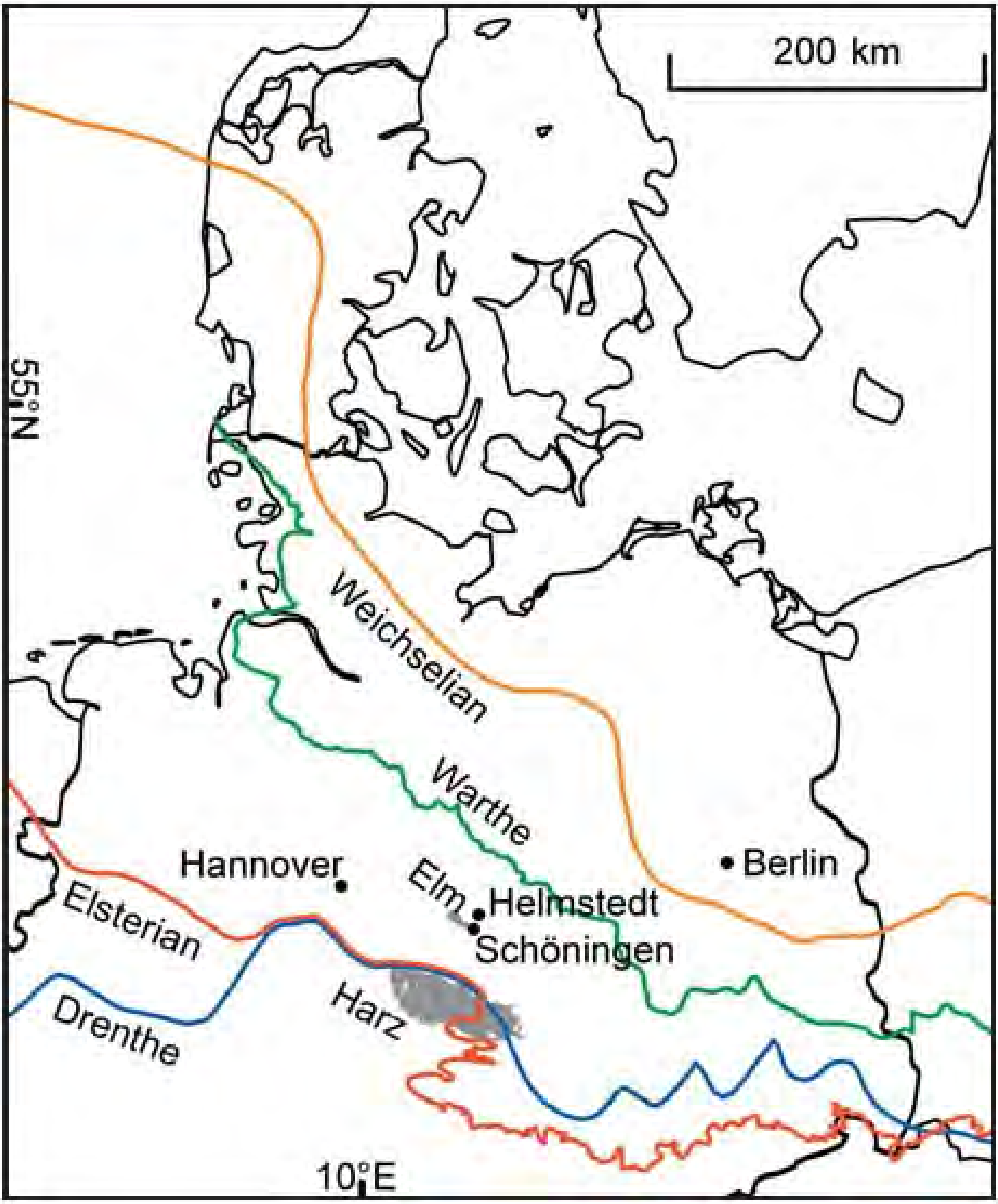
1	Niedersächsische Nordseeküste und Marschen
1.1	Deutsche Bucht
1.2	Watten und Marschen
2	Ostfriesisch-Oldenburgische Geest
3	Stader Geest
4	Ems-Hunte-Geest und Dümmer-Geestniederung
5	Lüneburger Heide und Wendland
5.1	Lüneburger Heide
5.2	Wendland, Untere Mittelelbeniederung
6	Weser-Aller-Flachland
7	Börden
7.1	Börden (Westteil)
7.2	Ostbraunschweigisches Hügelland
8	Weser- und Weser-Leinebergland
8.1	Osnabrücker Hügelland
8.2	Weser-Leinebergland
9	Harz

- Küste (atlantische biogeographische Region)
- Tiefland (atlantische biogeographische Region)
- Tiefland (kontinentale biogeographische Region)
- Hügel- und Bergland (atlantische biogeographische Region)
- Hügel- und Bergland (atlantische biogeographische Region, tlw. kontinental geprägt)
- Hügel- und Bergland (kontinentale biogeographische Region)

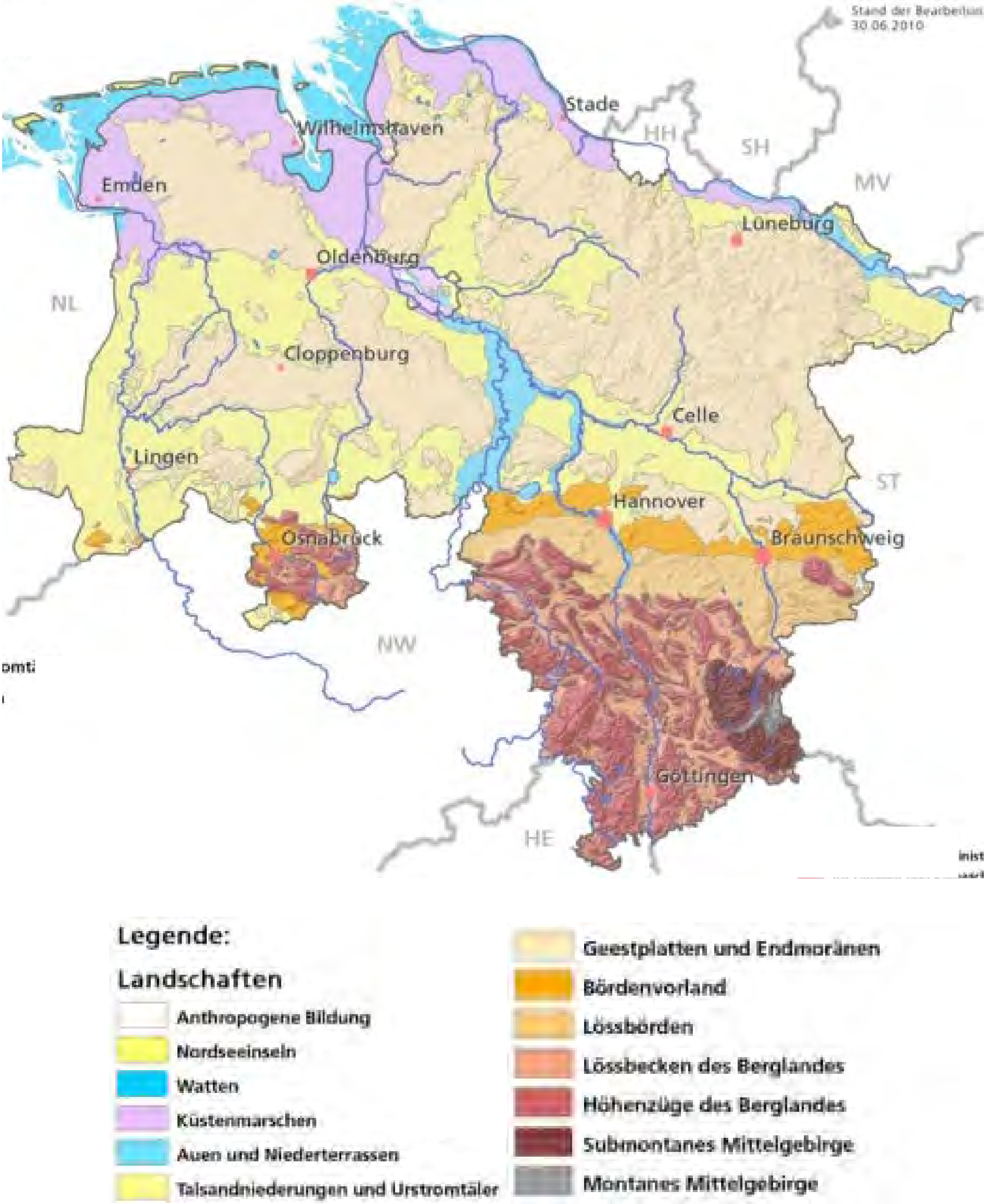
Geology of Lower Saxony



Maximum extent of ice advances

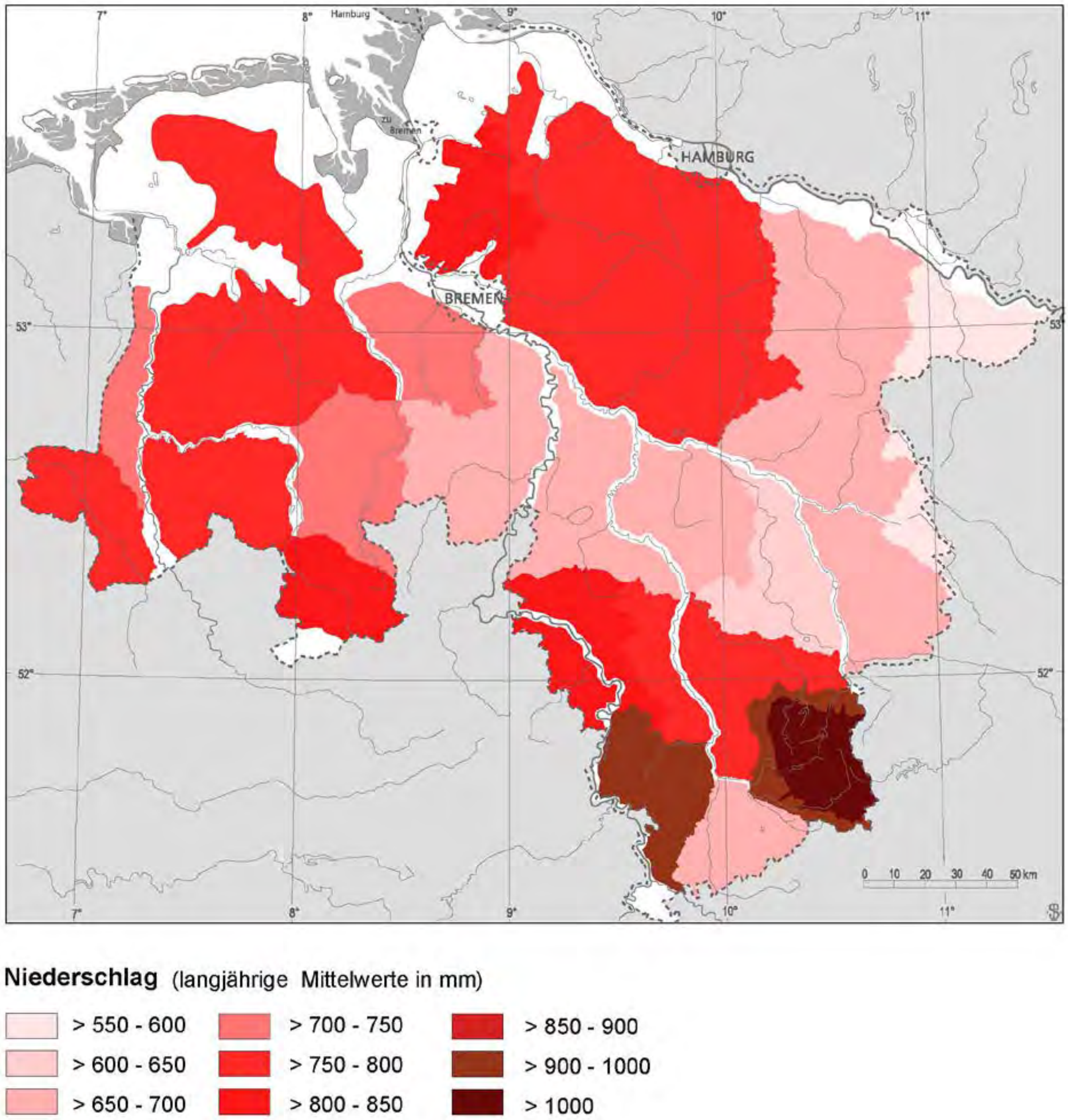


Soils of Lower Saxony

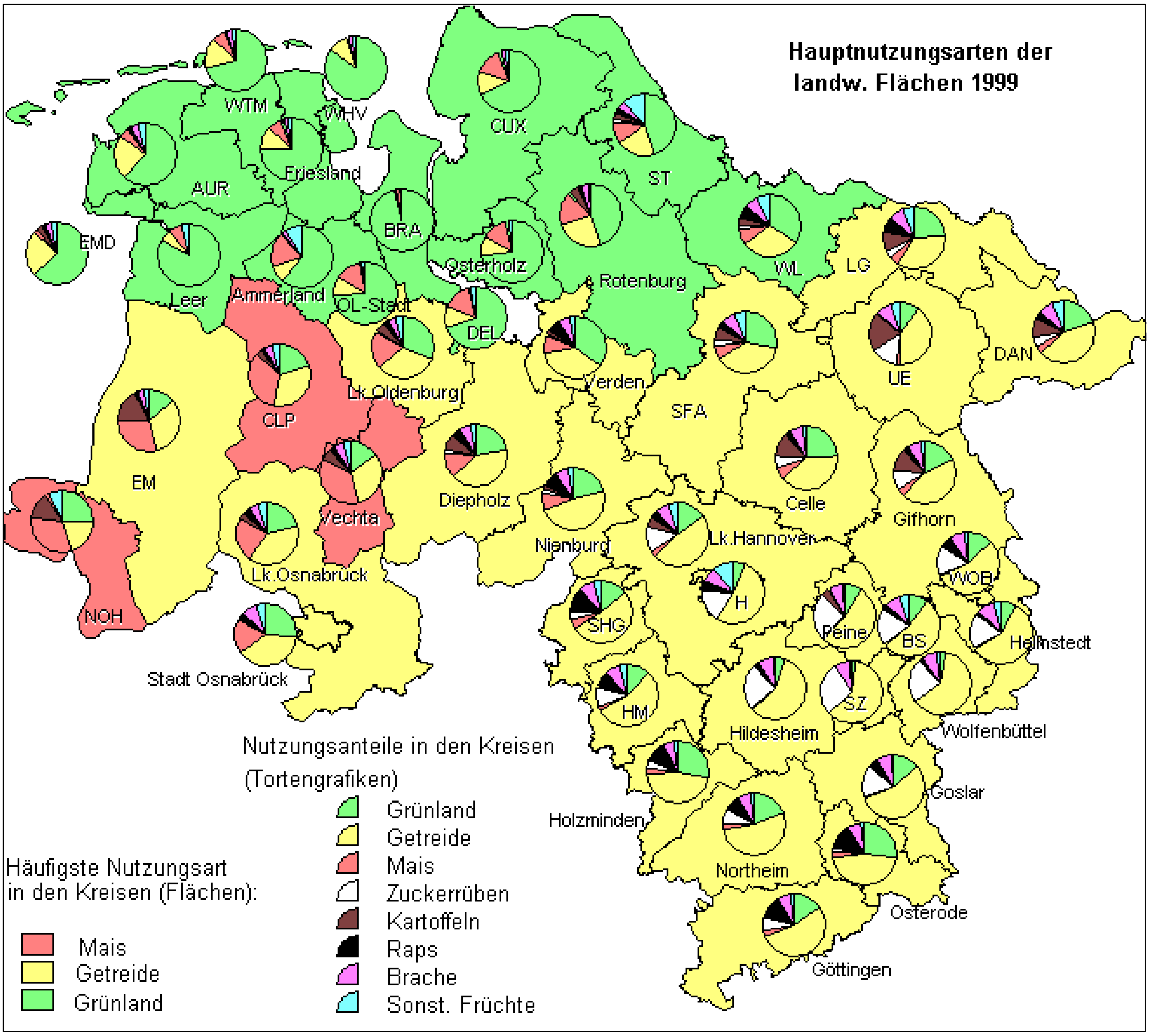


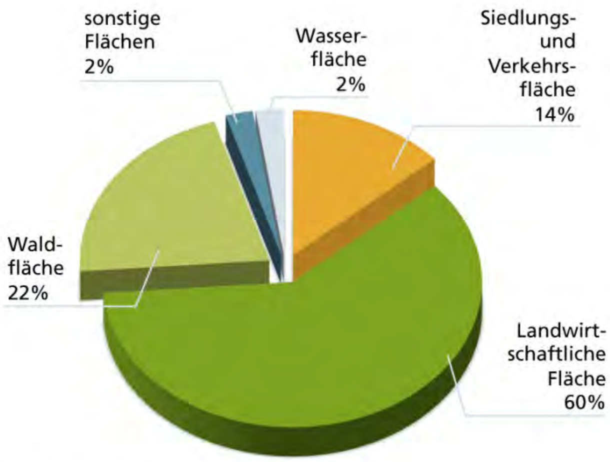
Precipitation in Lower Saxony

tidally influenced areas omitted



Agriculture and land use in Lower Saxony





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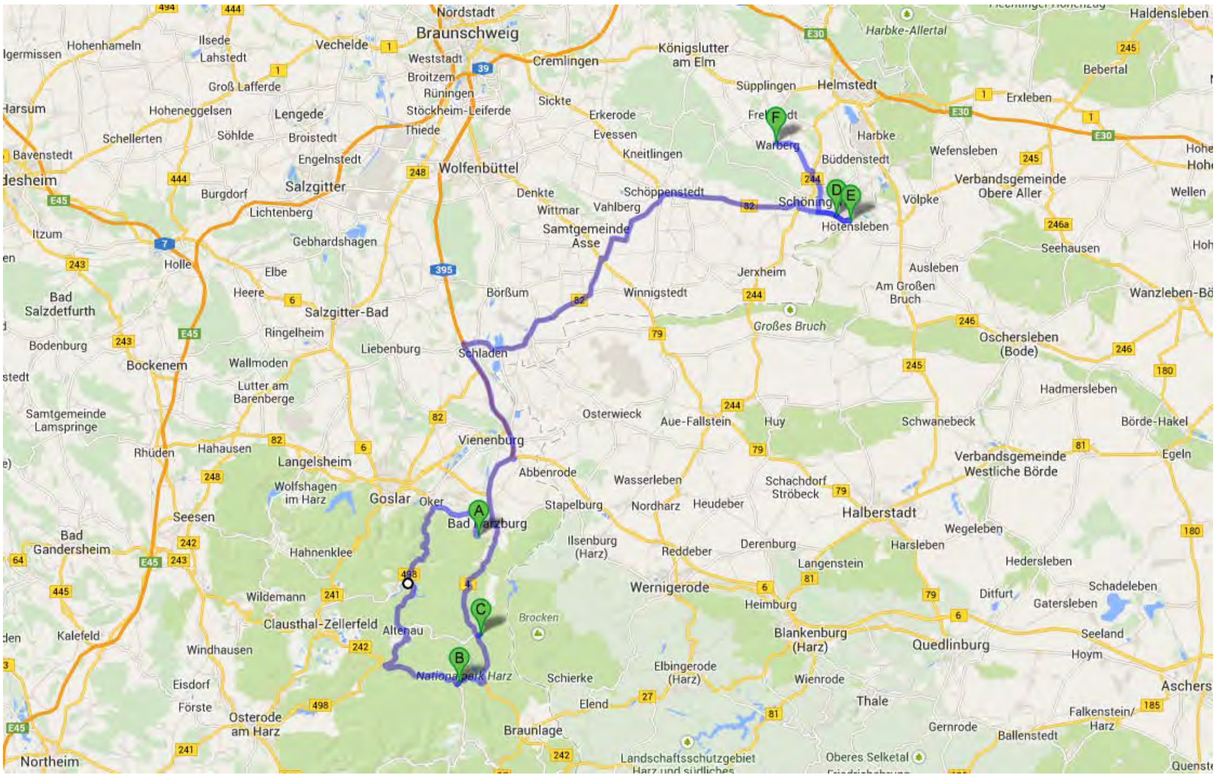
Monday, 08.09.2014
Bogs of the Harz mountains and Schöningen

Bogs of the Harz mountains (H.-U. Kison, K.-E. Behre, F. Bittmann)

Paläon Center and Palaeolithic excavation in the opencast mine Schöningen (T. Terberger, K.-E. Behre, F. Bittmann)

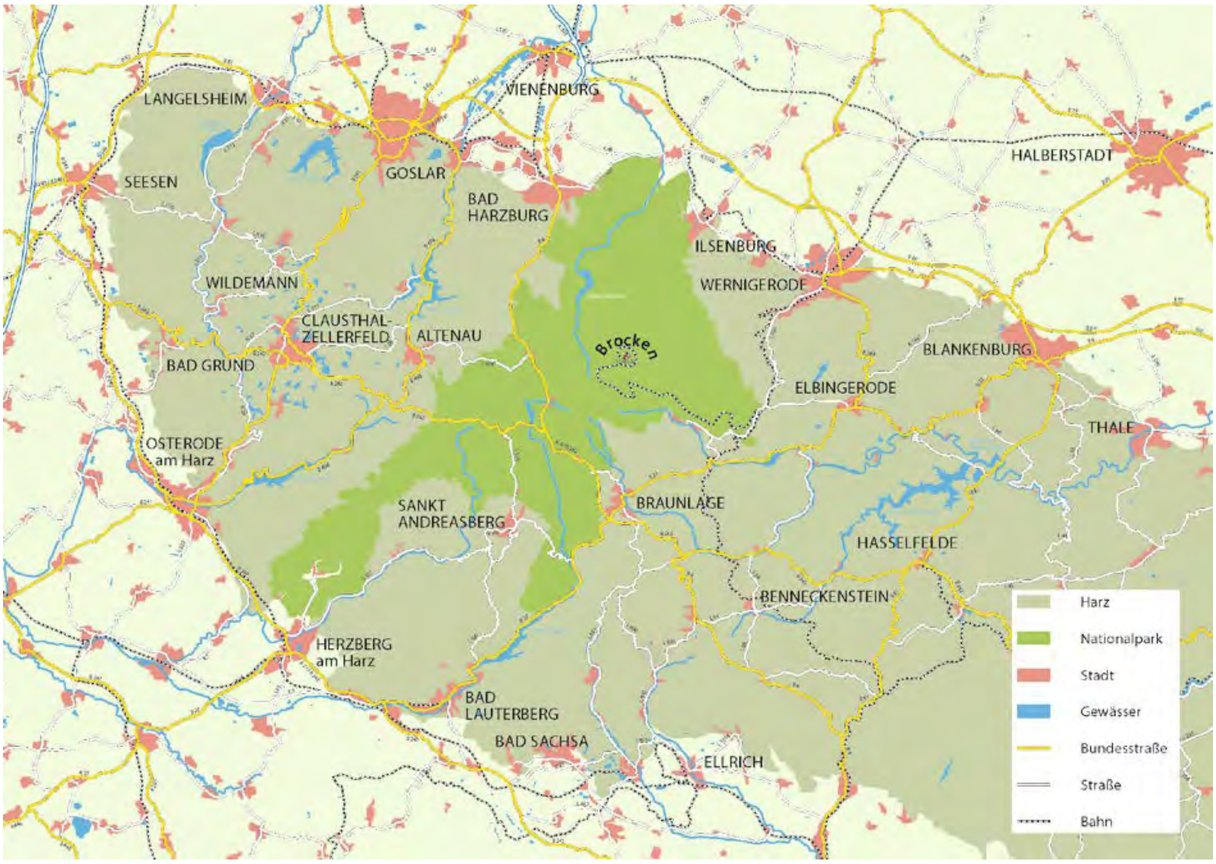
Memorial of the inner German border at Hötensleben

Accomodation and dinner at Burg Warberg



Some facts on the Harz mountains

Geography, Geology



Map of the Harz mountains (http://www.nationalpark-harz.de)

The Harz Mountains are the highest mountains in N-Germany, belonging to Lower Saxony, Saxony-Anhalt and Thuringia. The area (110 x 30-40 km, 2.226 km²) is characterised by steep mountain ridges, stone runs, relatively flat plateaus with many raised bogs and by long, narrow V-shaped deep valleys (Bode gorge, Oker, Selke and Sieber valley among many others) with rivers and many (artificial) lakes. The center called Hoch-Harz comprises all "summits" above 800 m a.s.l.: Brocken 1141.2 m a.s.l., Saxony-Anhalt, Wurmberg 971.2 m, Acker-Bruchberg range with Auf dem Acker 865.1 m and Bruchberg 927 m and Achtermannshöhe 924.7 m, Lower Saxony). The Harz is a fault-block mountain range, which rises abruptly from the surrounding lowlands in the west and northeast and gradually dips towards the south.

The Harz is geologically the most diverse of the German Central Uplands, although it is overwhelmingly dominated by base-poor rocks. The most common rocks lying on the surface are argillaceous shales, slaty (geschieferte) greywackes and granite intrusions in the shape of two large igneous rock masses or plutons. The Gießen-Harz surface layer of the Rhenohercynian zone, which is widespread in the Harz, consists mainly of flysch. Well-known and economically important are the limestone deposits around Elbingerode and the Gabbro of Bad Harzburg.

The Harz Mts. as today were formed during the last 30 million years (Ma) as an uplifted crustal block. Deep reaching erosion removed the former deposited cover rocks – so the sedimentary and magmatic rocks of Paleozoic age became exposed at the surface. This outcropping rock pile of Paleozoic became folded and sheared intensely in the Hercynian (Variscan) orogenesis caused by plate collisions in the Carboniferous (about 350-305 Ma). At that time numerous high mountains appeared in Western Europe, including the Fichtelgebirge and Rhenish Massif. They were, however, heavily eroded due to their height (up to 4 km) and were later covered by Mesozoic rocks.

Magmatic melts were generated since the acid crust became stacked and thickened in the course of the Variscan plate collisions. Granitic, dioritic and gabbroid melts, generated in the middle and lower crust, invaded 295 Ma ago to higher crustal levels. In this time three oval shaped magmatic plutons were formed in the area of the Harz Mts. They penetrated the before folded sediments of Paleozoic and the Ecker gneiss. In the case of the Brocken massif a sequence of magmatic intrusions formed a slab-shaped body of magmatic rocks (laccolithe). Magmatic activities started with the emplacement of the Harzburg gabbro and dioritic rocks, followed by the intrusion of more acid melts (granites).

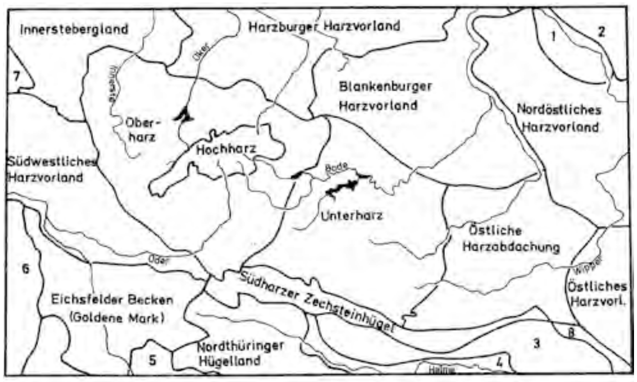


Abb. 2.2: Die naturräumliche Gliederung des Harzes (Oberharz, Hochharz, Unterharz, östliche Harzabdachung) und seines Vorlandes. Nach Hövermann (1963) und Spönemann (1970), verändert.
1 Bode-Niederung, 2 Magdeburger Börde, 3 Unteres Unstrut-Berg- und Hügelland, 4 Helme-Unstrut-Niederung, 5 Unteres Eichsfeld, 6 Göttingen-Northeimer Wald, 7 Alfelder Bergland, 8 Querfurter Platte.

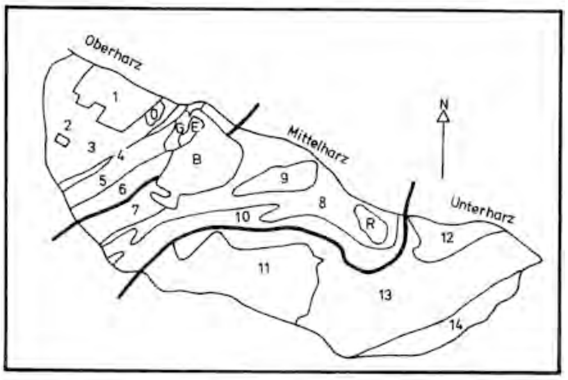
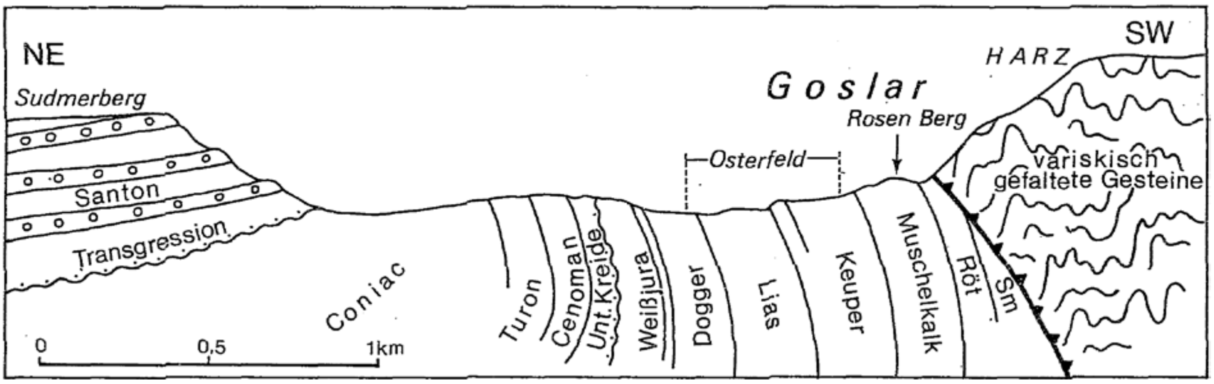


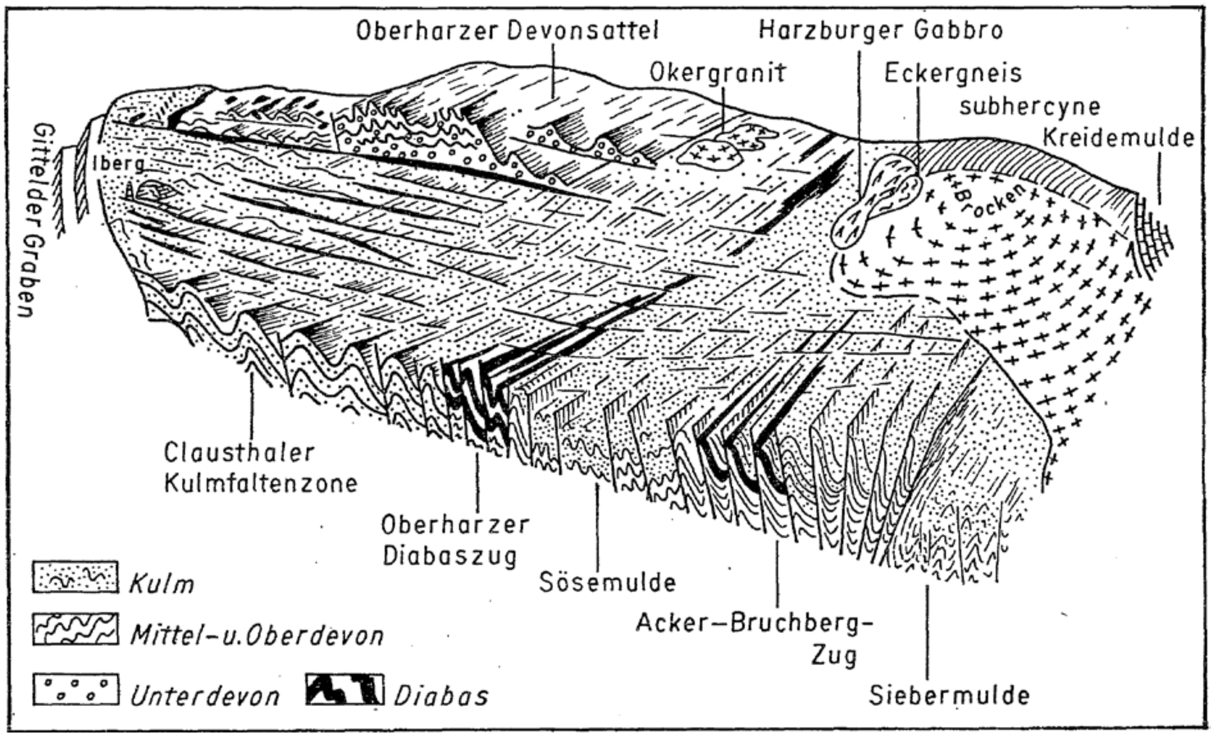
Abb. 2.6: Die geologische Gliederung des Harzes. Aus Mohr (1984), verändert. Erläuterungen zu den Ziffern 1-14 S. 16-17. B Brockengranit, O Okergranit, G Harzburger Gabbro, E Eckergneis, R Ramberggranit

Natural and geological regions of the Harz mountains (Figures from Beug et al. 1999)

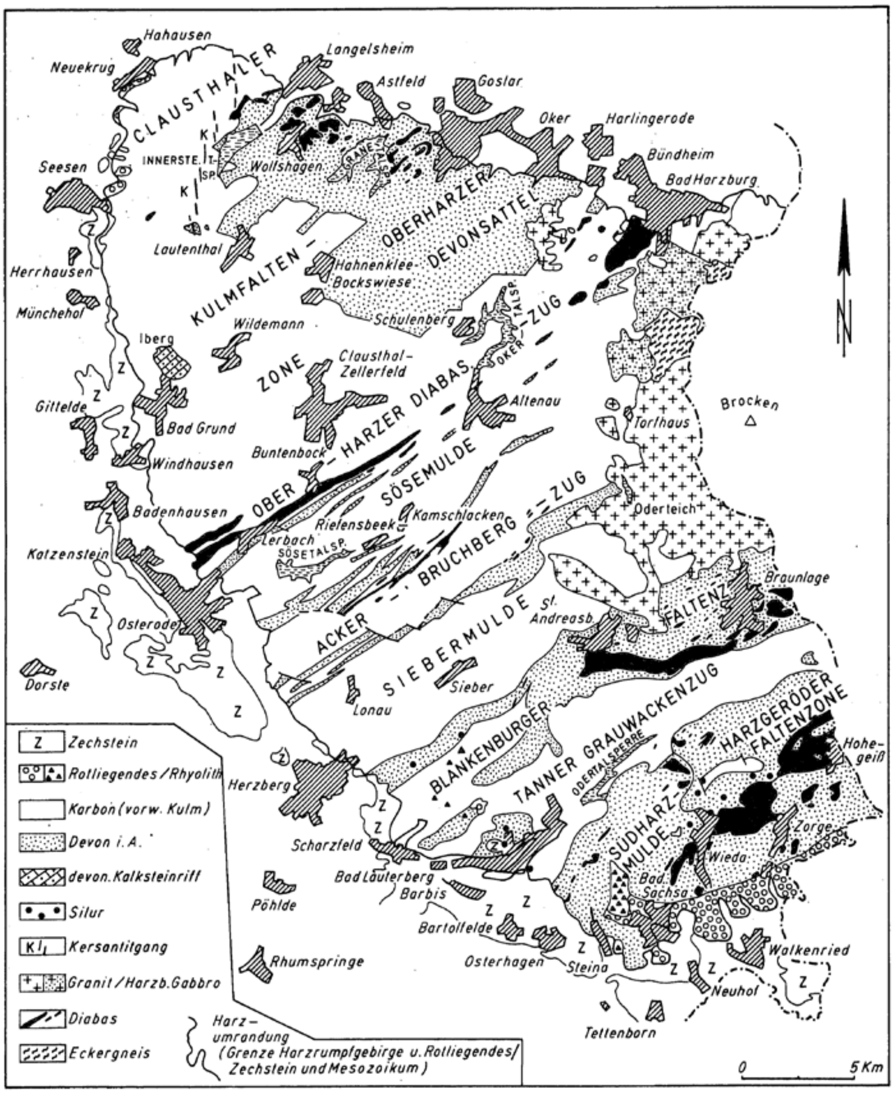
From the Early Cretaceous and into Late Cretaceous times the Harz was uplifted in a single block by tectonic movements and, particularly during the Tertiary period, the younger overlying strata were eroded and the underlying base rock left standing as low mountains. The most important uplift movements were during the sub-Hercynian phase (83 mya), when the northern edge was steeply tilted. This formed a fault zone on the northern border of the Harz (the Northern Harz Boundary Fault or Harznordrandverwerfung). The original horizontal deposited Mesozoic sediments were tilted almost vertical building escarpments which can be followed northwards.



Erection and tilting zone at the northern rim of the Harz (after Mohr 1973)



Geological units of the Ober-Harz (After Mohr 1973)



Simpified geological map of the W-Harz (from Mohr 1984)

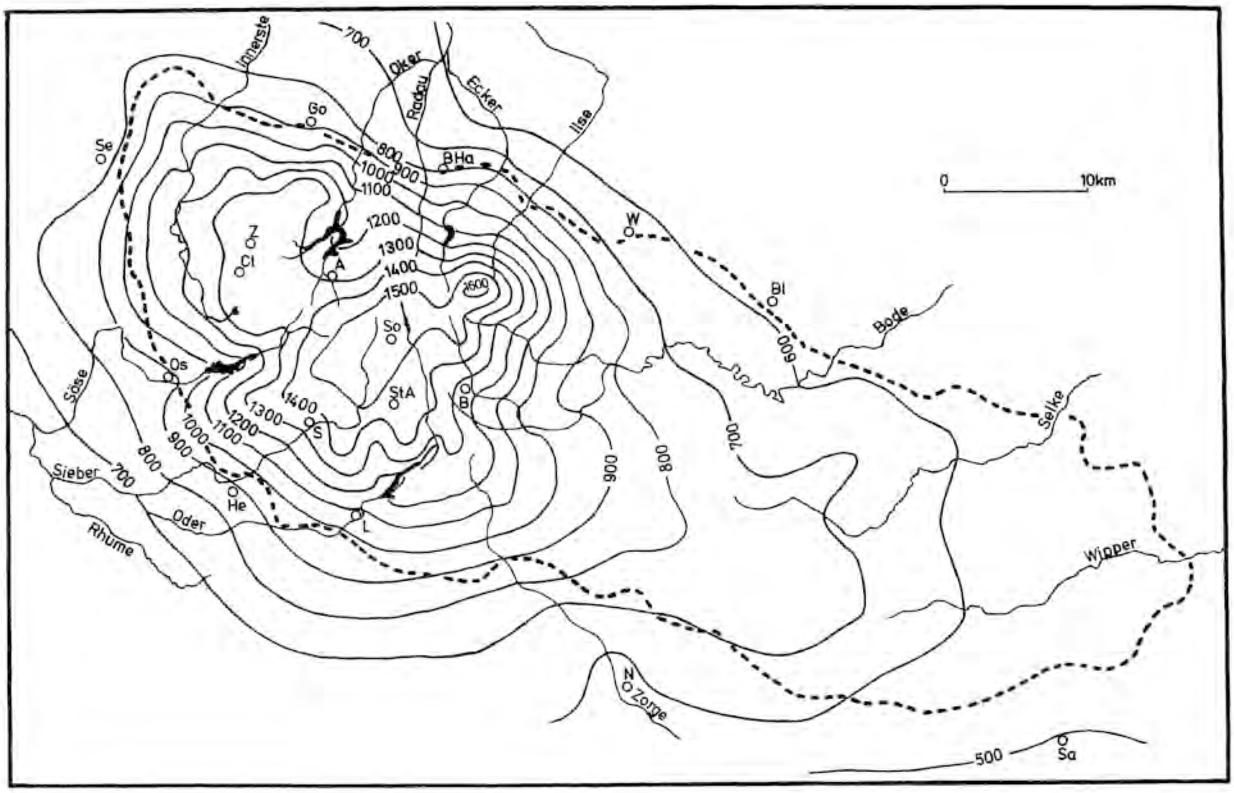
North of the mountains lie the Cretaceous layers of the sub-Hercynian depression in the rolling hills of the Harz Foreland; south of the Harz, Permian sediments lie flat on southwest-dipping Palaeozoic beds.

As a result of the northern fault zone and the vertical or, sometimes even overfolded, geological strata, the geology of the Harz sometimes changes frequently within a relatively small area of just a few square kilometres. As a consequence of this it is also referred to as the "Classic Geological Square Mile" (Klassische Quadratmeile der Geologie).

Climate, hydrology

Exposed to westerly winds from the Atlantic, the windward side of the mountains has up to 1,600 mm of rain annually (West Harz, Upper Harz, High Harz); in contrast, the leeward side only receives an average of 600 mm of precipitation per annum (East Harz, Lower Harz, Eastern Harz foothills) and the central German dry area (450-550 mm).

Drainage goes towards Weser and Elbe, roughly following the division of Upper and Lower Harz respectively. The largest rivers in the Harz are in the north the Innerste (to Leine-Aller-Weser) with the tributaries Nette and the Grane , the Oker (to Aller-Weser) with the Radau, Ecker and Ilse and the Bode (to Saale-Elbe) with Hassel, Selke and Holtemme; in the east the Wipper (to Saale-Elbe) with the Eine; and in the south the Oder (to Rhume-Leine-Aller-Weser) with Söse fed by the Sieber. Also draining to the south are Zorge, Wieda and Uffe, all flow into the Helme (to the Unstrut-Saale-Elbe).



Annual precipitation (after Haase 1954 in Beug et al. 1999); Se Seesen, He Herzberg, L Bad Lauterberg, N Neuhausen, Bl Blankenburg, W Wernigerode,, B Ha Bad Harzburg, Go Goslar, Cl Clausthal, Z Zellerfeld, StA St. Andreasberg, A ALtenau, So Sonnenberg, B Braunlage

There are 17 modern dams in the Harz to block a total of twelve rivers. Because the Harz is one of the regions of Germany that experiences the most rainfall, its water power is still used today, primarily to generate electricity, to provide drinking water for cities as far as

Bremen, to prevent flooding and to supply water in times of scarcity. Modern dam-building began in the Harz with the construction of the Söse Valley Dam, which was built between 1928 and 1931. The dams of the Upper Harz lakes are some of the oldest dams in Germany that are still in operation.

Pre-history and early history

A few finds give evidence for the early presence of humans in the Harz mountain area: Tools used by Neanderthals were discovered for example in the Einhorn Cave in the southern Harz (100,000 years old) and in the Rübeland Caves. Finds of birch pitch near Aschersleben on the northern edge of the Harz point to the use of this prehistoric adhesive by Neanderthals about 50,000 years ago.

Many discoveries in the Harz, such as the bronze club of Thale (celtic), give evidence of human occupations during the Holocene. However, settlement within the mountains began only about 1000 years ago, as in ancient times dense forests made the region almost inaccessible.

The Harz(gau) was first mentioned as Hartingowe in an 814 deed by the Carolingian King Louis the Pious. According to the Fulda annals of 852, the Harzgau was occupied by the Harudes and after whom the Harudengau (Harudorum pagus) was named. Harud, from which Hard, Hart and Harz are derived, means forest or forested mountains, and the Harudes were the residents or dwellers in the Harud.

Charlemagne declared the Harz a restricted imperial forest or *Reichsbannwald*. Later the Saxon Mirror (*Sachsenspiegel*), the oldest German law book (*Rechtsbuch*), probably published around 1220/30 at Falkenstein Castle in the Selke valley, made the imperial restriction clear: "Whoever rides through the Harz Forest, must unstring his bow and crossbow and keep dogs on a line – only crowned royalty (*gekrönte Häupter*) are allowed to hunt here". But mining, ironworks, water management, increasing settlement, woodland clearances, cattle driving, agriculture and, later, tourism, all undermined this imperial protection in the centuries following.

As early as 1224, monks who had settled in Walkenried bought extensive tracts of forest in the western Harz, to secure economically the one quarter of the Rammelsberg ore profits promised to them by Frederick Barbarossa in 1129. From that it can be deduced that there was already a shortage of wood then. From the 12th to the 14th centuries, large parts of the Harz were managed economically by the Cistercian Abbey of Walkenried. As well as agriculture and fishing, they also controlled the silver mining industry in the Upper Harz and in Goslar.

In the middle of the 14th century, the settlements in the Harz became heavily depopulated as a result of the Black Death, and a systematic resettlement of mining villages in the Upper Harz did not take place until the first half of the 16th century.

In 1588, the Nordhausen doctor, Johannes Thal, published the first book on regional flora in the world, Silva hercynia, in which he described the flowers specific to the Harz.

In 1668, Rudolph Augustus, Duke of Brunswick-Lüneburg granted the first conservation order for Baumann's Cave. The ducal decree stated that the cave should be permanently preserved by all those responsible as a special, natural wonder. It also stated that nothing should be spoiled or destroyed, and that groups of ordinary strangers should not be allowed to enter without prior arrangement. A resident mine worker was entrusted to oversee the natural monument. Until the issue of this conservation order, there had only been an order for the protection of the forest, which had been issued by the ruling princes for real, practical considerations. But for the first time the 1668 cave order took ethical-aesthetic considerations into account. The year 1668 was the birth of classic nature conservation in the Harz. The order had been precipitated by the earlier, serious destruction of the cave's features by vandals. The first Harz 'rangers' were formed.

In 1705, the last bear was killed in the Harz, on the Brocken.

The steadily increasing consumption of wood by the pits and smelting works led to overexploitation of the forests and, from about 1700, to their outright destruction. There were no less than 30,000 charcoal piles in the Harz. In 1707, an order by Count Ernst of Stolberg forbade Brocken guides to take strangers or local folk to the Brocken without special permission, and the lighting of fires was forbidden. The first attempts at forest conservation in the Harz were centred on the Brocken, and began with a far-sighted nature conservation act over 275 years ago. In 1718, Count Christian Ernest of the House of Stolberg issued an ordinance in which destruction or damage to the forest on the Brocken would be severely punished.

As a young man, the famous German poet, Goethe visited the Harz several times and had a number of important lifetime experiences. These included his walks on the Brocken and his visit to the mines in Rammelsberg. Later, his observations of the rocks on the Brocken led to his geological research. His first visit to the Harz awakened in him a keen interest in science (see Goethes: Wahrheit und Dichtung). In 1777, Goethe climbed the Brocken, departing from Torfhaus. Goethe described his feelings on the summit later: So lonely, I say to myself, while looking down at this peak, will it feel to the person, who only wants to open his soul to the oldest, first, deepest feelings of truth.

On 23 March 1798, the last wolf was killed in the Harz.

Around 1800, large parts of the Harz were deforested. The less resistant spruce monoculture, a consequence of the mining industry in the Upper Harz, was largely destroyed by a bark beetle outbreak and a storm of hurricane proportions in November 1800. This largest known bark beetle infestation in the Harz was known as *Große Wurmtrocknis*, and destroyed about 30,000 ha of spruce forest and lasted about for 20 years. The woods were largely reforested with spruce. Continuous problems with bark beetle and storms were the negative side effects of mining in the Harz Mountains.

In 1818 the last lynx in the Harz was killed.

Prof. Dr. Albert Peter laid out the Brocken Garden in 1890. This was the first alpine flower garden to be established in Germany. And, in terms of its scientific concept and scope, the Brocken Garden was the first of its type worldwide.

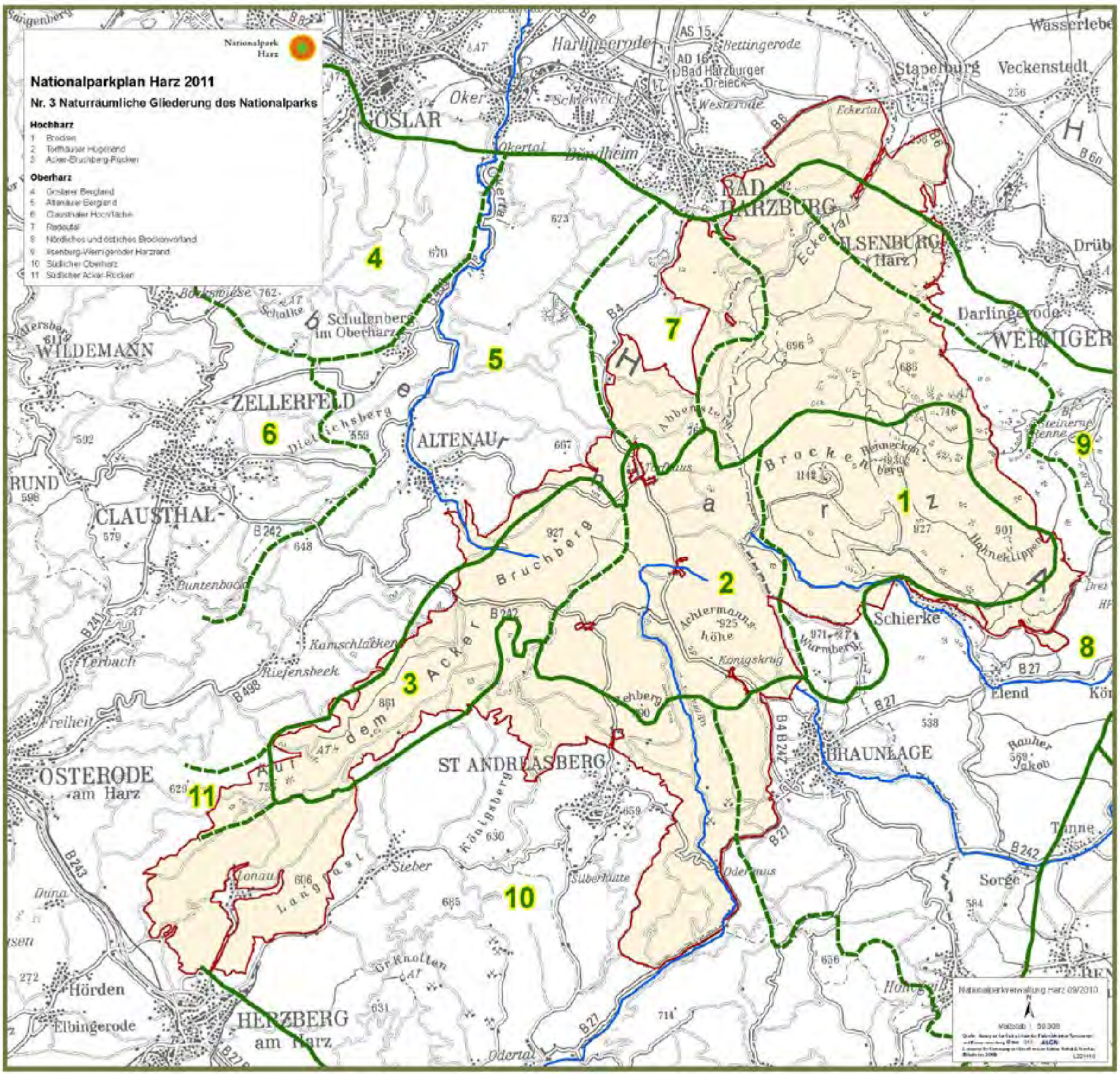
The Brocken Railway started in 1899, against the strong concerns of conservationists.

In 1907, Hermann Löns uttered his famous cry "More Protection for the Brocken" (*Mehr Schutz für den Brocken*) in light of the mass tourism that was beginning to affect the Brocken. By 1912, he effectively insisted on the establishment of a Harz “national park”, however calling it *Harzer Heimatspark*. The Harz played a special role in the life of the famous regional poet, naturalist and local patriot, undoubtedly not least because his second wife, Lisa Hausmann, came from Barbis in the South Harz.

Around 1920, the capercaillie (*Tetrao urogallus*) population in the Harz died out.

During the dark Nazi era, the Harz became an area for the armaments industry. Many factories, were located here increasingly staffed with forced labour. As a result, the Harz was the location of several hundred forced labour camps and KZs at that time.

After World War II the forests of the Harz mountains have been almost totally cleared by the British. Between 1945 and 1990, the inner German border ran through the Harz. Today the Harz forms a popular tourist destination for summer hiking as well as winter sports. Since January 1994 a National Park, one of the biggest forest national parks in Germany, is existing belonging to Lower Saxony and Saxony-Anhalt (http://www.nationalpark-harz.de/)



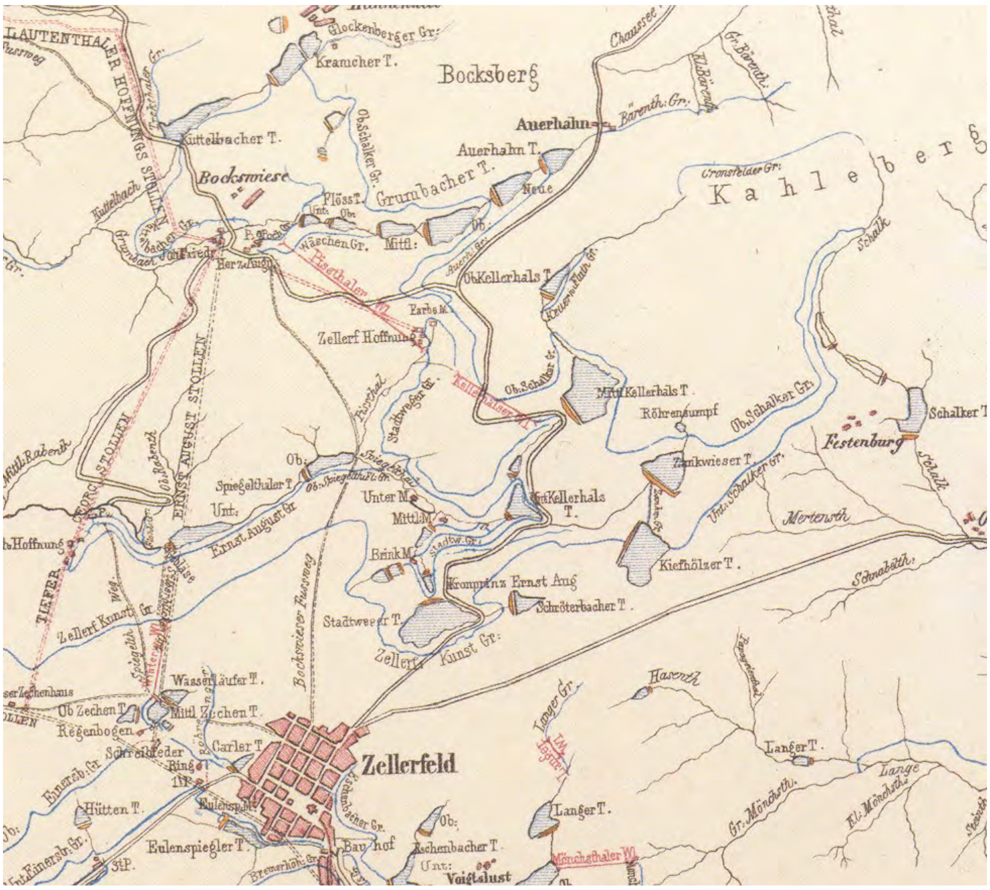
Nationalparkplan 2011 (http://www.nationalpark-harz.de/de/downloads)

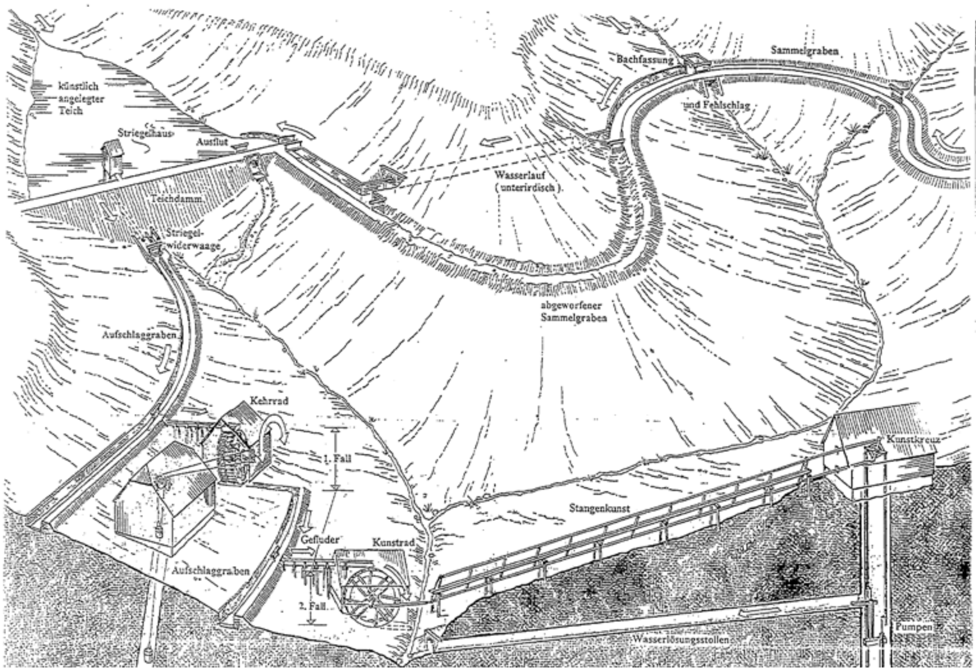
Mining

First traces of mining were proved for the Bronze Age (about 3000 yrs BP), however industrial mining started not before the High Medieval. Especially silver, but also copper, zinc and tin ores were exploited, especially at the Rammelsberg near Goslar where mining has been carried out for about 1000 years more or less continuously (since around 968 until 1988). However, the oldest evidences for the use of ores from the Rammelsberg date back to the 3rd century AD. Today it is open for visitors and since 1992 together with the old town of Goslar and the royal pallace (*Kaiserpfalz*) a UNESCO world heritage site. The Kaiserhaus is the greatest, oldest and best-preserved secular building of the 11th century in Germany. It was a favourite imperial residence, especially for the Salian emperors.

In contrast to the mineral deposits of the Upper Harz, the ore deposits at the Rammelsberg were caused by the escape of hot, metal-bearing, thermal springs on the sea floor in the Devonian period. This formation is referred to as a sedimentary exhalative deposit. At the bottom of the Devonian sea, two large lenses of ore were formed that were later caught up in the folding of rocks during the Carboniferous period and so lie overturned at an angle in the mountain. Especially silver played the major role and formed the base for the importance of Goslar. Mining heavily dominated the economic life of the Harz as well as its scenery since the 13th century.

Miners created the famous engineering system for the management of water in the Upper Harz, the Upper Harz Water Regale still used today.This system of 107 historical ponds, 310 km of ditches and 31 km subterraneous water courses belongs to the UNESCO world heritage since 2010. Without using the considerable hydropower output, silver mining in the Harz would never have been able to attain its major economic significance. It has been used for many purposes: draining the mines, bringing down miner to depth of 600 m, to run stamp mills…

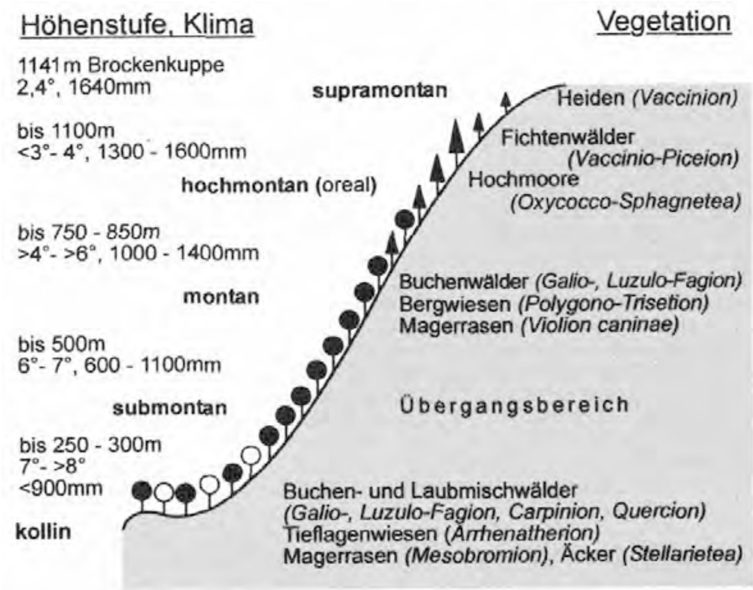




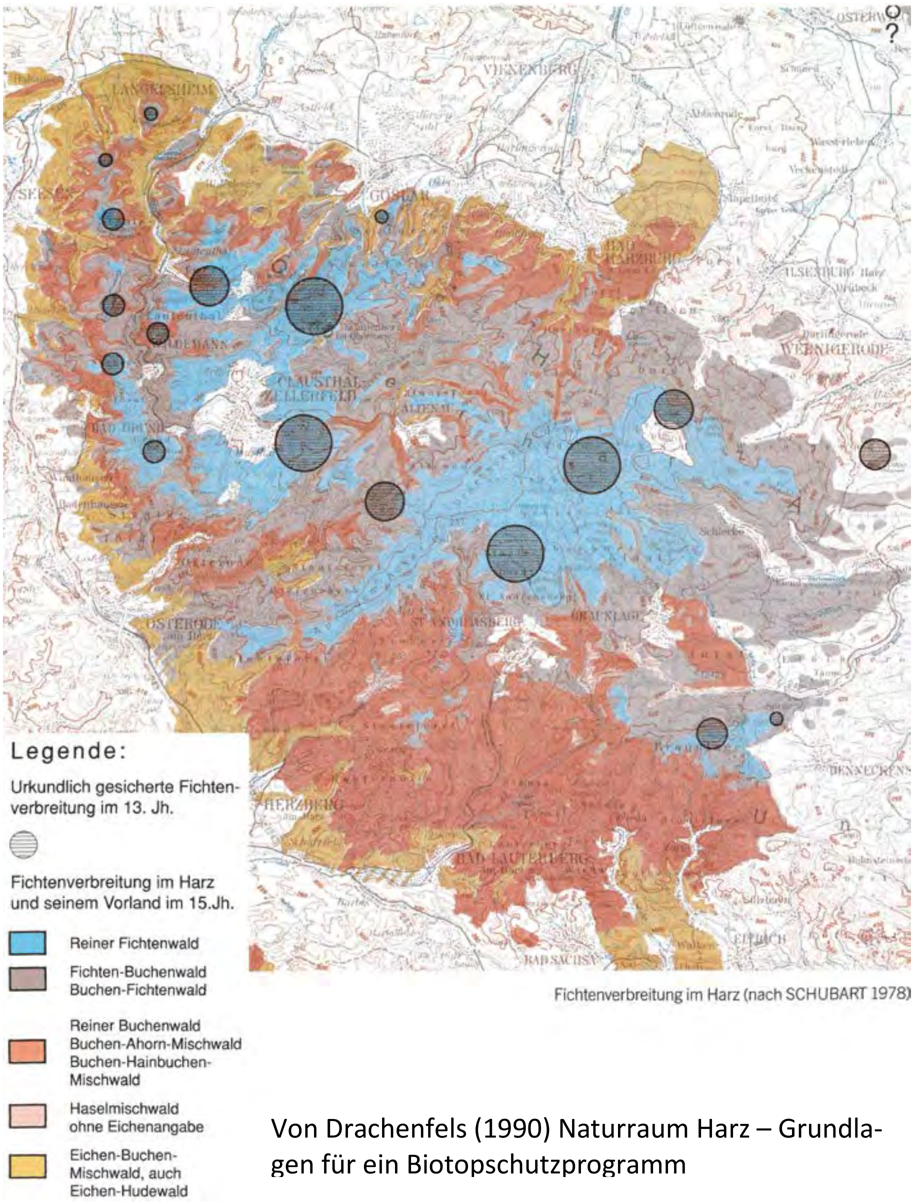
http://de.wikipedia.org/wiki/Oberharzer_Wasserregal

The year 968 saw the discovery of silver deposits near the town of Goslar, and mines became established in the following centuries throughout the mountains. During the Middle Ages, ore from this region was exported along trade routes to far-flung places, such as Mesopotamia. The seven Upper Harz mining towns - Clausthal (right of mining 1554), Zellerfeld (1529), Bad Grund (1524), Sankt Andreasberg (1521), Lautenthal (1538), Altenau (1617) and Wildemann (1529) - and around 30 other villages within and on the edge of the Harz owe their existence to the Upper Harz mining and smelting industries. The wealth of the region declined after these mines became exhausted in the early 19th century. The last mine in the Upper Harz – the Wolkenhügel Pit in Bad Lauterberg – closed its operations in June 2007 for economic reasons. Having formerly had 1,000 workers, the mine employed just 14 people towards the end, using the most modern technology to extract barite. With the closure of this facility, mining operations that had begun in the Middle Ages and had continued since the 16th century, extracting silver, lead and zinc, came to an end. Bearing witness to the industry are cultural monuments as well as the negative consequences of mining for the environment such as e. g. pollution of the ecosystem with heavy metals.

Vegetation

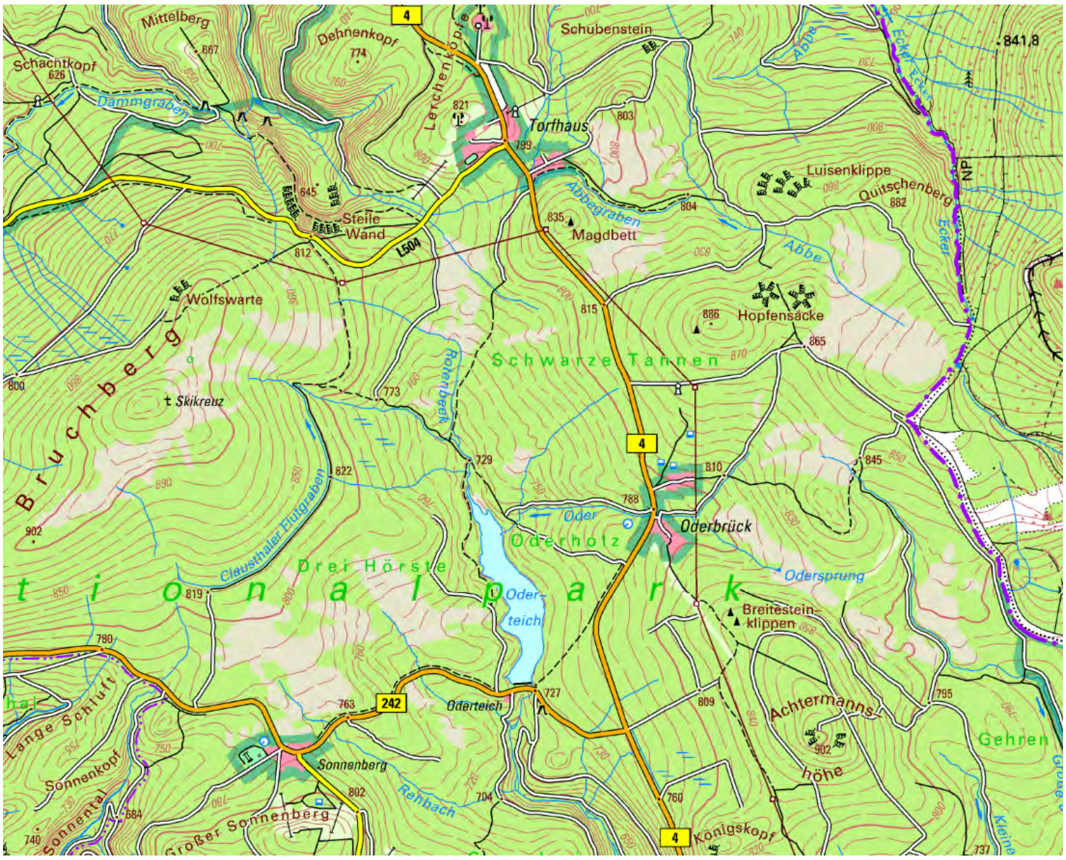


Nationalparkplan 2011 (nach Dierschke und Knoll 2002)



Von Drachenfels (1990) Naturraum Harz – Grundlagen für ein Biotopschutzprogramm

Mires



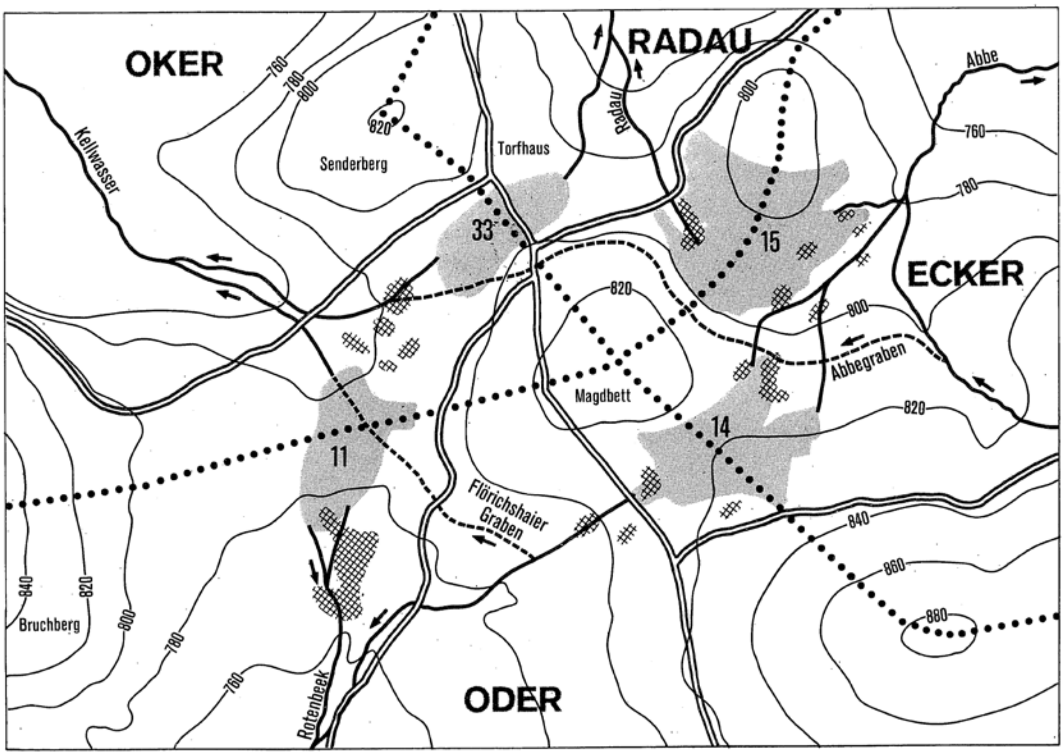


Abb. 33: Vom Magdbett gehen vier Wasserscheiden aus, die die Einzugsgebiete von Oker, Radau, Ecker und Oder trennen. Auf diesen Wasserscheiden liegen rund um das Magdbett dementsprechend vier Sattelmoore, nämlich Flörichshaier Sattelmoor (11), Lerchenfeldmoor (33), Radauer Born (= Großes Torfhausmoor; 15) und Magdbettmoor (14).

▩ = alte Moorkerne (nach HENRION 1982)

Jensen 1990, Die Moore des Hochharzes – Spezieller Teil

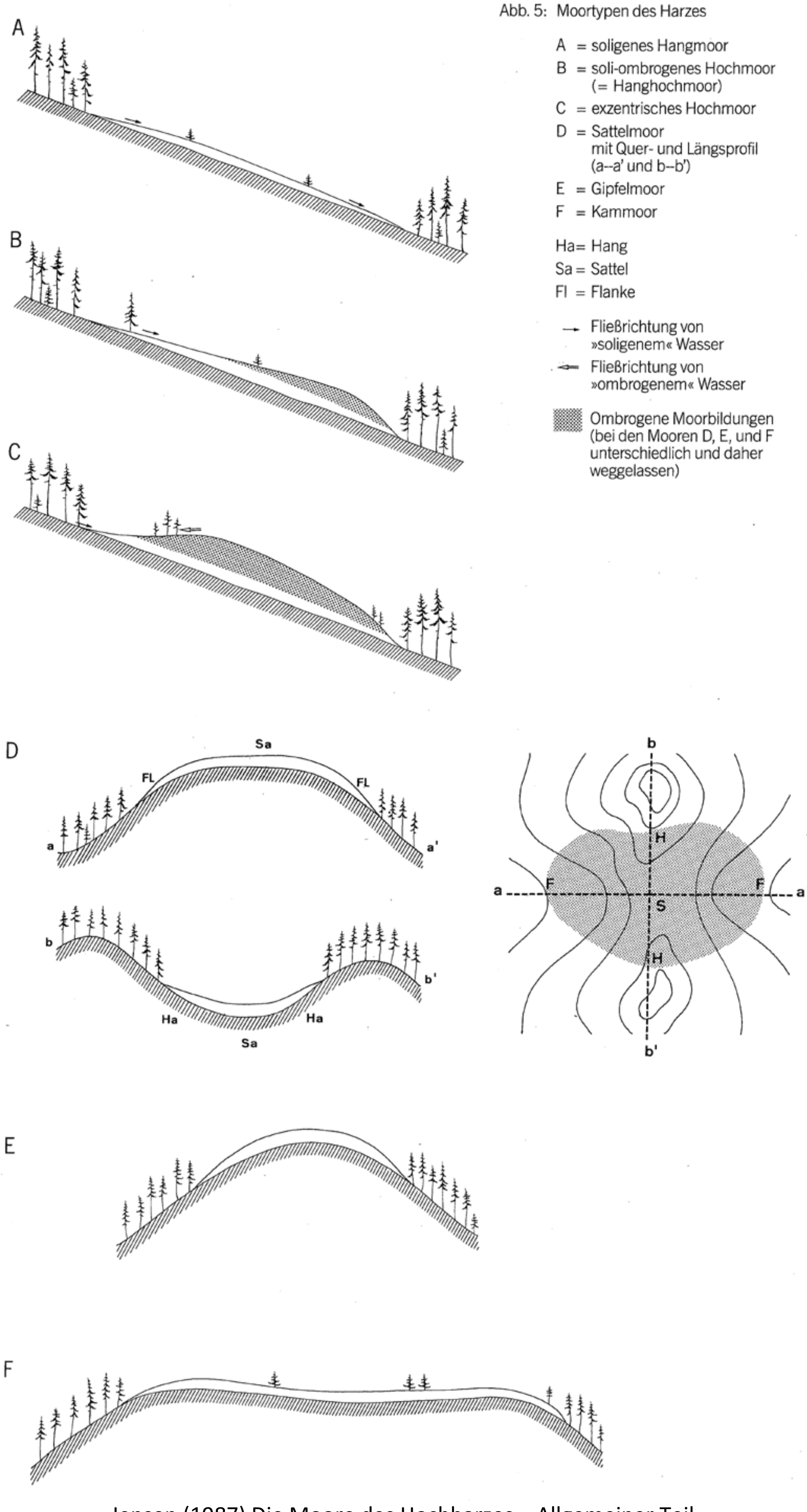


Abb. 5: Moortypen des Harzes

A = soligenes Hangmoor
B = soli-ombrogenes Hochmoor (= Hanghochmoor)
C = exzentrisches Hochmoor
D = Sattelmoor mit Quer- und Längsprofil (a--a' und b--b')
E = Gipfelmoor
F = Kammoor

Ha = Hang
Sa = Sattel
Fl = Flanke

→ Fließrichtung von »soligenem« Wasser
⇐ Fließrichtung von »ombrogenem« Wasser
▒ Ombrogene Moorbildungen (bei den Mooren D, E, und F unterschiedlich und daher weggelassen)

Jensen (1987) Die Moore des Hochharzes – Allgemeiner Teil

The mires of the Harz Mountains are subject to palaeoecological studies since many decades. Especially Wendt and von Bülow (1927), Firbas, et al. (1939) and Hesmer (1928) established a first general outline of the Holocene vegetation development.

On the age, development and growth of the mires worked Von Bülow (1932c), Firbas, et al. (1939), Beug (1957) and Willutzki (1962). The most recent and comprehensive work is from Beug, et al. (1999).

The vegetation was studied especially by Hueck (1928) and later Jensen (1961, 1987, 1990). It has been recently updated by K. Baumann (2010).

Sonnenberger Moor

115 ha (105 ha with mire), 755-822 m a.s.l., annual preciptitation 1468 mm, mean annual temperature 4.6 °C
Drainage: SW Rehbach, NO Hühnerbrühe, W Sieber, all flowing to the Oder-Rhume-Leine

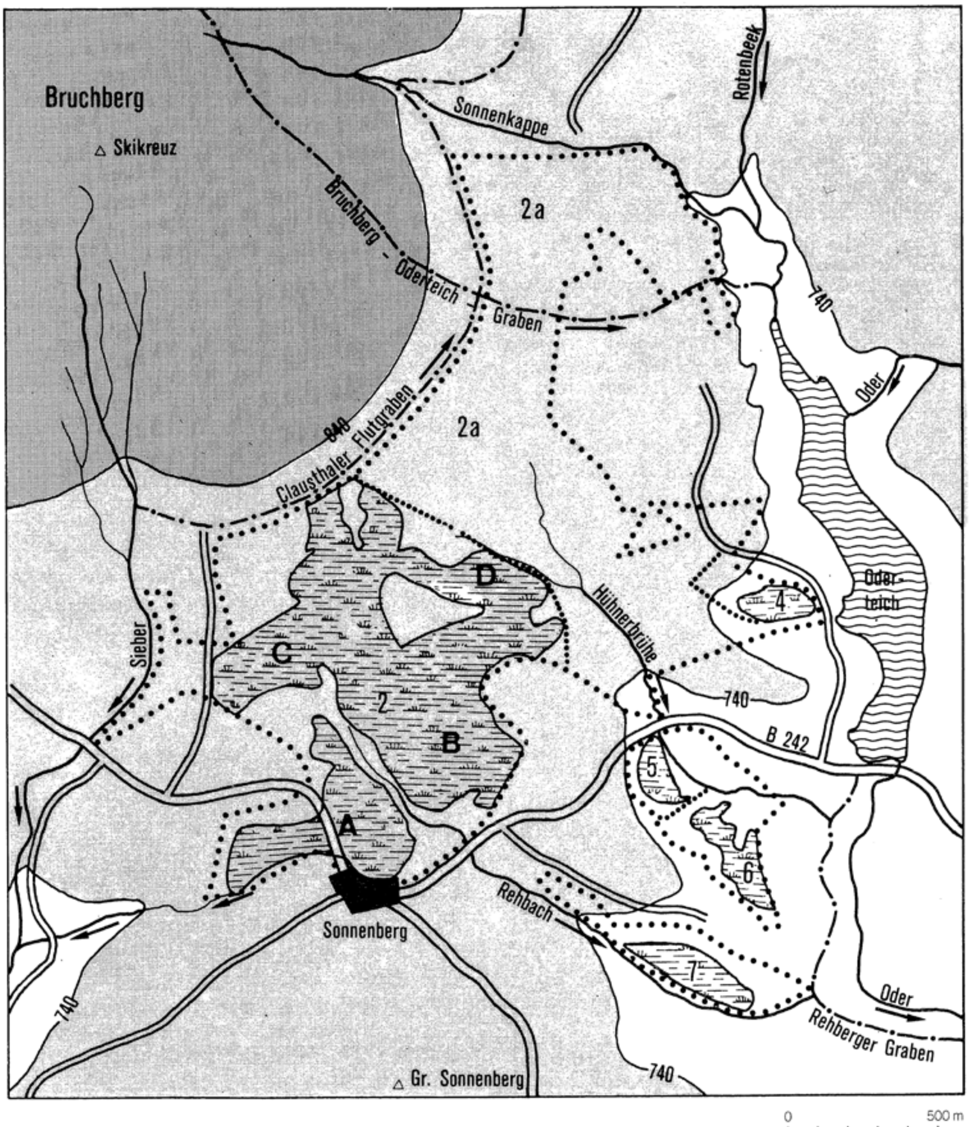
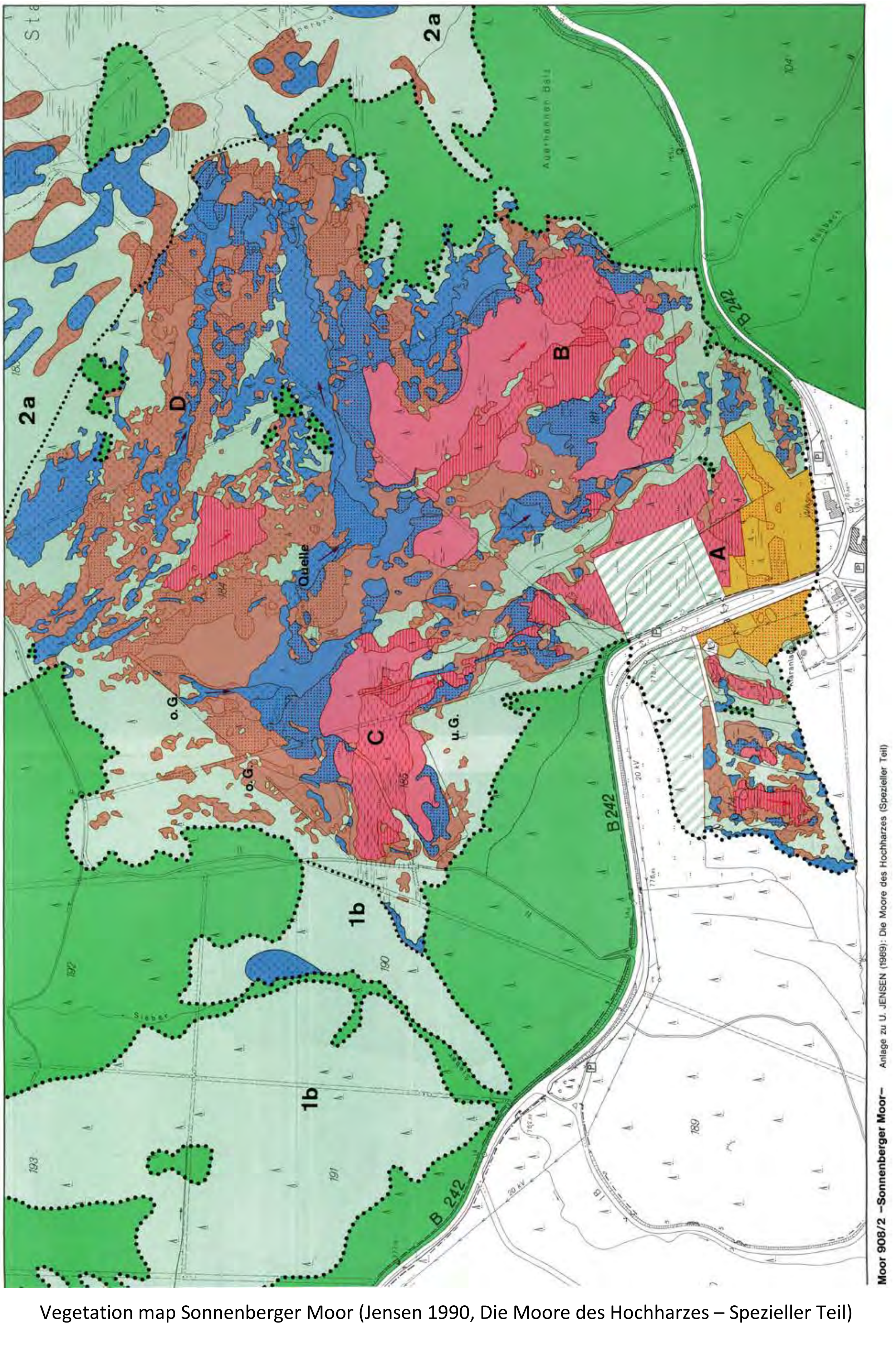


Abb.12: Moore und Brücher zwischen den Einzugsgebieten von Oder und Sieber, nämlich Sonnenberger Moor (2, mit Moorteilen A, B, C, D), Drei-Hörste-Bruch (2a) und Hörstemoor (4) sowie Moore im Einzugsgebiet der Oder zwischen Hühnerbrühe und Rehbach, nämlich Rotes Moor (5), Hinteres Rotes Moor (6) und Rehbachmoor (7). Während die kleineren Moore unterhalb der 740 m-Isohypse im Bereich des oberen Odertales liegen, sind Sonnenberger Moor und Drei-Hörste-Bruch zwischen 740 und 840 m entstanden. Legende siehe Klappseite hinten.

Jensen (1990) Die Moore des Hochharzes – Spezieller Teil



Vegetation map Sonnenberger Moor (Jensen 1990, Die Moore des Hochharzes – Spezieller Teil)

Waldvegetation

- Mineralboden-Fichtenwald, Piceetum hercynicum calamagrostidetosum
- Moorfichtenwald, Piceetum hercynicum sphagnetosum
- Großflächiges Mosaik aus dem Moorfichtenwald und der Molinia-Variante der Reisermoorvegetation
- dichte Fichtenaufforstung auf Moorflächen

Reisermoorvegetation

- Piceo-Vaccinietum sphagnetosum, Molinia caerulea-Variante
- dto., Eriophorum angustifolium-Variante
- dto., typische Variante
- dto., typische Variante; hochmoorartige Flächen

Hochmoorvegetation

- Wachstumskomplex mit ganz vereinzelten Niedermoorarten
- Wachstumskomplex
- Hochmoorvegetation mit wachsenden und nichtwachsenden Anteilen („Regenerationskomplex")
- Stillstandskomplex
- Erosionskomplex

Niedermoorvegetation

- Übergangs-Niedermoor-Stufenkomplex; nur noch vereinzelte Niedermoorzeiger; häufig großflächige Matten von Polytrichum strictum
- Sphagnum recurvum-Niedermoor-Stufenkomplex
- Eriophorum angustifolium-Niedermoor-Stufenkomplex
- Molinia caerulea-Niedermoor-Stufenkomplex

Vegetation der Braunseggensümpfe

- Carici canescentis-Agrostietum caninae Subassoziation von Festuca rubra, Var. von Sphagnum girgensohnii
- dto., Var. von Trifolium repens
- Carici canescentis-Agrostietum caninae, Subassoziation von Calamagrostis villosa

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- Juncus-squarrosus-Trichophorum cespitosum-Gesellschaft
- durch Tritt veränderte Moorfläche; Carex canescens und Drepanocladus fluitans dominieren

Aufsignaturen

- e Eriophorum angustifolium
- c Carex pauciflora
- R Carex rostrata
- N Betula nana
- m Molinia caerulea
- M Fazies von Molinia caerulea
- b Sphagnum balticum
- p Sphagnum papillosum

- Wasserscheide (im Bereich eines Moores)
- Einfluß von Mineralbodenwasser
- früherer Einfluß von Mineralbodenwasser
- Gefällerichtung
- Randgehänge
- Trichter

- baumfreie Moorflächen
- Grenze der Vermoorung
- Begrenzung der einzelnen Moore bzw. Brücher innerhalb der Vermoorungen
- Straßen
- Wege
- Flutgräben
- Bäche, Flüsse

Waldvegetation

- Mineralboden-Fichtenwald, Piceetum hercynicum calamagrostidetosum
- Moorfichtenwald, Piceetum hercynicum sphagnetosum

Reisermoorvegetation

- Piceo-Vaccinietum sphagnetosum, Molinia caerulea-Variante
- dto., Eriophorum angustifolium-Variante
- dto., typische Variante

Hochmoorvegetation

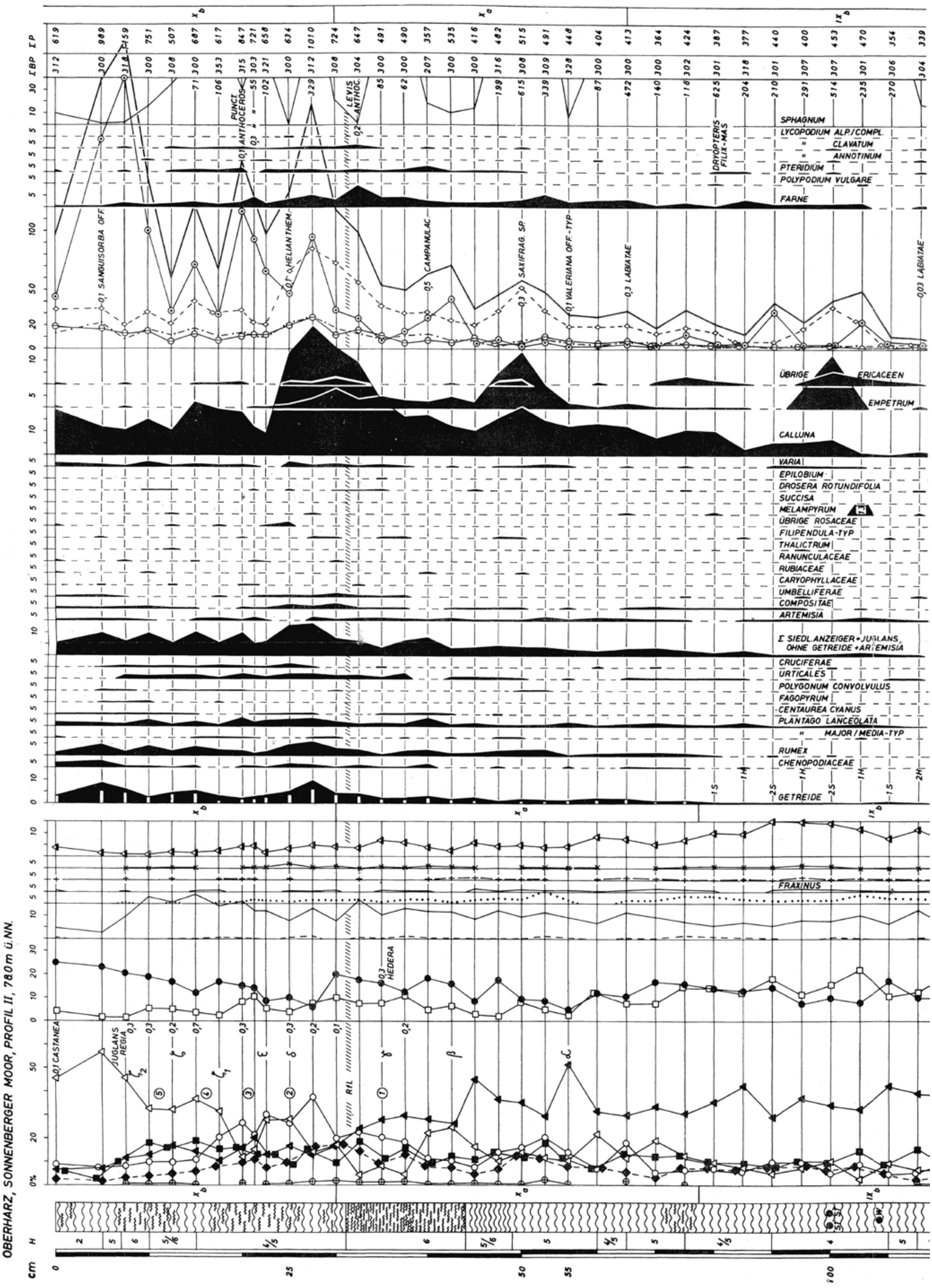
- Wachstumskomplex
- Hochmoorvegetation mit wachsenden und nichtwachsenden Anteilen („Regenerationskomplex")
- Stillstandskomplex

Niedermoorvegetation

- Übergangs-Niedermoor-Stufenkomplex; nur noch vereinzelte Niedermoorzeiger; häufig großflächige Matten von Polytrichum strictum
- Sphagnum recurvum-Niedermoor-Stufenkomplex
- Eriophorum angustifolium-Niedermoor-Stufenkomplex
- Molinia caerulea-Niedermoor-Stufenkomplex

- Torf
- Mineralboden

- gutwüchsige Fichten (meist auf Mineralboden)
- schlechtwüchsige Fichten (meist auf Torfboden)



Pollen diagram Sonnenberger Moor, upper part, Willutzki 1962

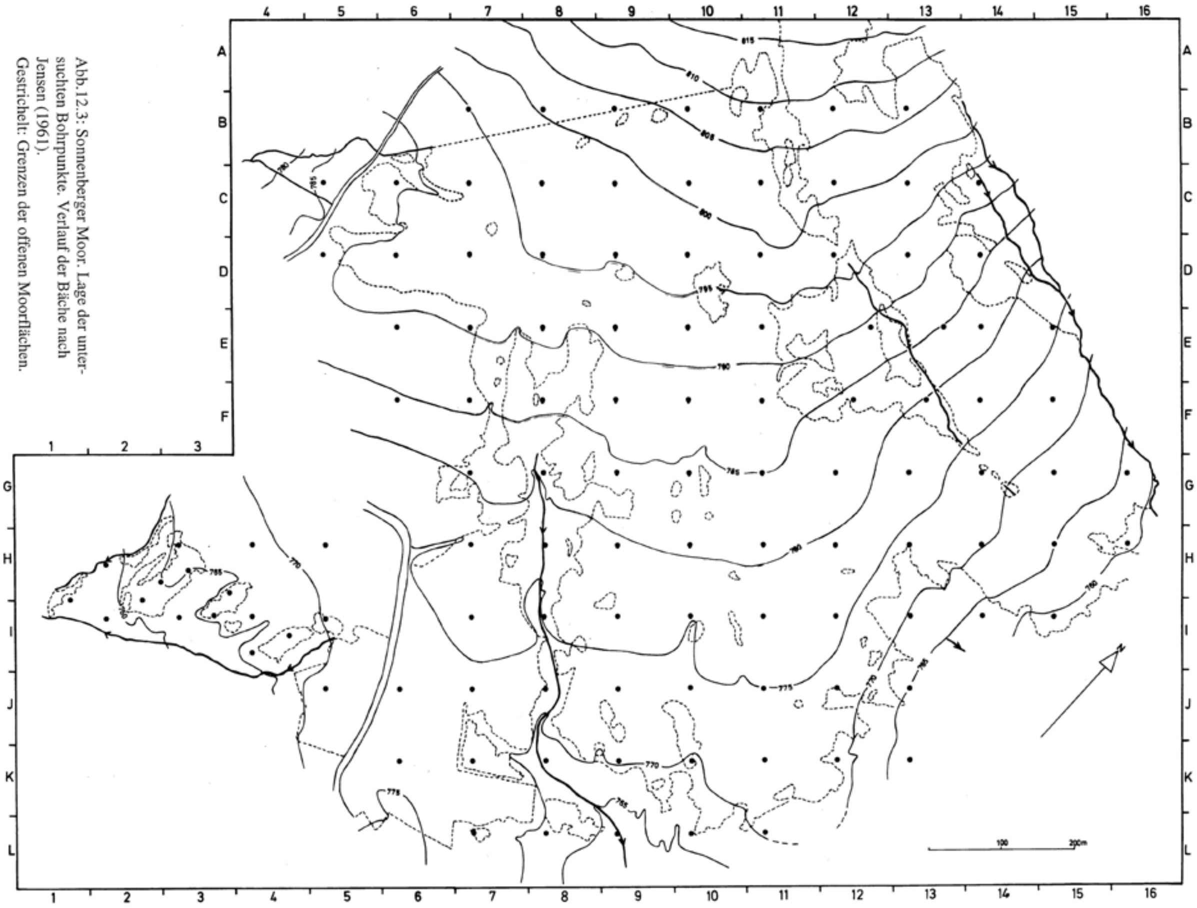


Abb.12.3: Sonnenberger Moor. Lage der untersuchten Bohrpunkte. Verlauf der Bäche nach Jensen (1961). Gestrichelt: Grenzen der offenen Moorflächen.

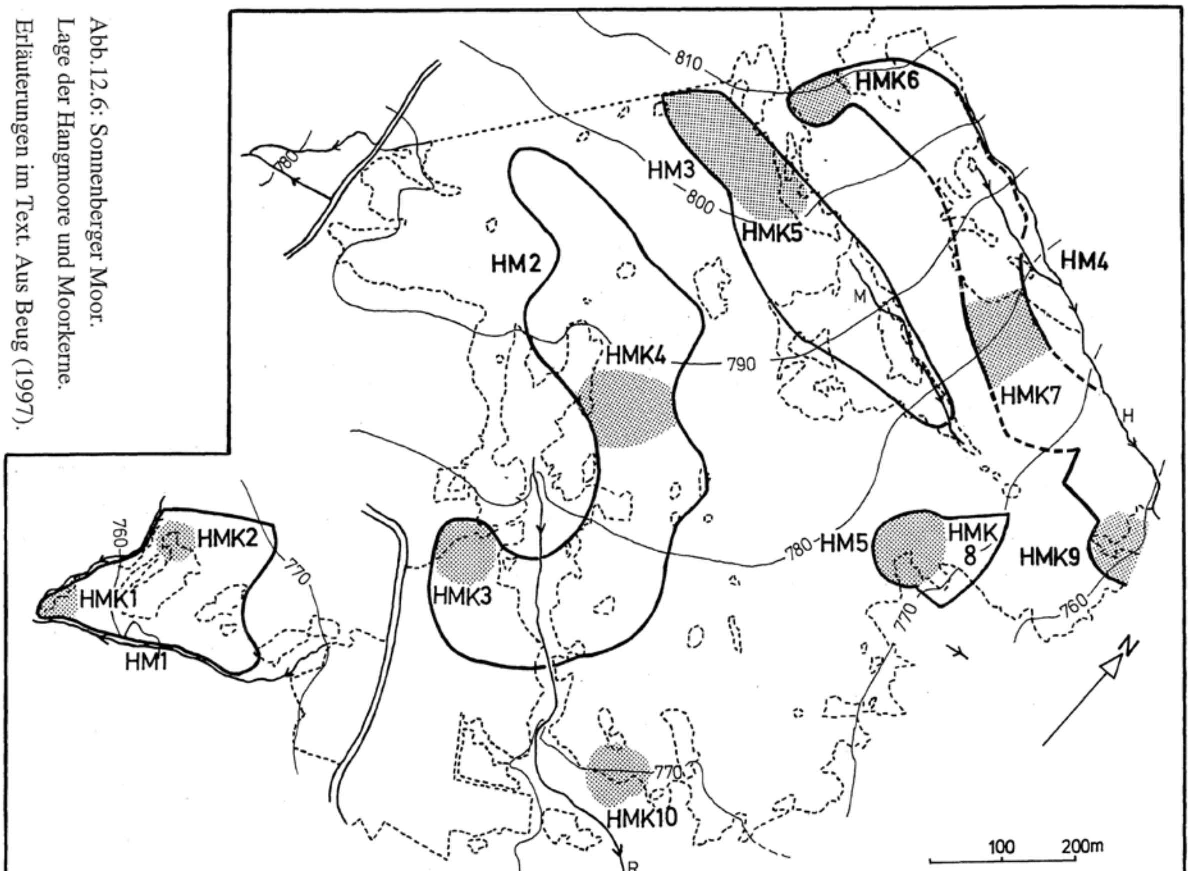
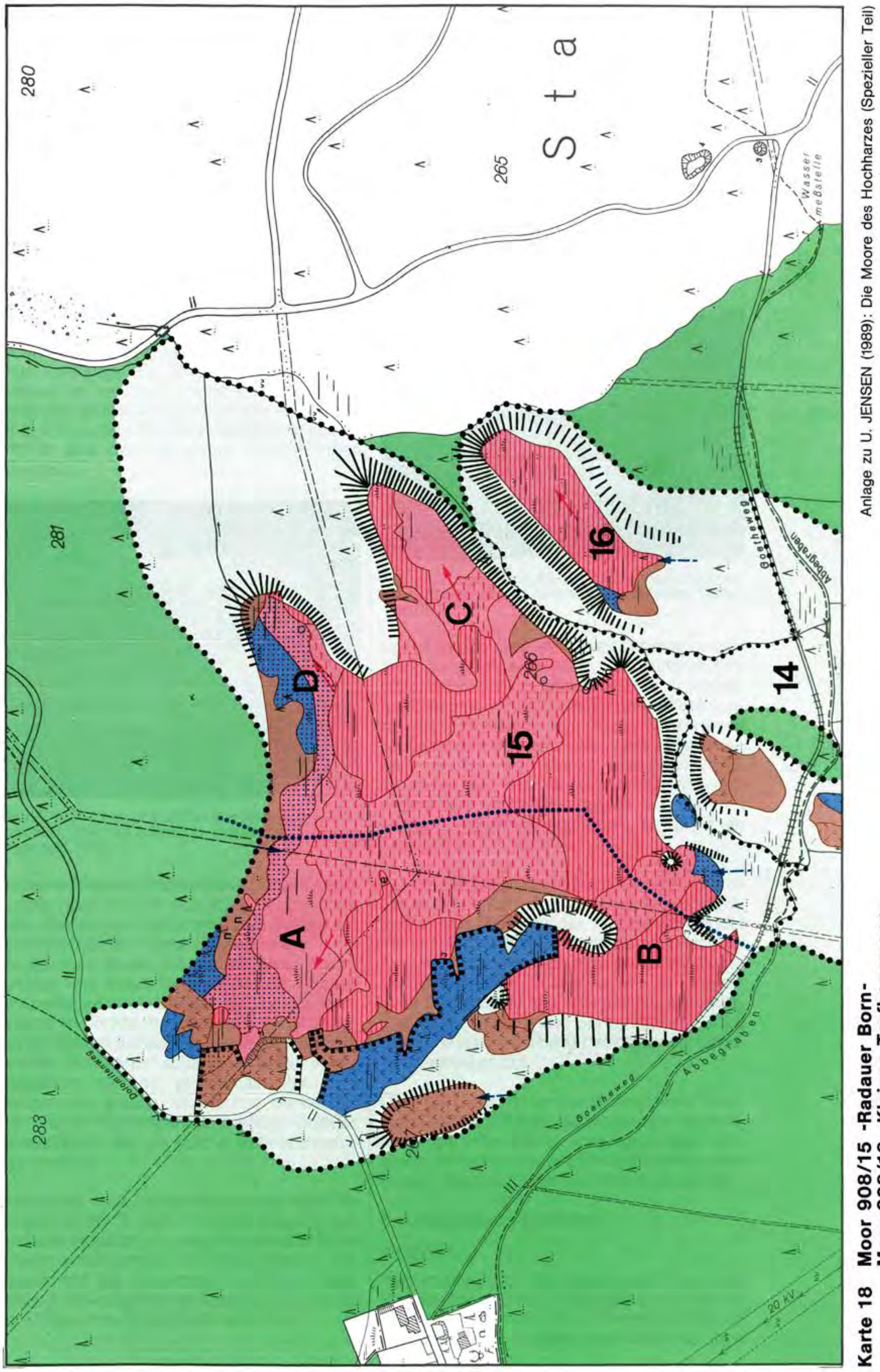


Abb.12.6: Sonnenberger Moor. Lage der Hangmoore und Moorkerne. Erläuterungen im Text. Aus Beug (1997).

Sonnenberger Moor, mire development (Beug et al. 1999)

Radauer Born = Großes Torfhausmoor



Vegetation map Radauer Born (Jensen 1990, Die Moore des Hochharzes – Spezieller Teil)

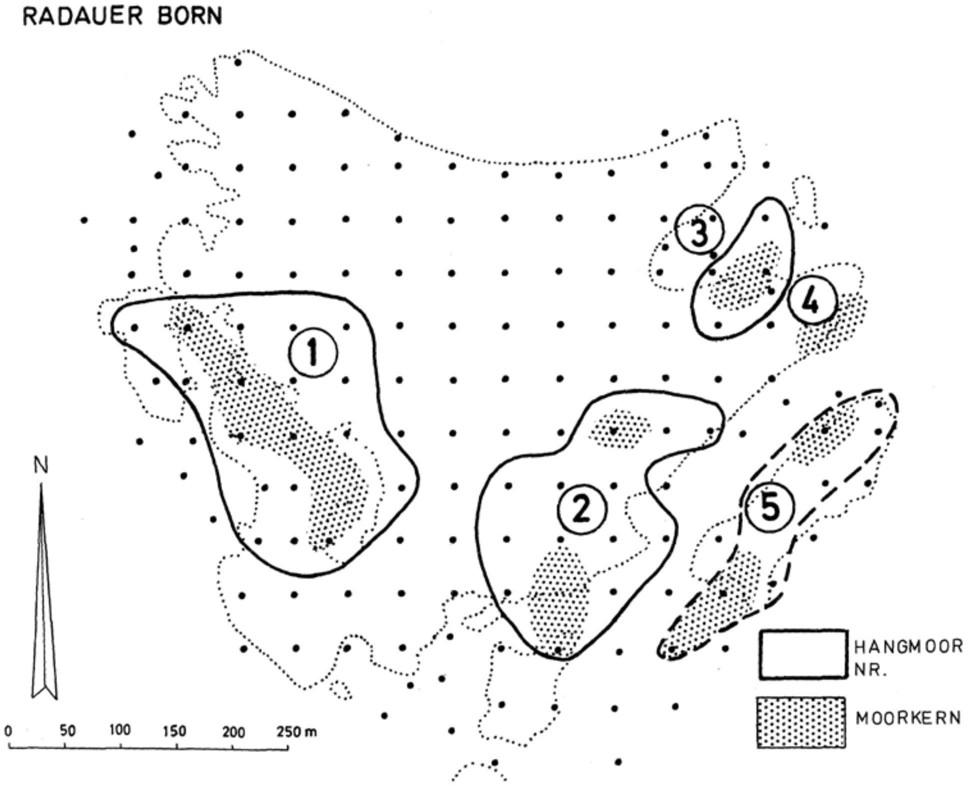


Abb. 8.7. Radauer Born und Kleines Torfhausmoor. Lage und Form der einzelnen Hangmoore mit ihren Moorkernen. Punktierte Flächen: Moorkerne. Punktierte Linien: Grenzen der offenen Moorflächen. Die Darstellung stellt die Hangmoore 1-4 für die Pollenzone IV, das Hangmoor 5 für die Pollenzone VI dar. Aus Henrion (1982).

Mire nuclei (Younger Dryas), development of slope mires (Preboreal), according to Henrion 1982 in Beug et al. 1990

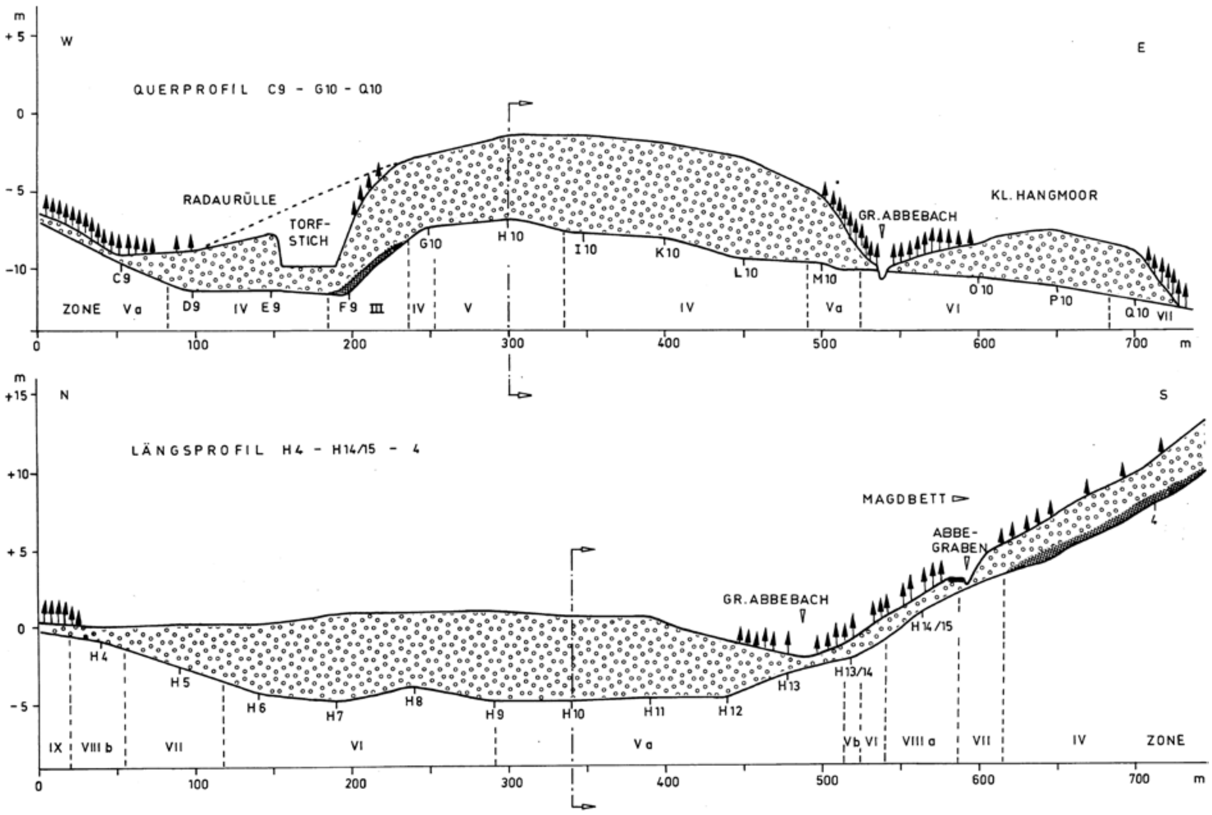
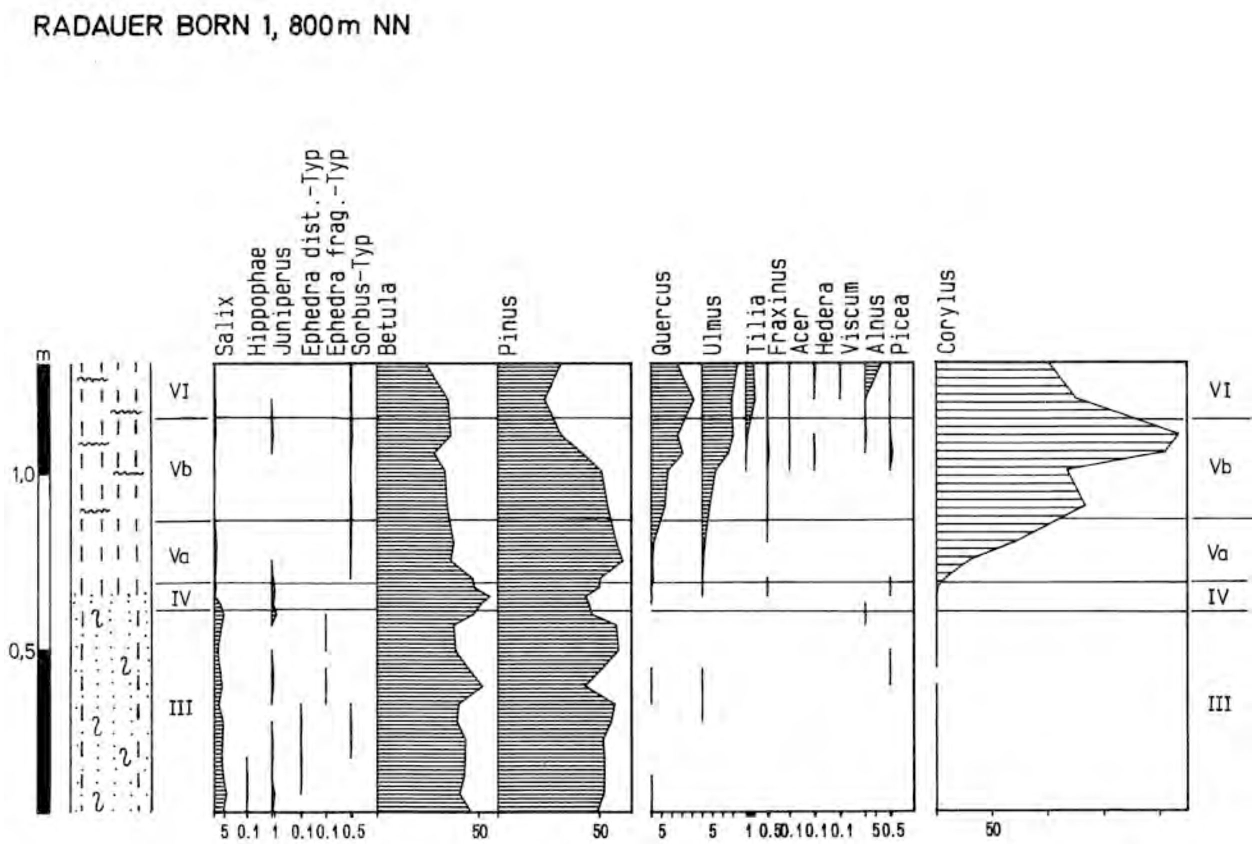


Abb. 8.3: Radauer Born und Kleines Torfhausmoor. Längs- und Querprofil (10fach überhöht) mit Angaben zum Vermoorungsalter. Lage der Moorkerne punktiert. Pfeile und strichpunktierte Linie: Schnittpunkt der Längs- und Querprofile. Aus Henrion (1982).

Beug et al. 1999, aus Henrion 1982



Pollen diagram Radauer Born in Beug et al. 1999, after Henrion 1990, simplified

Summary (Beug et al. 1999)

Introduction. The region known as the Harz Mountains in North Central Germany is the northernmost upland area in Central Europe. It may be divided into the western Upper Harz and the eastern Lower Harz, which lie in the states of Lower Saxony and Saxony-Anhalt, respectively. That part of the Upper Harz, which exceeds 700 m in altitude, is referred to as the High Harz Mountains and consists mainly of a hilly plateau at an altitude between ea. 700 and 850 m a.s.l. It also includes some higher mountains such as Mt. Brocken (1141 m a.s.l., the highest peak), Acker-Bruchberg, Wurmberg and Rehberg. The bedrock consists mainly of granite and quartzite and the High Harz Mountain area was completely glaciated during the last glaciation (Weichselian). The High Harz Mountain region is at present dominated by spruce forest and mires. More than 30 slope mires, which are surrounded by spruce carr at altitudes between 700 and 1100 m a.s.l., cover an area of about 1600 ha. Of this area, 600 ha are occupied by open vegetation and 1000 ha by spruce carr, respectively. The annual precipitation ranges between 1300 and 1600 mm with a maximum during winter and a secondary maximum during summer. The mean annual temperature is less than 5 °C with an average January mean temperature of less than -3 °C and July temperatures not higher than 13 °C.

Vegetation zones. Modern spruce forests dominate between 500 and 1100 m a.s.l. At lower altitudes there is a beech (Fagus sylvatica) dominated zone and small patches of beech forest are found within the spruce forest of the High Harz Mountains. Today, beech does not grow at altitudes above 900-950 m. The timberline of the Mt. Brocken summit, at 1090-1100 m a.s.l., consists exclusively of spruce (Picea abies). Above the timber line, subalpine meadows are mainly dominated by the grass Calamagrostis villosa.

Mires. All mires of the Harz Mountains are situated on slopes. They have up to 8-m-thick peat layers and include ombrotrophic raised bogs, minerotrophic mires (fen) and forested mires (carr). Raised bogs are surrounded by a fen belt that is influenced by ground or slope water. Water table level in the raised bogs itself is maintained by the bog itself. The outward-sloping margins are steep sided except on the uphill side and it is only rarely that the steeply sloping marginal feature forms a complete circle. Up slope of a raised bog, there is often an extensive fen that is fed by minerotrophic water running downslope into the mire. The fen vegetation is classified according to the degree to which the irrigating minerogenic waters affects species composition. The raised bog vegetation is classified into three units, each consisting of a number of syntaxa at association or sub-association level. The units are referred to as growth-complexes, stand-still-complexes and erosion-complexes. A growth-complex, under optimal conditions, does not form hummocks and hollows but has a flat surface. The surface of an erosion-complex is more uneven and is dominated by Scirpus cespitosus and Calluna vulgaris. Compared with the lowland and upland mires south of the Harz Mountains, the vegetation is species poor.

Archaeology and palaeoeconomy. Very little evidence for human activity during the Mesolithic, Neolithic and Bronze Age exists at higher altitudes in the Harz Mountains. The beginning of traceable human influence on the vegetation dates back to (silver) mining activities during the l0th century A.D. It is assumed, however, that mining started somewhat ealier i.e at least in the 8th century A.D. To obtain charcoal for ore smelting and pit-wood gathering, large quantities of timber were needed. Consequently, considerable areas of the Harz Mountains were repeatedly deforested during periods when there was considerable mining activity. Identifying and dating of charcoal pieces from surviving charcoal heaps has revealed much relating to the practice and history of the charcoal production and composition of the ancient forests. From historical sources, we know that miners and their families were poor and needed additional resources to make a living in the mining areas of the Harz Mountains. They raised cattle that grazed in the forests and this contributed further to forest decline. Near houses and settlements, meadows produced hay to feed the cattle in winter time. Arable farming was not practised in the High Harz Mountains and hence cereals had to be imported from the Harz forelands. Peat cutting is known since the 16th century but most of the peat bogs were not greatly affected.

History of vegetation. Palynological studies on mires elucidated the vegetation history of the High Harz Mountains. The development of mires, located at altitudes between 700 and 1100 m a.s.l., started at the end of the Younger Dryas period (pollen zone III after Firbas). There is no evidence of an Alleröd-type interstadial and the uppermost part only of the Late Glacial has been recorded. During the Younger Dryas, the timberline was below 150 m a.s.l. and the High Harz Mountain area lay far above the timberline in the nival zone where conditions were unfavourable for peat formation. Any peat that may have been formed during the Alleröd period was probably destroyed by solifluction processes during the Younger Dry as, at the end of which the Harz Mountains were covered by alpine or tundra-like vegetation types. Birch (Betula) forest, which formed a small belt, developed at the beginning of the Holocene and was followed by pine (Pinus sylvestris). The birch and pine forest zone migrated to higher altitudes.

During the Preboreal (zone IV), forests reached the highest peaks and, at the close of the Preboreal period (ea. 8500 cal. B.C.), pine forest with scattered birches covered the top of Mt. Brocken. Most alpine and tundra elements disappeared except for Betula nana and Selaginella selaginoides which found favourable habitats in peat bogs or open wind-exposed places. The present day vegetation in the subalpine zone at Mt. Brocken is, therefore, not traceable back to the Late Glacial period although some of the Late Glacial species were able to survive.

The Boreal period (zone V) which lasted from ca. 8500 to 6600 cal. B.C., is first of all characterised by the spread unto the area and rapid expansion of the hazel (Corylus avellana). The maximum Corylus percentage values vary from ea. 200% of arboreal pollen at 800 m a.s.l. to 660% of AP at 1050 m a.s.l. on the summit of Mt. Brocken. The Boreal period is furthermore characterised by the spread of the species that subsequently constituted the mixed oak forests. Macrofossil evidence does not exist but it can be assumed that after 8000 cal. B.C., elm (Ulmus) especially dominated in the high altitudinal forest. It is postulated that the forests above 1000 m a.s.l., were mainly composed of Ulmus glabra and Corylus avellana while Pinus sylvestris and Betula were successively displaced.

Trees of the mixed oak forests, and especially Ulmus glabra, Quercus, Tilia cordata and Fraxinus excelsior dominated during the Atlantic period (pollen zones VI and VII), e.g. from about 6600 to 4100 cal. B.C. At about 4800 cal. B.C. (beginning of pollen zone VII), spruce (Picea abies) spread into the High Harz Mountains and co-existed with the deciduous trees of the mixed oak forests and may have dominated on special habitats, e.g. on wet soil or rocky ground. It is noteworthy that on Mt. Brocken, i.e. above 1000 m a.s.l., Picea pollen is lower than those at lower elevations. One may therefore conclude that spruce did not form a subalpine belt as was the case in other Central European upland areas. Forests, consisting mainly of elm and hazel and possibly with some spruce, persisted through the Atlantic period at Mt. Brocken.

Vegetation development during the Subboreal (zones VIIIa and VIIIb), which lasted from ca. 4800 to 800 cal. B.C., is characterised by the spread and expansion of beech (Fagus sylvatica). Large-scale expansion of beech started at ca. 1700 cal. B.C., so that during the following 900 years, a complete change from elm, oak and lime-dominated forest to forests with beech as dominant occurred at low and high altitudes of the Harz Mountains and the forelands. One may assume that beech forest at the summit of Mt. Brocken consisted mostly of small and severely wind-affected specimens similar to the situation that can nowadays be observed at high altitudes of the Vosges Mountains. Remarkably, spruce continued being a relatively rare tree within the subalpine forest belt of the Harz Mountains.

The period of dominating beech forests started with the early Subatlantic period (zone IX) which lasted from 800 cal. B.C. to AD 900. It can be assumed that human impact, i.e that traceable by pollen analysis, on the vegetation of the High Harz Mountains did not yet exist. Small quantities of pollen types of anthropogenic pollen indicators may be explained with long-distance transport from the forelands.

All pollen spectra relating to younger Subatlantic (zone X) contain considerable quantities of cereal and other anthropogenic indicator pollen. It is known, however, that cereals are not grown in the High Harz Mountains and so it is concluded that part of the total pollen rain derives from low altitudes and from the forelands. Characteristic oscillations in the curves of beech and spruce are explained by tree cutting for the mining industries. Zone X is divided into subzones Xa and Xb in which beech and spruce dominated, respectively. The beginning of the present-day dominance by spruce dates back to the 15th century A.D. That important change also took place at higher altitudes and is most probably attributable to human activity. During the mining periods, from at least Middle Ages onwards, the Harz Mountains have been repeatedly deforested. In addition, a climate deterioration that was initiated at the onset of the Little Ice Age, may have further favoured the widespread expansion of spruce. Finally, forest management starting in the 18th century, resulted in spruce plantations.

In all, twelve pollen diagrams, many of which have not been previously published, are presented, as well as the results of pollen rain studies carried out on the summit of Mt. Brocken.

History of mire development. All mires have been directly developed on the minerogenous subsoil and no mires are derived from lakes by terrestrialization. Rather than using the well known terminology for categorizing the different mire types, we use terminology that relies not on the influence of nutrients or present-day mire morphology but rather the subsoil situation on which mires developed, i.e. simple slope, saddle, ridge and summit mires. Simple slope mires are mostly situated along small streams. Saddle-mires occupy saddle positions (depressions) in watersheds and ridge-mires cover extended parts of watersheds. Simple slope mires and saddle mires are the most frequent mire types in the Harz Mountains, ridge and summit-mires are rare and plateau mires are not present.

The process of paludification has been documented by study of horizontal growth of 36 mires. In most instances, coring of the basal part of the peat layer, including the transition to the minerogenous subsurface, was carried out within a 50 x 50 m grid. In addition, the mire surface was surveyed. From the lowermost part of the peat layer at each coring point, a pollen spectrum gave information about the age of the beginning of peat formation by correlating it with the well known and reliably established chronology of the regional vegetation development. By this method, maps of the mire development, of surface and subsurface isolines and of the peat thickness have been produced.

Mires started their development from small areas, i.e. mire nuclei, where sufficient water was available for peat-producing plants to become established. Mire nuclei were formed near small streams or on slopes where the soils were permanently wet. Small mires have only one or a few mire nuclei, while in large mires as many as 40 to 50 mire nuclei have been found. A high percentage of mire nuclei has been dated to the end of the Younger Dryas or to the early Holocene. However, mire nucleus formation continued through the successive millennia and came to an end during the late Subboreal period (zone VIIIb). Mire nucleus formation is not known any more from the Subatlantic period. The long period of mire nucleus formation should not be attributed to a continuous increase in precipitation. Rather it is proposed that fine soil components continued to move downslope over a long period, so that this continuous accumulation of fine soil material gave rise to permanently wet soils and hence to the formation of further mire nuclei.

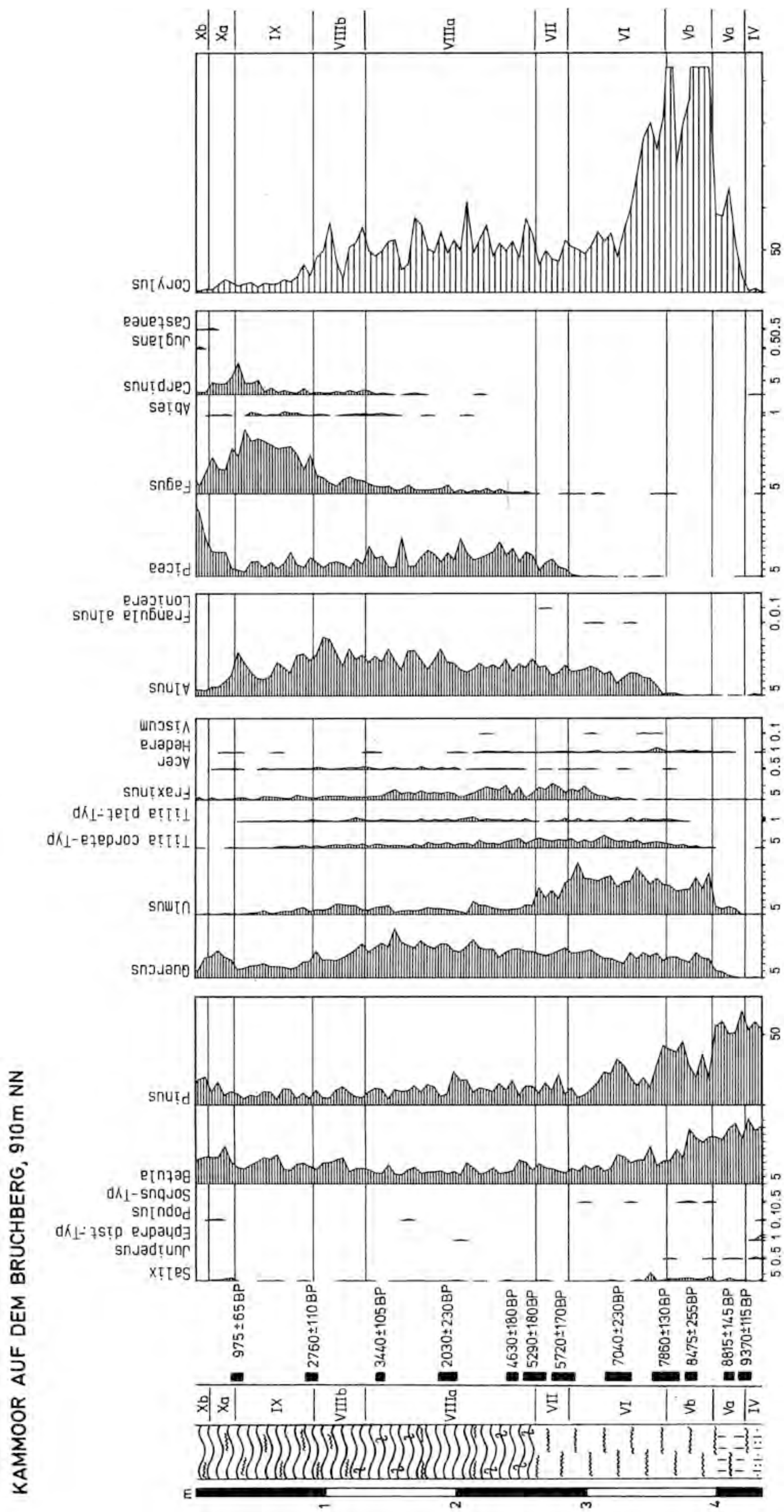
During the early Subboreal period (pollen zone VIIIa), the youngest mires started their growth. The rate of horizontal growth of most mires declined during the late Subboreal (zone VIIIb) when they were already close to their present-day form. Bog growth appears to be limited by topographical factors.

With further development, mire nuclei normally increase in area and form small, simple slope-mires. Adjacent small mires of such an origin coalesce and form larger units (integration processes). Saddle mires start their growth in most cases from mire nuclei situated on the slopes at either side below the watershed. First they act as slope-mires and during their successive growth they climb up the slopes towards the watershed where they coalesce so that the paludification of the uppermost part of the saddle is the last step in saddle mire development. A similar way of development has been observed in case of the ridge-mires.

Control mechanisms for mire growth. On the basis of available information, paludification appears to have been initiated by the climate change from a cold and dry to a warm and wet climate at the Late Glacial/Holocene transition. It has been demonstrated by the rates of horizontal and vertical mire growth that, throughout the whole of the Holocene, the climate was favourable for mire growth and dry periods were not a limiting factor. At the other hand, a few periods with accelerated mire growth rates were noted and these are attributed to increased habitat wetness caused by a decrease in temperature. These periods with accelerated growth occurred in the late Atlantic period (zone VII) and the late Subboreal (zone VIIIb) (both instances, for a comparatively short period) and also in second part of the early Subatlantic period (zone IXb). To a certain extent, it is possible to correlate those events with cold periods as recorded by glacier advances in the Alps. In addition to the control mechanisms already discussed, the influence of topographical features is essential. Slope inclination, irregularities in the subsurface and distance between mire nuclei had profound effects on the process of paludification in a particular area. On the other hand, deforestation did not accelerate paludification.

Pollenzone	III	IV	V	VI	VII	VIIIa	VIIIb	IX	X	S
Rotes Moor	-	2	-	-	-	-	-	-	-	2
Mittleres Rotes Moor	-	-	1	-	-	-	-	-	-	1
Hinteres Rotes Moor	-	-	1	-	-	-	-	-	-	1
Rehbachmoor	-	4	1	1	1	2	-	-	-	9
Radauer Born	4	2	-	-	-	-	-	-	-	6
Kleines Torfhausmoor	-	-	2	-	-	-	-	-	-	2
Magdbettmoor	-	4	1	-	-	-	-	-	-	5
Bruchbergmoor	-	20	12	10	1	4	-	-	-	47
Stieglitzmoor	-	-	2	1	1	-	-	-	-	4
Gipfelmoor auf dem Rehberg	-	-	-	-	-	1	2	-	-	3
Flörichshaier Sattelmoor	1	1	-	-	-	-	-	-	-	2
Flörichshaier Moore	1	2	-	1	-	-	-	-	-	4
Oberes Schwarzes Moor	1	1	2	-	-	-	-	-	-	4
Unteres Schwarzes Moor	-	2	-	-	-	-	-	-	-	2
*Rotenbeektal	10	10	5	3	1	3	-	-	-	32
Sonnenberger Moor	-	3	-	3	1	3	-	-	-	10
Hörstemoor	-	1	2	-	-	1	-	-	-	4
Drei-Hörste-Bruch	-	2	1	-	2	1	-	-	-	6
Odersprungmoor	-	1	1	-	1	2	-	-	-	5
Oderbruch	-	1	1	1	-	-	-	-	-	3
Oderbrückmoor	-	2	1	1	-	-	-	-	-	4
Bodemoor	-	-	-	-	1	2	-	-	-	3
Kaiserwegbruch	-	1	1	1	1	-	-	-	-	4
Großes Rotes Bruch	-	1	1	1	-	2	1	-	-	6
Hügelmoor	-	-	1	-	-	-	-	-	-	1
Sandbeekmoor	-	-	-	-	1	1	-	-	-	2
Kleines Rotes Bruch	1	1	2	-	1	-	-	-	-	5
Schwarzer Sumpf	2	2	1	1	-	-	-	-	-	6
Königsmoor	-	2	-	-	-	-	-	-	-	2
Brockenfeldmoor	-	-	4	-	2	9	3	-	-	18
Eckersprungmoor	-	-	-	-	-	1	2	-	-	3
Goethemoor	-	-	2	6	6	1	-	-	-	15
Moor an der Heinrichshöhe	-	2	1	-	2	-	-	-	-	5
Moor an den Rabenklippen	-	-	-	5	1	1	-	-	-	7
Brockenbett	-	-	-	-	1	-	-	-	-	1
NW Brockenkuppe	-	-	-	3	-	1	-	-	-	4
Summe	20	67	46	38	24	35	8	-	-	238

Number and age of the mire nuclei of 36 mires investigated

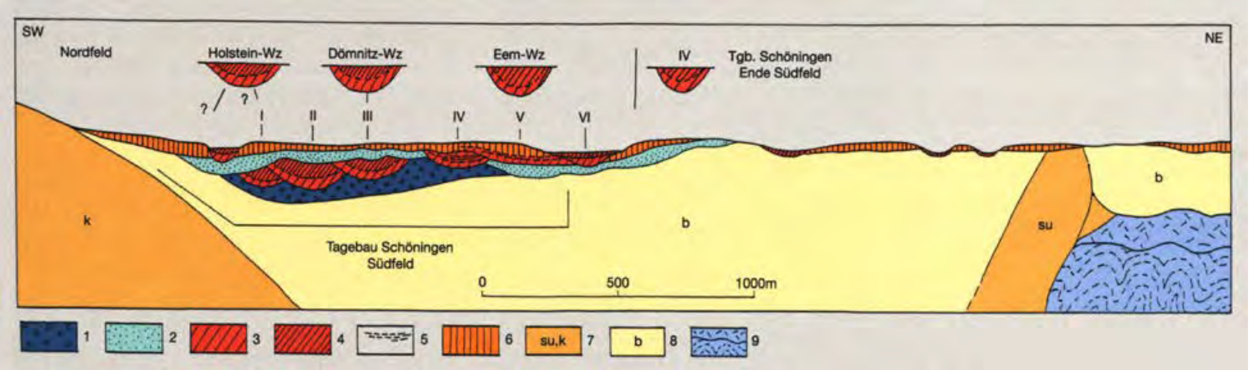


Pollen diagram Bruchbergmoor, after Bartens 1990 in Beug et al. 1999, simplified

Paläon Center and Palaeolithic excavation in the opencast mine Schöningen

http://www.palaeon.de/home.html

H. Thieme (2007) Die Schöninger Speere – Mensch und Jagd vor 400 000 Jahren



D. Mania in Thieme (2007)

Schöningen spears made of *Picea* and *Pinus* (length 1,80 – 2,50 m)

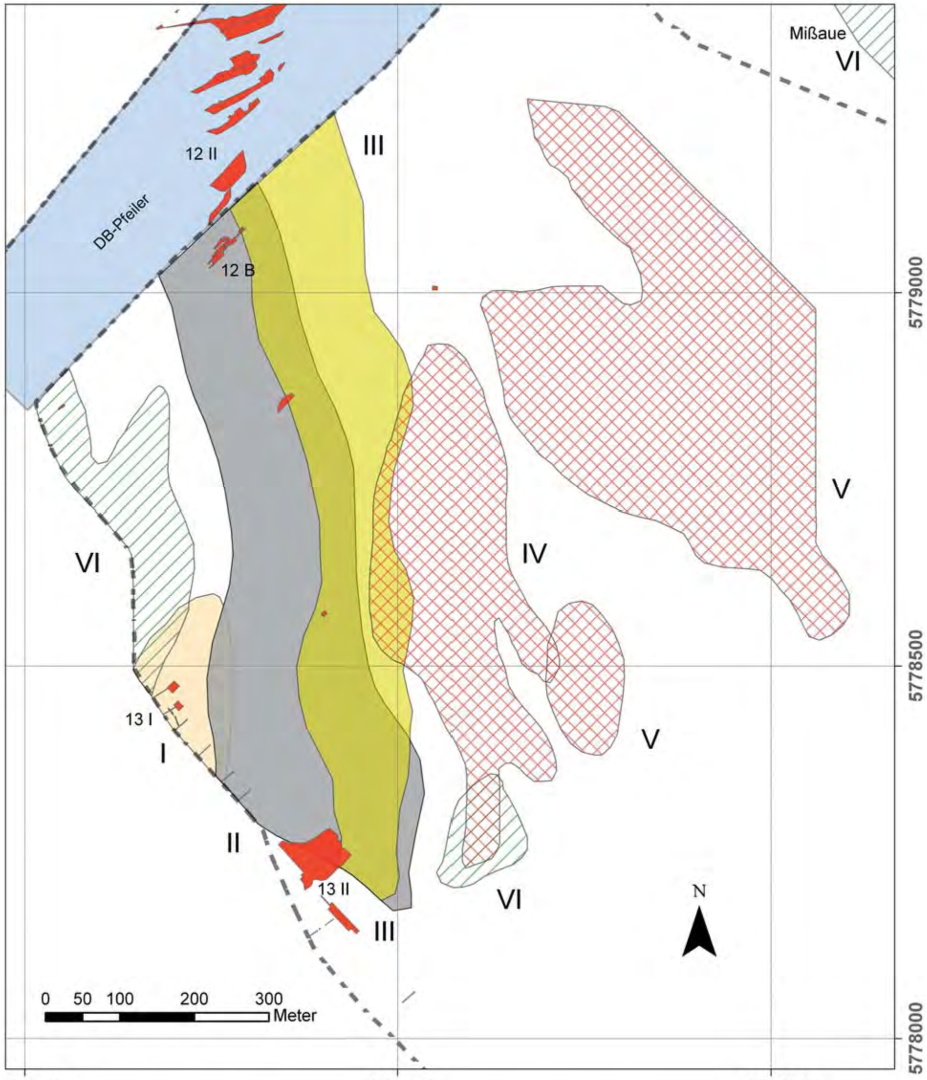


Abb. 6 Verlauf und Ausdehnung der »Rinnen« im Tagebau Schöningen (Südfeld) nach D. Mania. **I** und **II**: organische Ablagerungen aus dem Holstein/Reinsdorf-Interglazial, **III**: saalezeitliche Schmelzwasserrinne, **IV** und **V**: fossile Bodenkomplexe (Pseudogley/Parabraunerde), **VI**: spätglaziale bis holozäne Sedimente. Rot: pleistozäne Fundstellen, blau: Profilschnitte an der Endböschung 2011. – (Verändert nach Mania 2007, 179 Abb. 146).

Serangeli et al. 2012

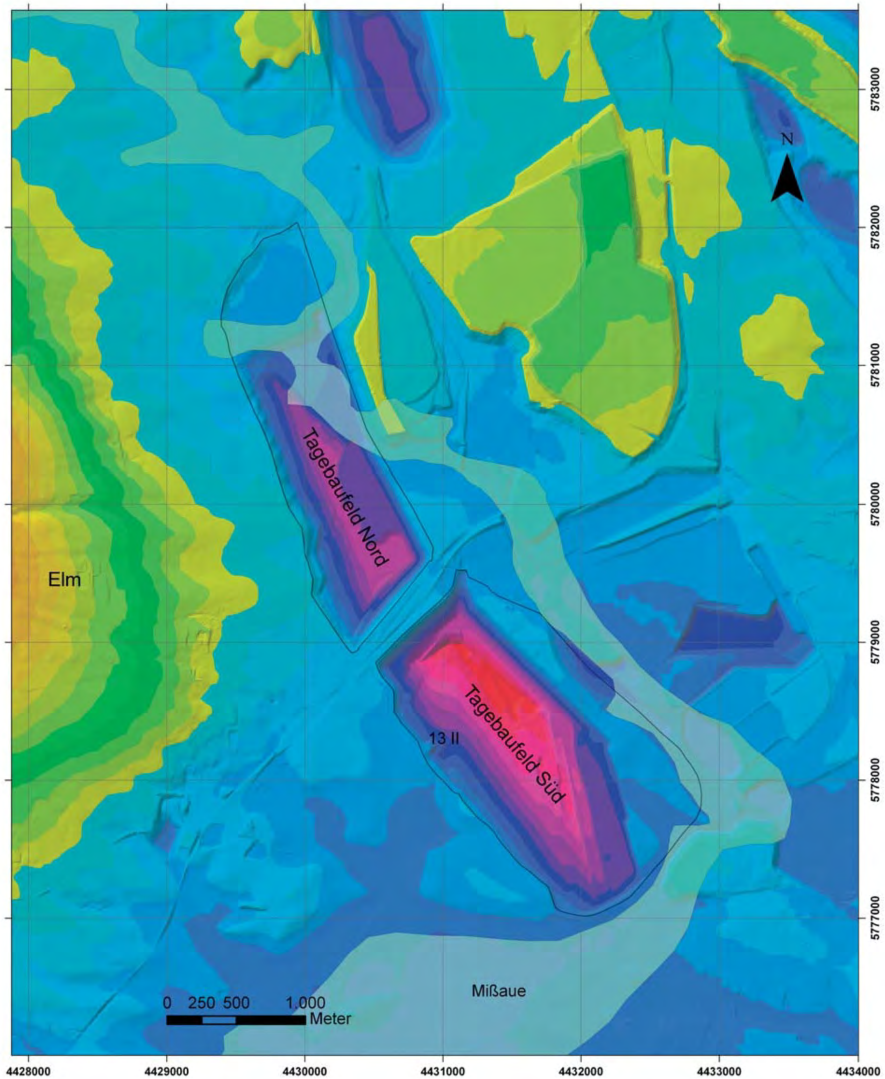


Abb. 2 Digitales Geländemodell (DGM5), Tagebau Schöningen. Holozäner Verlauf der Mißaue. – (Bearbeitung U. Böhner).

Serangeli et al. 2012

Bittmann F. (2012) Die Schöninger Pollendiagramme und ihre Stellung im mitteleuropäischen Mittelpleistozän. In: Behre K.-E. (Ed.) Die chronologische Einordnung der paläolithischen Fundstellen von Schöningen - The chronological setting of the Palaeolithic sites of Schöningen. Forschungen zur Urgeschichte aus dem Tagebau von Schöningen 1: 97-112

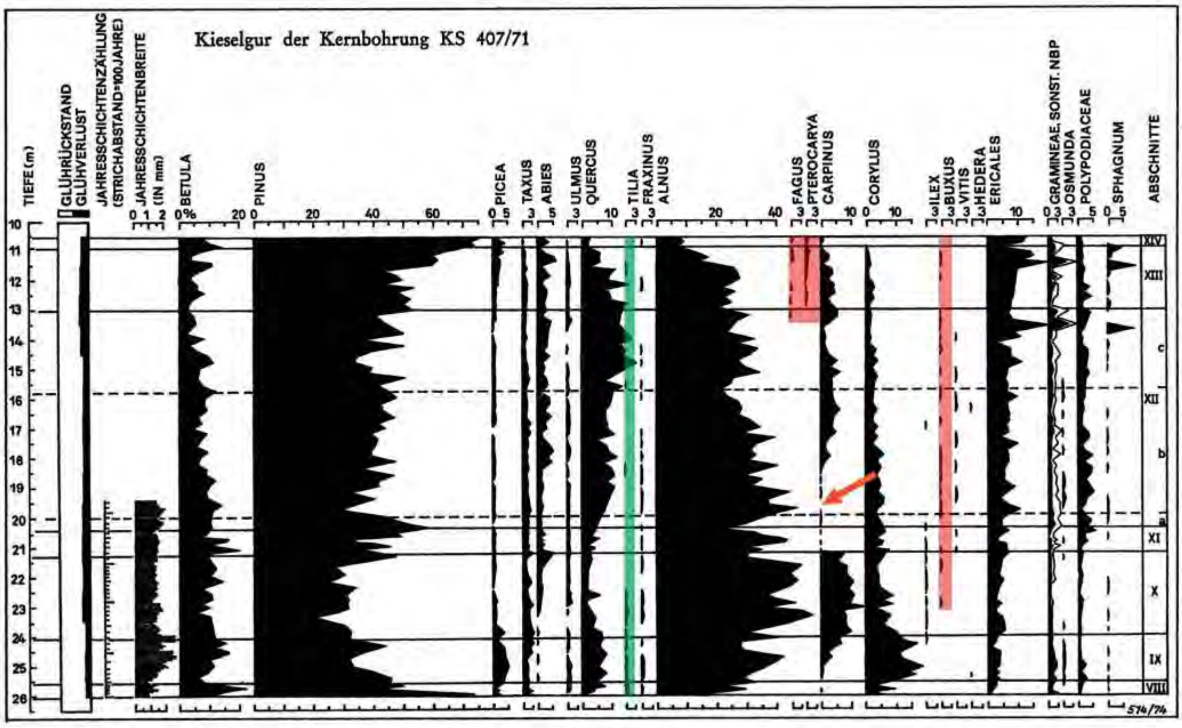


Abb. 1 Pollendiagramm der Holstein-Warmzeit, Bohrung KS 407/71 von Munster-Breloh (Heidekreis). – (*Tilia* ist grün, stratigraphisch wichtige Elemente sind rot markiert, der Pfeil weist auf den *Carpinus*-Rückschlag hin). – (Verändert nach Müller 1974, Abb. 3).

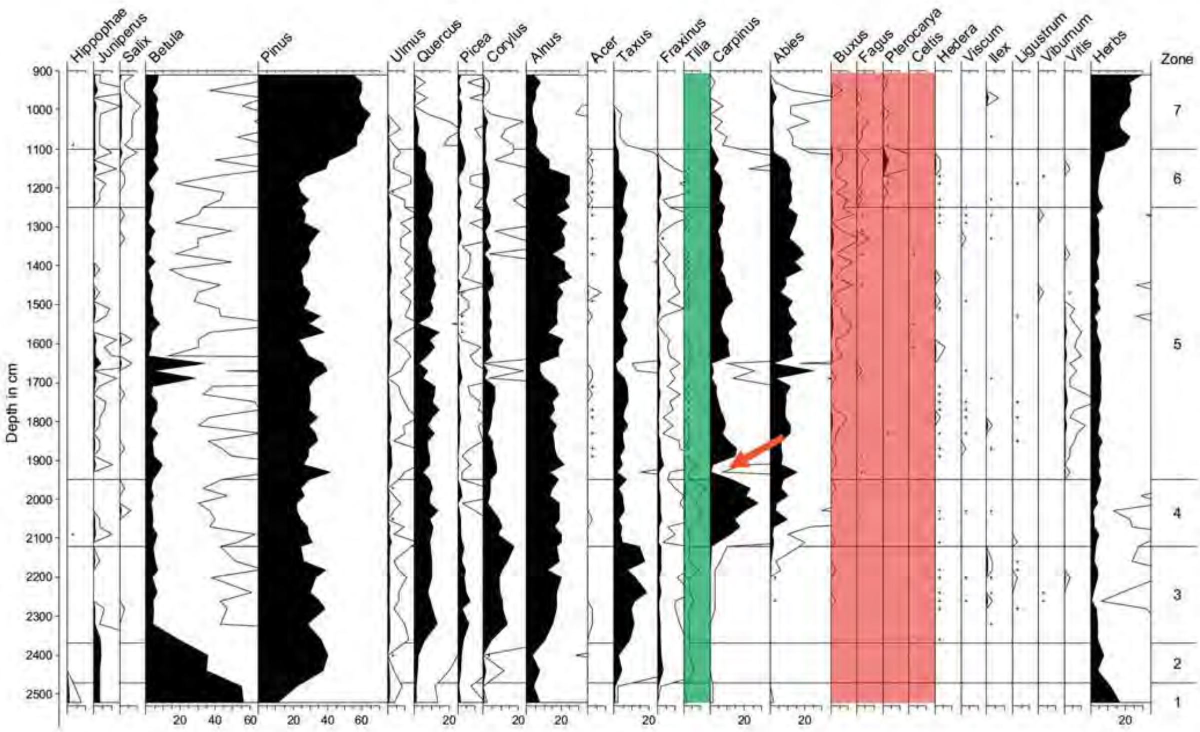


Abb. 2 Pollendiagramm der Holstein-Warmzeit, Gröbern-Schmerz (Lkr. Meißen). – Weitere Erläuterungen s. **Abb. 1**. – (Verändert nach Kühl / Litt 2007, Abb. 16, 3).

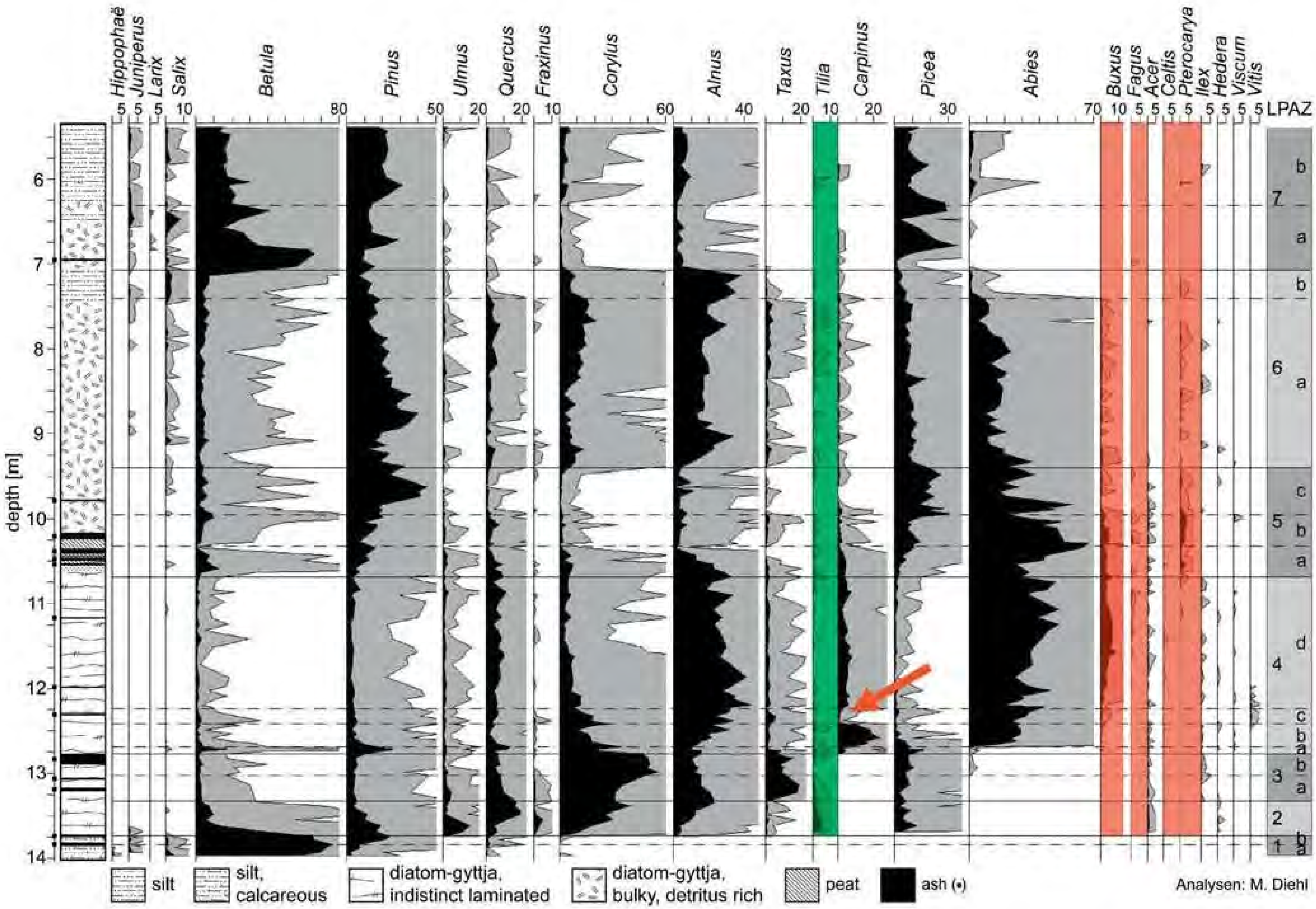


Abb. 3 Pollendiagramm der Holstein-Warmzeit, Döttingen (Lkr. Mayen-Koblenz). – (Verändert nach Diehl / Sirocko 2007, Abb. 27, 6).

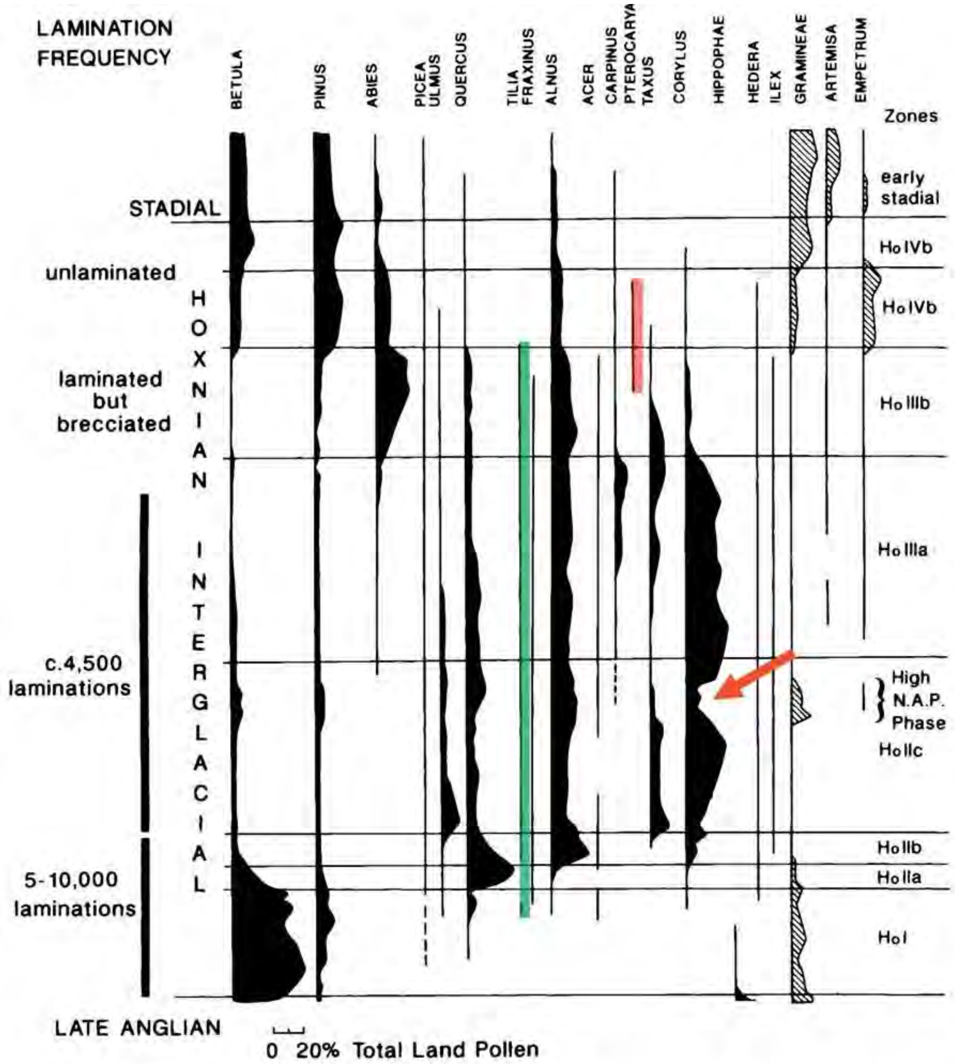


Abb. 4 Pollendiagramm der Hoxne-Warmzeit von Marks Tey (Essex/GB). – Weitere Erläuterungen s. **Abb. 1**. – (Verändert nach Turner 1970, Abb. 15 in Rowe u. a. 1999, Abb. 2).

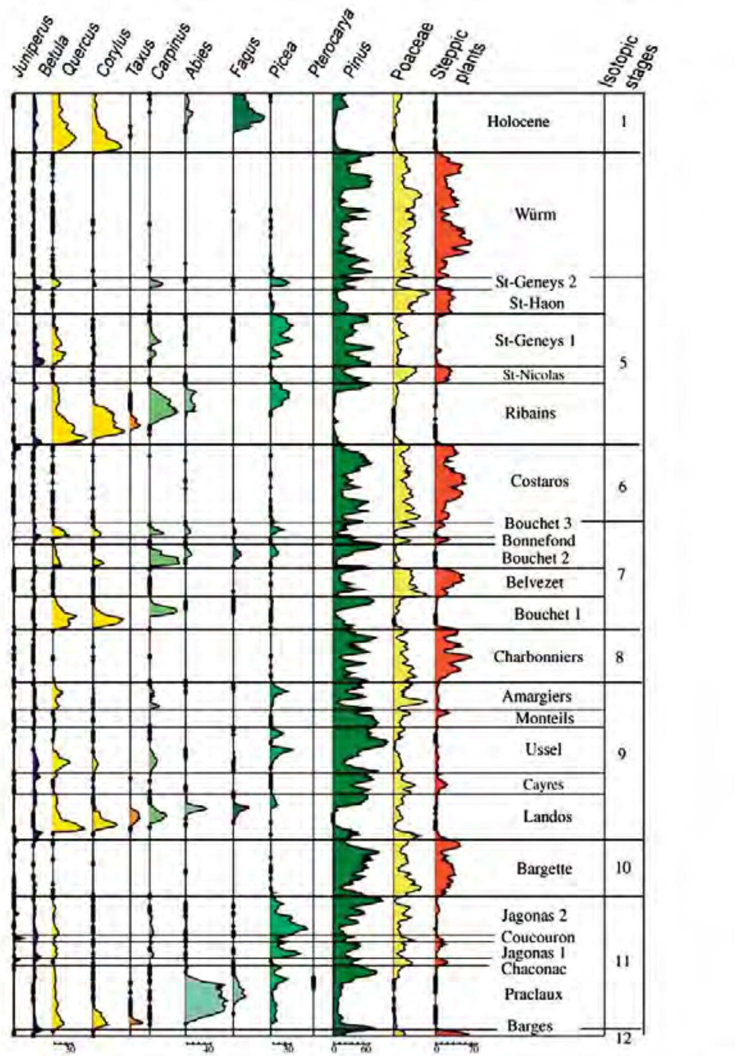


Abb. 5 Schematische Darstellung eines aus zwei Bohrungen (Lac du Bouchet und Praclaux, dép. Haute-Loire/F) zusammengesetzten Profils aus dem Massif Central. – Überlappung im oberen Bereich von Isotopenstadium 9. – (Verändert nach de Beaulieu u. a. 2001, Abb. 2).

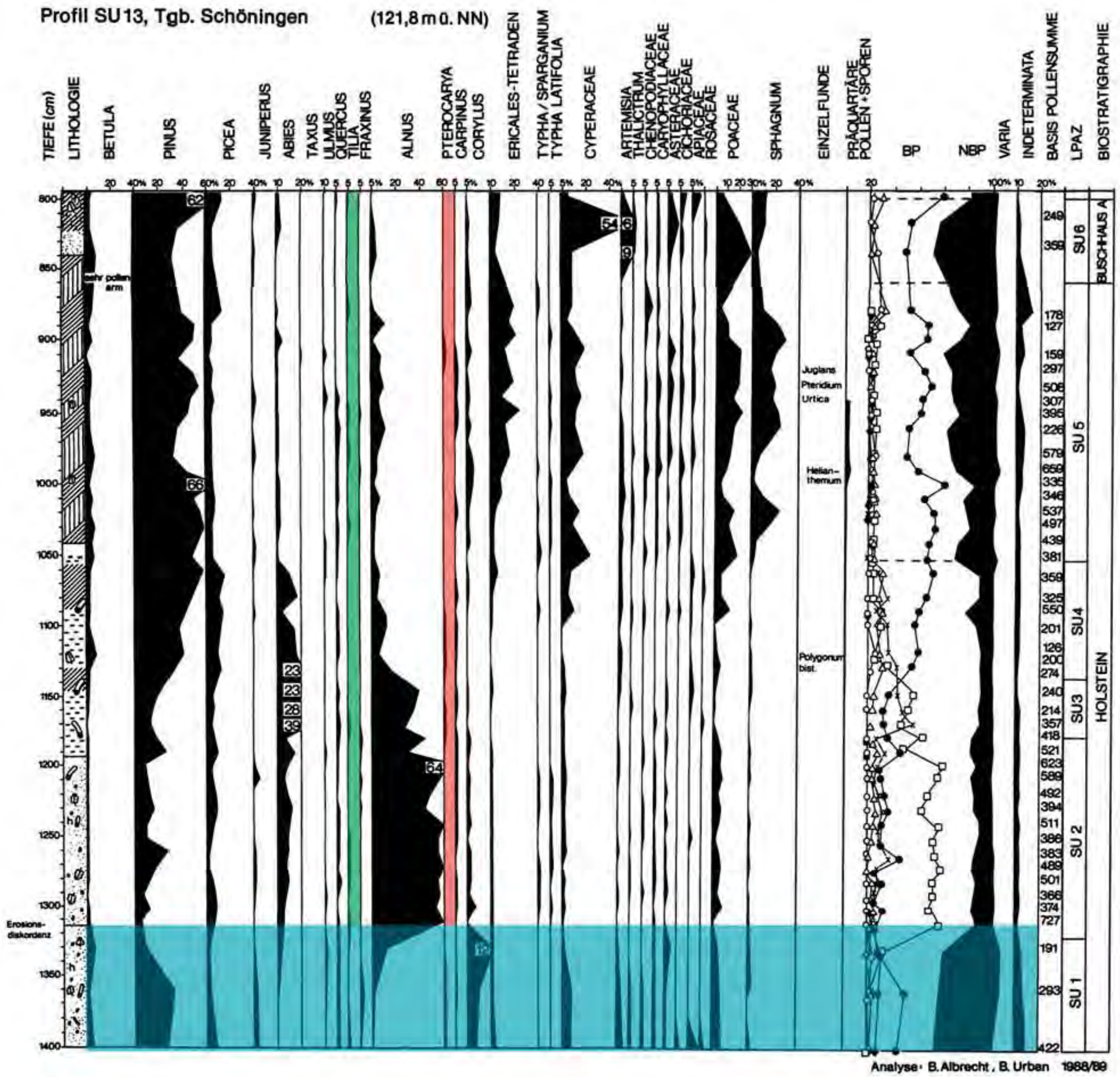


Abb. 6 Pollendiagramm der Holstein-Warmzeit, Profil SU 13. – Weitere Erläuterungen s. **Abb. 1**; blau markiert: gestörter Bereich unterhalb der Erosionsdiskordanz. – (Verändert nach Urban u. a. 1991, Taf. 1 Abb. 3).

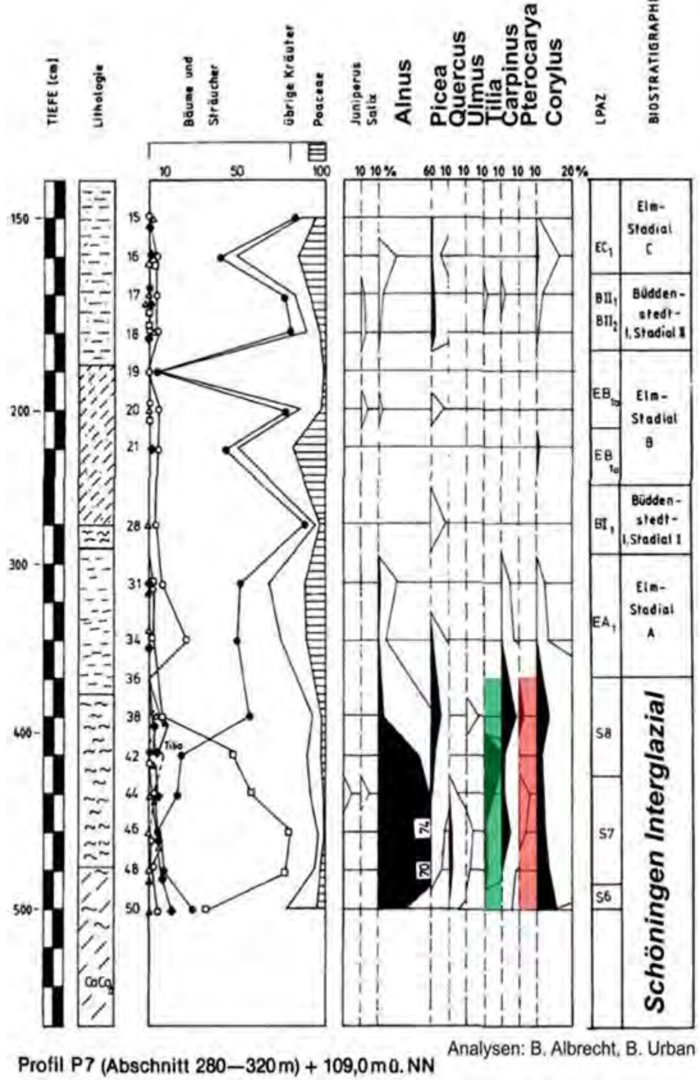


Abb. 7 Pollendiagramm der Schöningenzeit (Wacken-Dömnitz, Kr. Steinburg). Weitere Erläuterungen s. **Abb. 1**. – (Verändert nach Urban u. a. 1991, Taf. 1 Abb. 5).

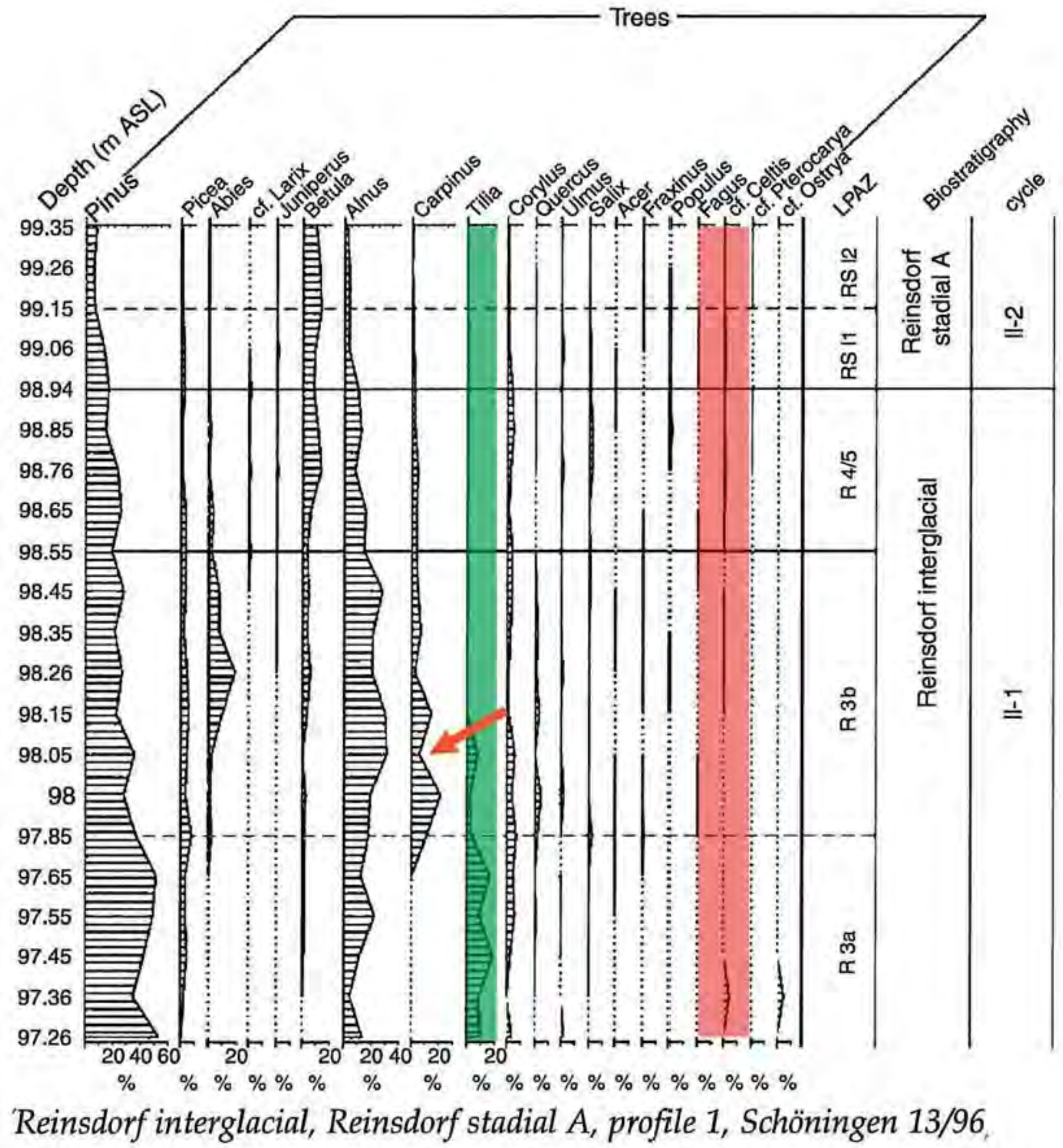


Abb. 8 Pollendiagramm Schöningen 13 II (96) der Reinsdorf-Warmzeit. – Weitere Erläuterungen s. **Abb. 1**. – (Verändert nach Urban 2007b, Abb. 28, 9).

The Schöningen pollen diagrams and their position within the central European Middle Pleistocene

During the past 20 years pollenanalytical studies were conducted on several profiles available during different stages of the ongoing lignite exploitation within the open cast quarry of Schöningen. Interglacial sediments between moraines of the Elsterian and the Saalian glaciation were in focus because palaeolithic finds became known among them wooden spears, known as the oldest ones worldwide. Three fragments of interglacials were identified in this part, the new interglacial type Reinsdorf bearing the spears was positioned between the Holsteinian and the Schöningen (Wacken/Dömnitz) interglacials. A supraregional comparison of the pollen sequences suggests that the Reinsdorf Interglacial is only a local specification of the Holsteinian and that the spears are of Holsteinian age. New datings of this interglacial sediments gave an age of about 295 000 years and correlate this with the marine isotope stage 9. Therefore the wooden spears are about 100 000 years younger than thought before.

Karl-Ernst Behre Die chronologische Einordnung der paläolithischen Fundstellen von Schöningen - The chronological setting of the Palaeolithic sites of Schöningen. Forschungen zur Urgeschichte aus dem Tagebau von Schöningen, Bd. 1, 2012

open access:
http://www.denkmalpflege.niedersachsen.de/portal/live.php?navigation_id=32511&article_id=112370&_psmand=45

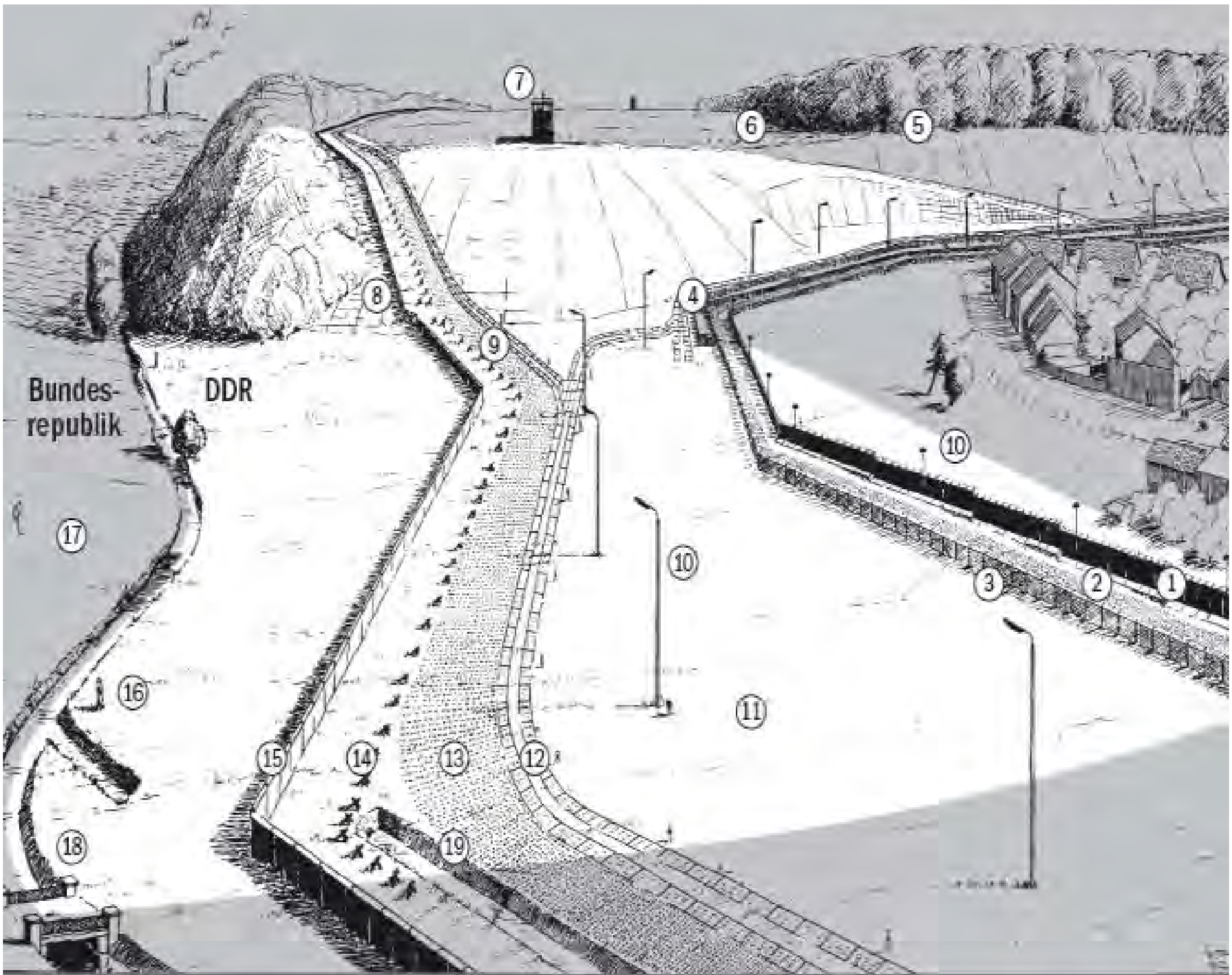
Some other recent literature

Lang J, Winsemann, J, Steinmetz D et al. (2012) The Pleistocene of Schöningen, Germany: a complex tunnel valley fill revealed from 3D subsurface modelling and shear wave seismics. Quaternary Science Reviews 39: 86-105

Urban B, Sierralta M, Frechen M (2011) New evidence for vegetation development and timing of Upper Middle Pleistocene interglacials in Northern Germany and tentative correlations. Quaternary International 241: 125-142

Van Kolfschoten, Th. (2014) The Palaeolithic locality Schöningen (Germany): A review of the mammalian record: Quaternary International 326–327: 469-480

Memorial of the inner German border at Hötensleben



Die Sperranlagen an der innerdeutschen Grenze bei Hötensleben 1989

1. »Sichtblendmauer«, Bewegungs- und Sichthindernis, 3 m hoch mit Lichtsperre (Tafel 16)
2. »K2«, Kontrollstreifen zur Erkennung von Fußspuren, 2 m breit (Tafel 16)
3. »Grenzsicherungs- und Signalzaun« (GSSZ) aus Streckmetall mit Signaldrähten, 2,40 m hoch (Tafel 16)
4. Hundelaufanlage (Tafel 14)
5. Land- oder forstwirtschaftlich genutzte Fläche
6. Minen (Tafel 13)
7. »Führungsstelle« (Tafeln 11/12)
8. Grenzzaun aus Streckmetall, 3 m hoch (Tafel 16)
9. »Kraftfahrzeugsperrgraben« (Tafel 10)
10. »Lichttrassen« (Tafel 15)
11. »Sicht- und Schussfeld«
12. »Kolonnenweg« (Tafel 5)
13. »K6«, Kontrollstreifen zur Erkennung von Fußspuren, 6 m breit (Tafel 6)
14. »Kraftfahrzeughöcker« aus Stahl (Tafel 7)
15. »Grenzmauer« (Tafel 8)
16. »Vorgelagertes Hoheitsgebiet« mit DDR-Grenzsäule (Tafel 9)
17. Schild »Bachmitte ist Grenze, Bundesgrenzschutz«
18. Brücke der Straße nach Schöningen
19. Wassergraben als KfZ-Hindernis

Hauptaufgabe der DDR-Sperranlagen...

...an der innerdeutschen Grenze war die Vereitelung von Fluchtversuchen der eigenen Bevölkerung. Das unterscheidet sie von anderen Grenzbefestigungen wie z.B. dem römischen Limes, der chinesischen Mauer, oder der befestigten Grenze zwischen Israel und den Palästinensergebieten, die - bei allen damit verbundenen Problemen - der Gefahrenabwehr dienen.

Zum Grenzsperrsystem der DDR gehörten insbesondere:

- die Transport- und Volkspolizei, die Fluchtwillige schon im Hinterland, z.B. in Bahnhöfen festnahm;
- der ca. 5 km breite, streng kontrollierte Streifen des »Sperrgebietes« mit seinen für die Bewohner eingeschränkten Bewegungsmöglichkeiten;
- der zwischen Sperrgebiet und Grenze liegende 250 bis ca. 1.500 m breite »Schutzstreifen«. Hier sollten die Grenztruppen »Republikflüchtige« stellen. Er war »freundseitig« mit dem »GSSZ« (3) und »feindseitig« mit der »Grenzmauer« (15) abgesperrt. Mit Hilfe der »freundseitig« an den beiden Zäunen befindlichen »Spurensicherungsstreifen« (2/13) sollte festgestellt werden, wo sich der Flüchtende befand. Bei Alarmauslösung aktivierte der Führungsoffizier im Führungsturm (7) die »Alarmgruppe«. Diese hatte sich dort, wo der Flüchtende zu erwarten war, in Doppelposten auf dem »Kolonnenweg« (12) aufzustellen und ihn dann auf dem »Sicht- und Schussfeld« (11) »vorläufig festzunehmen oder zu vernichten«.

Wegen der grenznahen Ortsbebauung (z.T. nur 80 m) konnte der vorgeschriebene Mindestabstand des GSSZ (3) zur Grenze nicht eingehalten werden. Diese Stelle des »Schutzstreifens« wurde deshalb durch eine zusätzliche Sichtblendmauer (1), zwei Lichttrassen (10), geringere Abstände der Beobachtungstürme, Grenzmauer (15) statt Grenzzaun sowie Kraftfahrzeughöcker (14) verstärkt. Der »Ausbau vor Ortschaften« entsprach dem an der Berliner Sektorengrenze und ist eine Besonderheit an der innerdeutschen Grenze.

Am Turm auf dem Hügel (7) ist der für die offene Landschaft typische »normale pioniertechnische Ausbau« zu erkennen. Er besaß eine geringere Ausbaudichte und war durch land- und forstwirtschaftlich genutzte Flächen (5) zwischen »GSSZ« (3) und Kolonnenweg (12) gekennzeichnet.

Bilanz

Insgesamt verließen ca. 4,4 Millionen Deutsche »illegal« die sowjetische Besatzungszone/DDR, davon 40.000, die unter Lebensgefahr direkt die Sperranlagen überwanden, und viele, die über die Ostsee oder Drittstaaten flüchteten. Bisher sind ca. 1.000 Todesopfer des DDR-Grenzregimes bekannt.

Zwischen 1961 und 1989 sind nach derzeitigem Kenntnisstand im 17 km langen Grenzabschnitt zwischen Offleben und dem Großen Graben mindestens folgende Zwischenfälle zu verzeichnen:

332 »Festnahmen« von Flüchtlingen, darunter

- eine Person durch Minen getötet,
- mindestens acht Personen durch Minen verletzt,
- eine Person vermutlich durch Hunde verletzt,
- Festnahmeumstände bei ca. 310 Personen unbekannt,

ferner:

- vier durch Minen verletzte Grenzsoldaten
- der Selbstmord zweier Offiziere der Grenztruppen
- der Selbstmord eines Grenzsoldaten
- 225 Grenzdurchbrüche, darunter 24 Fahnenfluchten.

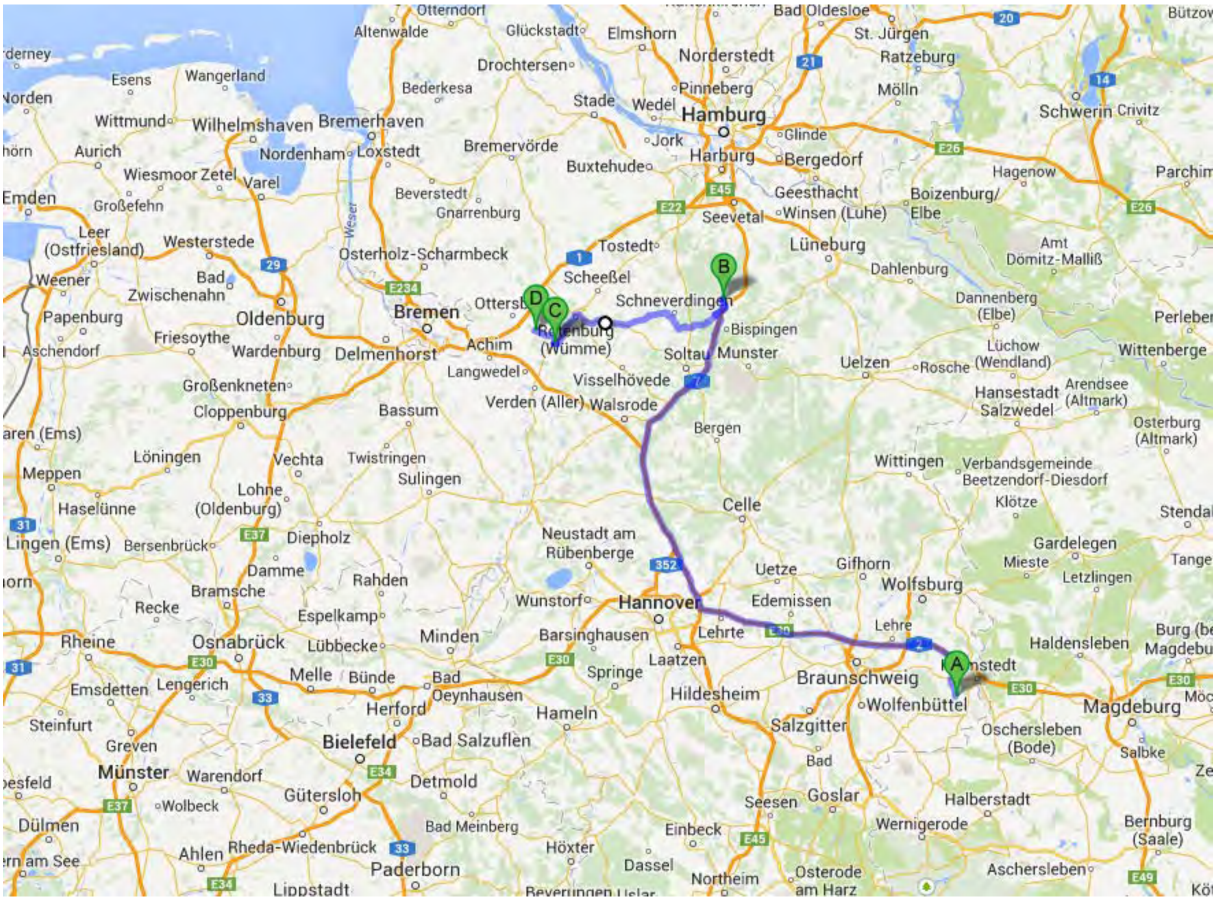
Das Grenzdenkmal Hötensleben dokumentiert den Zustand von 1989 und steht seit Januar 1990 unter Denkmalschutz. Es gilt als das weitaus am besten und umfassendsten erhaltene Zeugnis der innerdeutschen Grenzbefestigung.

Obwohl alle Grenzanlagen bis 1993 abgerissen werden sollten, gelang es engagierten Einwohnern, den heutigen Denkmalbereich nördlich der Straße nahezu originalgetreu zu bewahren. Südlich der Straße blieben nur einzelne Objekte erhalten. Auf den Linien der beiden abgebrochenen Mauerstücke wurden dort in einer Spendenaktion Bäume gepflanzt.

Seit 1993 betreut der Grenzdenkmalverein Hötensleben e.V. das Denkmal. Seit Januar 2004 befindet es sich in Trägerschaft des Landes Sachsen-Anhalt und ist Bestandteil der Gedenkstätte Deutsche Teilung Marienborn. Das Denkmalsgelände ist frei zugänglich. Führungen sind nach Absprache mit der Gedenkstätte Deutsche Teilung oder dem Grenzdenkmalverein möglich.

Tuesday, 09.09.2014
Lüneburg Heath and Lake Eversen

Lüneburg Heath (L. Kulenkampff, D. Mertens, K. E. Behre)
Human impact and environmental change at Lake Eversen (D. Enters, S. Wolters, K. Blume)
Accomodation at Prüsers Gasthof, Hellwege



Some facts on the Lüneburg Heath

The Lüneburg Heath (German: Lüneburger Heide; also Lunenburg Heath in English) is a large area of heath, geest and woodland in the northeastern part of the state of Lower Saxony in northern Germany. It forms part of the hinterland for the cities of Hamburg, Hanover, and Bremen and is named after the town of Lüneburg. Most of the area is a nature reserve. Northern Low Saxon is still widely spoken in the region.

The Lüneburg Heath has extensive areas of heathland, typical of those that covered most of the North German countryside until about 1800, but which have almost completely disappeared in other areas. The heaths were formed after the Neolithic period by overgrazing of the once widespread forests on the poor sandy soils of the geest, as this slightly hilly and sandy terrain in northern Europe is called. The Lüneburg Heath is therefore a historic cultural landscape. The remaining areas of heath are kept clear mainly through grazing, especially by a North German breed of moorland sheep called the Heidschnucke. Due to its unique landscape, the Lüneburg Heath is a popular tourist destination in North Germany.

The Lüneburg Heath lies in a temperate maritime climatic region moderated by the Atlantic, with mild winters, cool summers and precipation all-year round. It situated between the rivers Elbe to the north, the Aller to the south and southwest, the middle course of the Wümme to the west and the Harburg Hills (Harburger Bergen) to the northwest. The highest elevation on the Lüneburg Heath is the Wilseder Berg (169.2 m asl).

The immediate subsurface layers on the Lüneburg Heath are almost exclusively made up of deposits from the quaternary ice age. The landscape consists of flat plains of ground moraines, ridges of hilly terminal moraines and also of sandur. During the Saalian Stage (230,000–130,000 years ago) the area of the present-day Lüneburg Heath was covered three times by a continental ice sheet. In the last glacial period (110,000–10,000 years ago) the ice sheet no longer covered the Lüneburg Heath area; it reached only as far as the River Elbe. Due to the lack of vegetation, the much more rugged terrain at that time was heavily eroded by water, wind and by soil fluction; this resulted in valleys like the Totengrund.

In the northwestern part of the Lüneburg Heath is the Lüneburg Heath Nature Park which covers an area of 1,130 km^2. At its heart, around the Wilseder Berg, is the Lüneburg Heath Nature Reserve founded as long ago as 1921 with 234 km^2 of land which is roughly 58% woods and 20% heathland.

The region is mostly covered by a heathland landscape consisting of big heather and juniper areas, forests and some smaller swamps. In contrast to the areas in the north of the Lüneburg Heath, the landscape is very hilly, as it is placed on a terminal moraine.

Vegetation types

Ordinary sand heath (Genisto-Callunetum)

In addition to the Common Heather (*Calluna vulgaris*) only a few taller plants occur here, none of which can be classed as characteristic species. Amongst them are the Wavy Hair-grass (*Deschampsia flexuosa*) and Common juniper (*Juniperus communis*). Ordinary sand heath is the most widespread of the heathland types. Its proportion has increased in recent decades at the expense of other heath habitats. This reduction in the variety of heathland types may be due to increasing nitrogen levels from the air, the increase in plant litter (Rohhumusauflagen) and the natural ageing of the heathland.

Lichen-rich sand heath (Genisto-Callunetum cladonietosum)

The lichen-rich sand heaths can be told apart from the other types of heathland by the presence of various cup lichens (*Cladonia* sp.), Ciliated fringewort (*Ptilidium ciliare*) and Juniper Haircap (*Polytrichum juniperinum*). They occur frequently on dry, south-facing slopes. This type of heath is found west of Niederhaverbeck and near Sundermühlen.

Clay heath (Genisto-callunetum danthonietusum)

This can be identified by the presence of Heath Grass (*Danthonia decumbens*), Pill Sedge (*Carex pilulifera*), Mat grass (*Nardus stricta*), Fine-leaved Sheep's-fescue (*Festuca filiformis*), Mouse-ear Hawkweed (*Hieracium pilosella*) and Field Wood-rush (*Luzula campestris*). Clay heaths have become very rare within the Lüneburg Heath. They are found on the Wilseder Berg and south of Niederhaverbeck.

Blueberry sand heath (Genisto-Callunetum, Vaccinium myrtillus type)

Blueberries (*Vaccinium myrtillus*) are the signature species of this type of heath and, more rarely, cranberries (*Vaccinium vitis-idaea*). Blueberry heath is the second most common type of vegetation on the heathlands and occurs especially on northern slopes, the edges of woods and thick juniper hedges. This type of heath is particularly characteristic of the northern slopes of the Wilseder Berg, as well as the Steingrund and Totengrund. In those places cranberries have even ousted the common heather (*Calluna vulgaris*) in places.

Wet sand heath (Genisto-Callunetum, Molinia-type)

Wet sand heath is the ideal habitat for Purple Moor Grass (*Molinia caerulea*), Cross-leaved Heath (*Erica tetralix*) und Scirpus (*Scirpus cespitosus*). It occurs in places close to the water table and in the transition zone around bogs. Its primary locations are areas north of Wilsede and near the Hörpel Ponds.

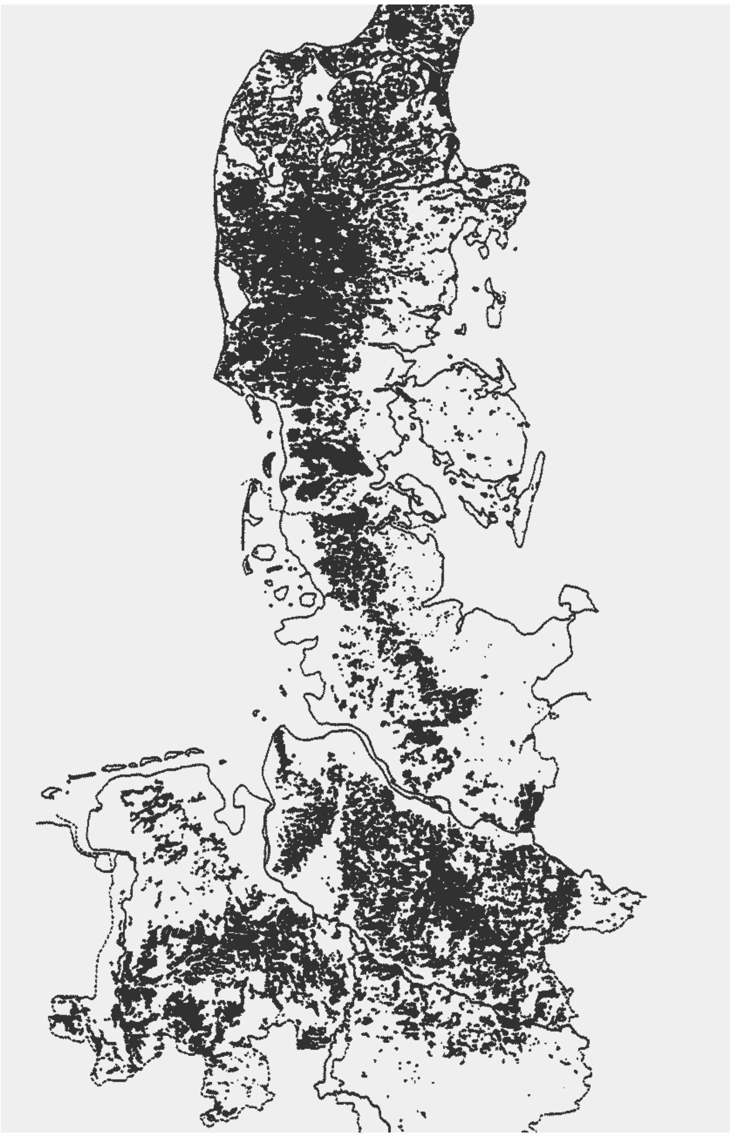
Woods

The greater part (about 58%) of the Lüneburg Heath Nature Reserve consists of woods, primarily pine forests, which were planted in the second half of the 19th century on former heathland and drifting sand. In some cases the dunes simply became naturally overgrown, again with pines. There are only a very few old stands of sessile oaks, which stem from the logging industry during the time of the Kingdom of Hanover. In many parts of the nature reserve there are so-called Stühbüsche (a form of coppice), trees that were coppiced by repeatedly being cut short. In the meantime they have grown wild again and have a characteristic and unusual appearance with their multiple trunks. Near Wilsede there is the remnant of a Hutewald - a wood pasture with giant, multi-stemmed beech trees.

Bogs

The largest bog on the Lüneburg Heath is the Pietzmoor, which lies east of Schneverdingen. It was drained however and peat was cut there until the 1960s. The Nature Park Association carried out work in the 1980s to try and turn it back to its natural waterlogged state. For example, some of the drainage ditches were filled which led to a considerable rise in the water levels of the former peat cuts. However typical bog vegetation has not yet re-established itself. Also of importance are other smaller bogs in sinkholes, like the Grundloses Moor near Walsrode or the Bullenkuhle near Bokel.

Bronze Age tumulus built with heath sods indicate early heathland



Heathland areas in NW Germany and Denmark at their maximum extent around 1780

The Middle Ages and the formation of heaths

The settlement phases of the Roman period and, in many . parts of the region, those of the Migration period also are followed by a severe decline in population. Particularly in the immediate hinterland of the North Sea coast as in the area of the Siedlungskammer Flögeln, a distinct interruption of settlement can be shown. For about two hundred years, starting in the early 6th century and continuing until the late 7th century, there are no traces of settlements; further to the south a considerable decrease in population can be shown in pollen diagrams and also from archaeological sources. In some parts, however, and especially to the south of Bremen, areas with continuous settlements or at least burial grounds, e. g. Liebenau/Weser, still existed. Because of the scarcity of archaeological finds, as well as of written sources, these two centuries are called the “Dark Ages”.

During this time of little or no settlement, a full reforestation took place in large parts of the region. Mainly by the pollen analytical investigation of kettle-hole bogs, which give a high spatial resolution of the landscape history, the sequence of colonization by shrubs and trees during reforestation can be demonstrated. In some cases it starts – as in the Late Glacial – with high values of *Betula* and *Corylus* in the pollen diagram, followed by peaks of *Quercus* and a considerable increase of *Fagus* and *Carpinus*.

In most parts of the coastal area the next occupation phase started in the 8th century, i. e. in the Early Middle Ages. In Central Europe this period, by definition, ends at AD 1000 and thus roughly corresponds to the Viking Age of Northern Europe. As can be demonstrated by many place names ending with -holt, -loh or -horst, the Geest was – in many parts until the high Middle Ages – covered by woodland, which the colonists had to clear; this is shown in the pollen diagrams.

Due to the rapid rise in population, the rate of woodland exploitation increased as well. Additional demand for timber and firewood came from the towns, which were established at this time, and also from the coastal area, and particularly the treeless Clay district which at that time was also densely populated.

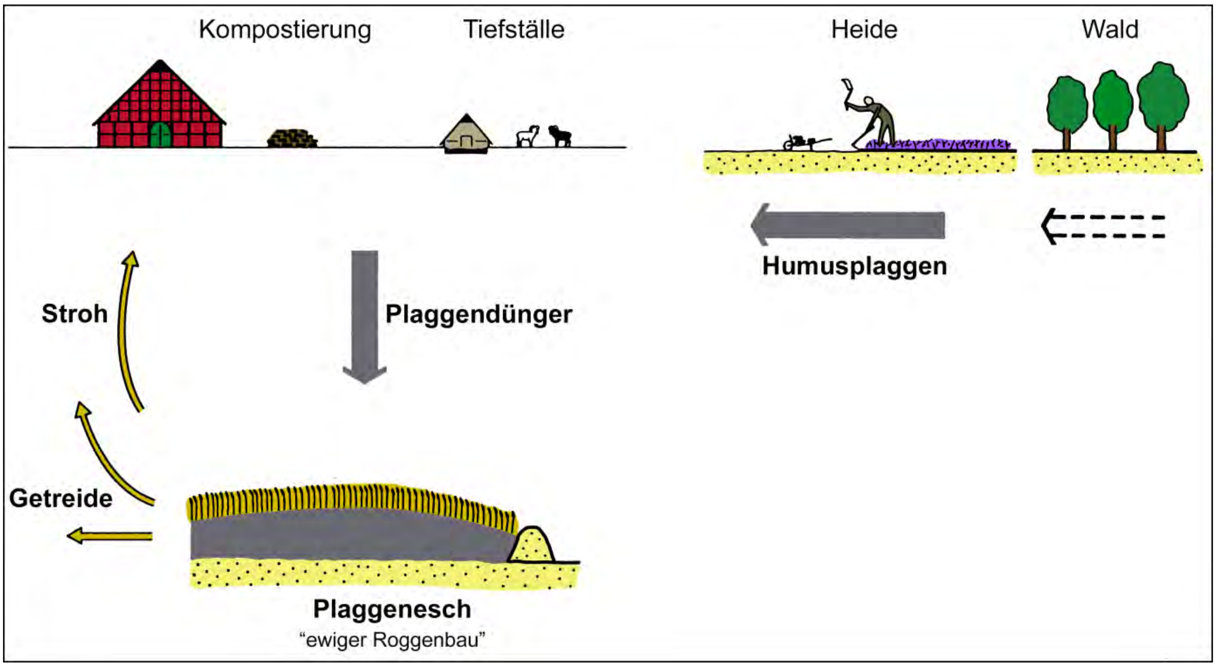
As in other parts of Europe, the forests served as pasture for cows and cattle and also for poultry. Planned management of the grazed forests (=Hudewald) started in the Middle Ages and led to a special form of open forest with selected species only, mainly *Quercus*, being protected. One of the last remnants of this forest type is represented by the Neuenburger Urwald, south of Wilhelmshaven; many others were documented by painters particularly during the Romantic period.

The permanent exploitation of the forests mostly as pasture and for wood, but also by removing leaves for fodder and litter and using the organic soil material as fertilizer, resulted in the degradation of the soils. On the poor sandy soils the continuous grazing soon led to the formation of heath areas. The strong expansion of these heaths in the Middle Ages and into Modern times was not, however, the result of grazing, but rather was caused by the demand for plaggen (=heath sods) as fertilizer for the arable fields. Starting in the 10th century, a fundamental change took place in arable farming practice on the Geest within the coastal region. This was triggered by the introduction of large scale rye cultivation within permanent fields. The requirement for adequate fertilization of the fields was met with by the use of plaggen (Behre 1976a, 1980). Large quantities of plaggen were needed to fulfil the nutrient requirements of fields permanently under rye. In the course of the·centuries, the areas representing the permanent fields, called “Esch”, were raised by the gradual accumulation of humic soil, someties by more than one metre.

Cross section of an Esch (accumulated plaggen soil)

Investigations in Dunum/East Frisia have provided evidence for a detailed reconstruction of this particular farming practice. The main crops on the Esch fields were of course rye (about 70%), together with *Avena sativa* and *A. strigosa*. *Hordeum vulgare* and *Linum usitatissimum* were also cultivated as has been demonstrated by carbonized plant remains from several East Frisian churches (Kucan 1979, Behre 1986a).

The permanent exploitatien of the heath areas, where the plaggen were cut as soon as the *Calluna* vegetation had regenerated, led to a strong degradation of the soil. Plaggen cutting involved skinning the heaths every ten to twenty years.



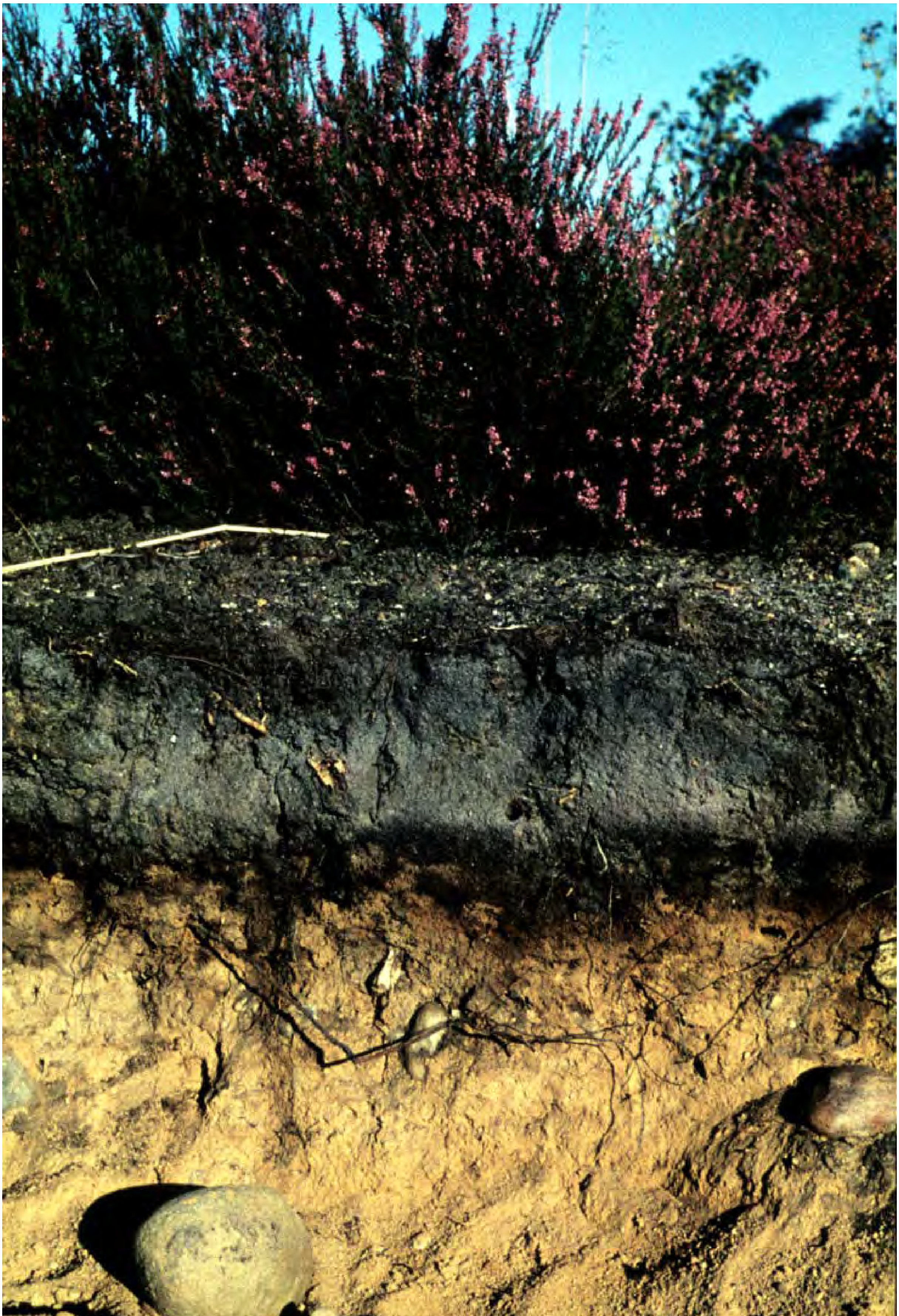
Scheme of the plaggen economy, showing, how heath plaggen have been dug, prepared and used as manure

This had the undesired side-effect of exposing large bare tracts to the wind which transported the sand, with the result that large coversand areas and even dunes were formed. Many written sources describe the problems when drifting sand spread across the fields or blocked roads and, in some instances, threatened villages and towns (Pyritz 1972); some areas even took on a steppe like character. Due to this overexploitation by sod cutting and grazing, the regeneration phase was extended while the constant demand for plaggen continuously resulted in extensive expansion of heathlands during the course of the Middle Ages and also in later periods. According to written sources, the area required for plaggen cutting was 20 to 40 times the size of the fields. These practices finally resulted in almost the entire Geest of northern Niedersachsen being covered with heath, treeless to the horizon, and with the villages and their associated fields on the plaggenesch looking like isolated islands. This appearance of the landscape was impressively encapsulated by the first general maps from the second half of the 18th century.

During the 19th century these vast heaths were transformed to quite another landscape with the introduction of artificial chemical fertilizers. There was no longer demand for plaggen. The heaths, which had been common land, were parcelled out to individual owners and were mainly turned into fields or were forested. The parcel boundaries had to be marked by earth ridges with hedges on top. This cultural landscape with fields and meadows surrounded by hedges is still characteristic of large parts of East Frisia today.

A typical Calluna podzol below grassland indicates former heathland

A few parcels of the former heathland have survived·cultivation and are today protected and managed as nature reserve as parts of the Lüneburg heath. The management, however, is restricted to sheep grazing and plaggen cutting no longer takes place. As a result these *Calluna* heaths, complete with fine juniper shrubs, look like gardens. They should be called tourist heaths, as they look quite different from the former open steppe-like heath areas which resulted from the plaggen economy. Many exposures in the area still show the typical soil profile of a *Calluna* podzol, now below a meadow, a forest or some other type of managed system, and bear witness to the vast heath areas of former times.



Characteristic podzol profile below *Calluna* heathland

Farmer cutting plaggen in the heathland around 1920

Sheep grazing in completely degraded heathland southwest of Oldenburg 1935

Mires in the Lüneburg Heath

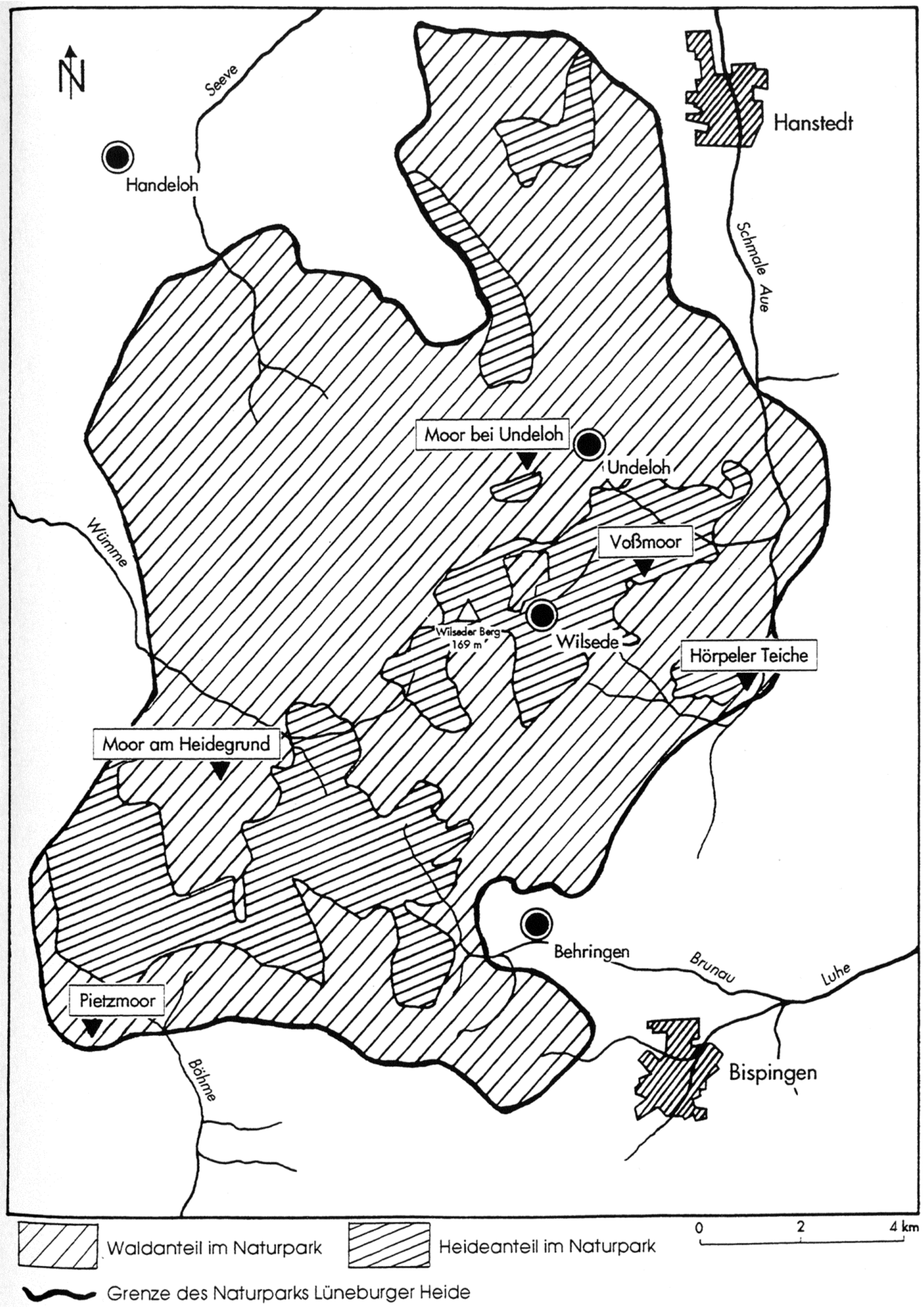
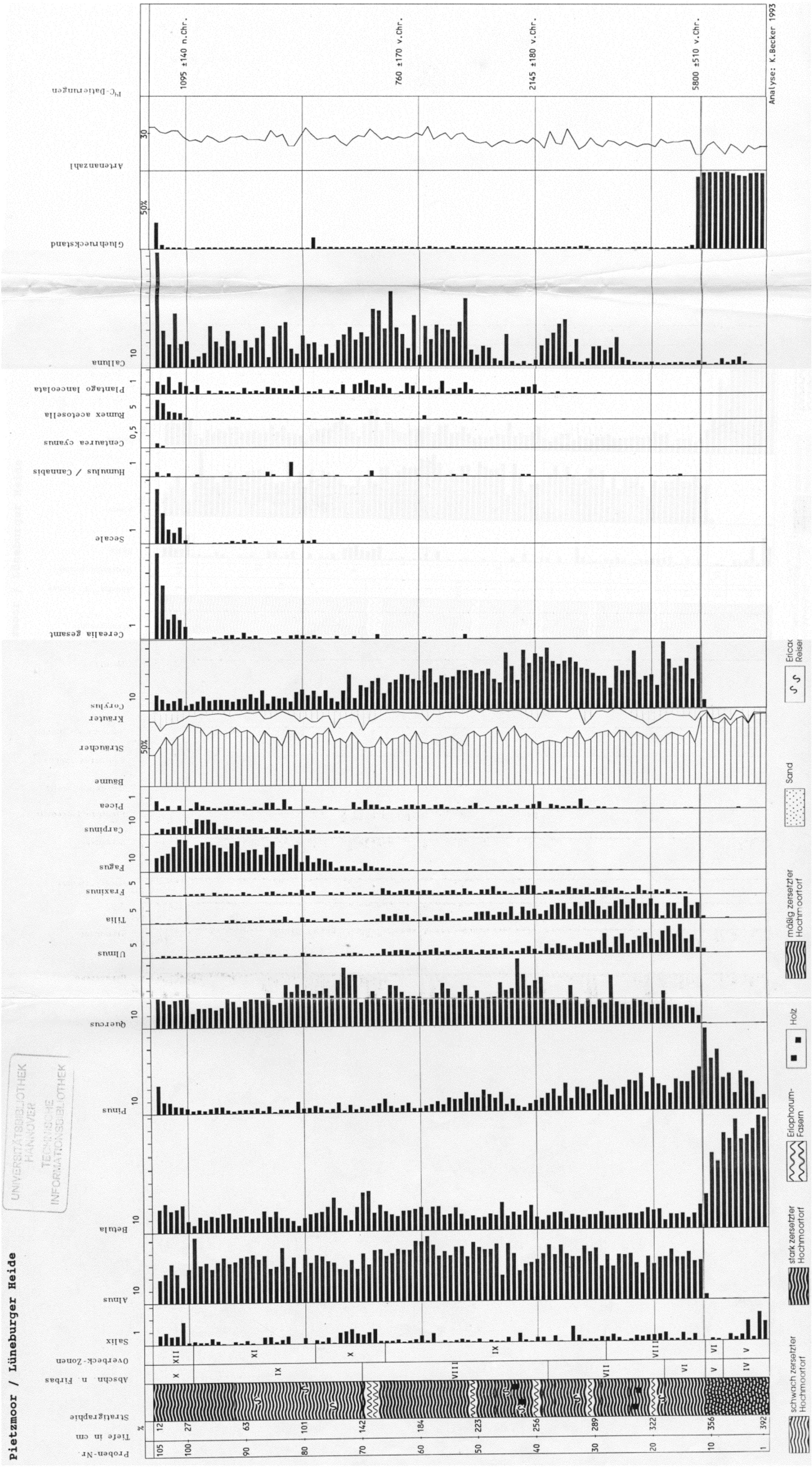
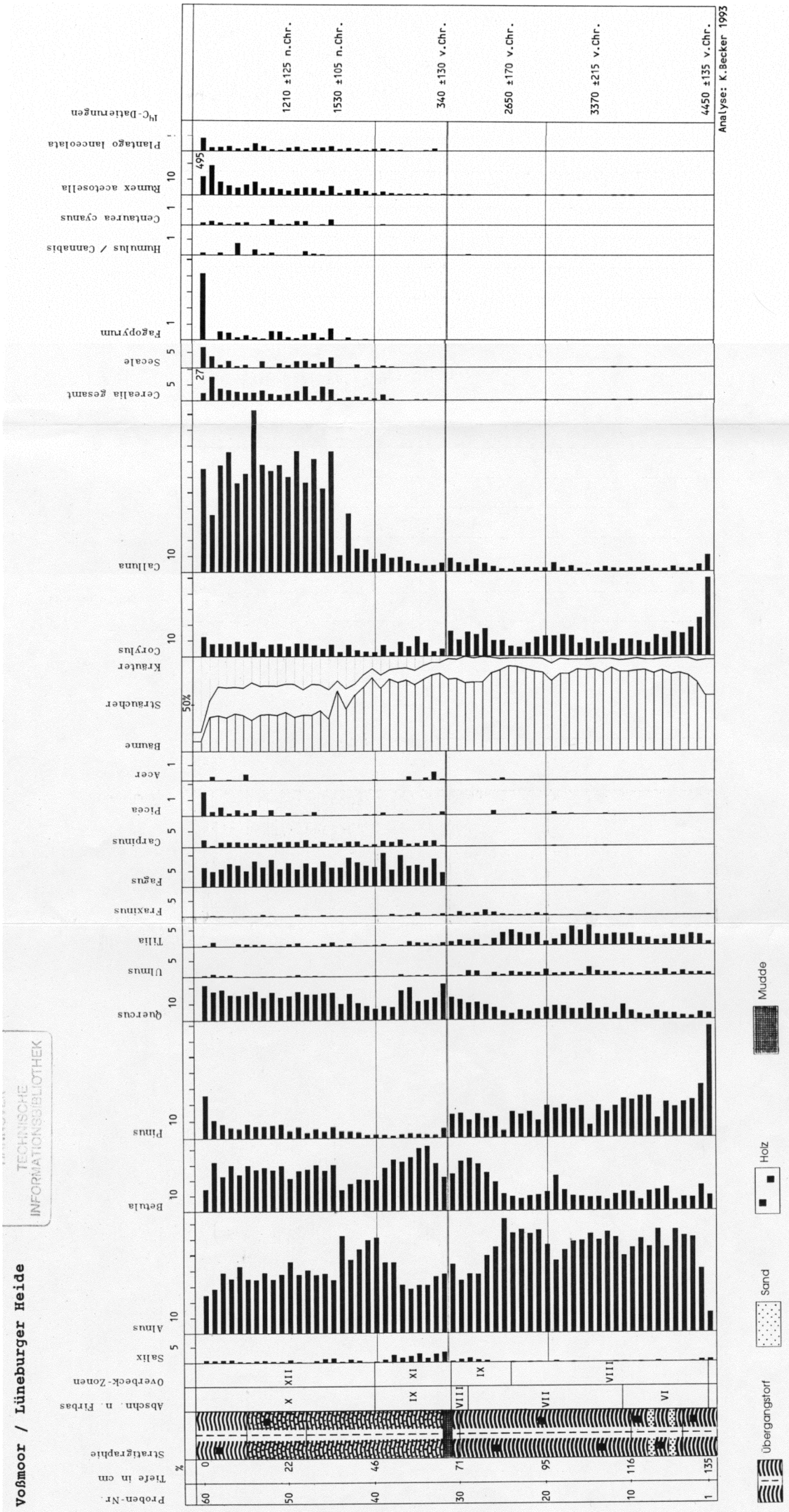
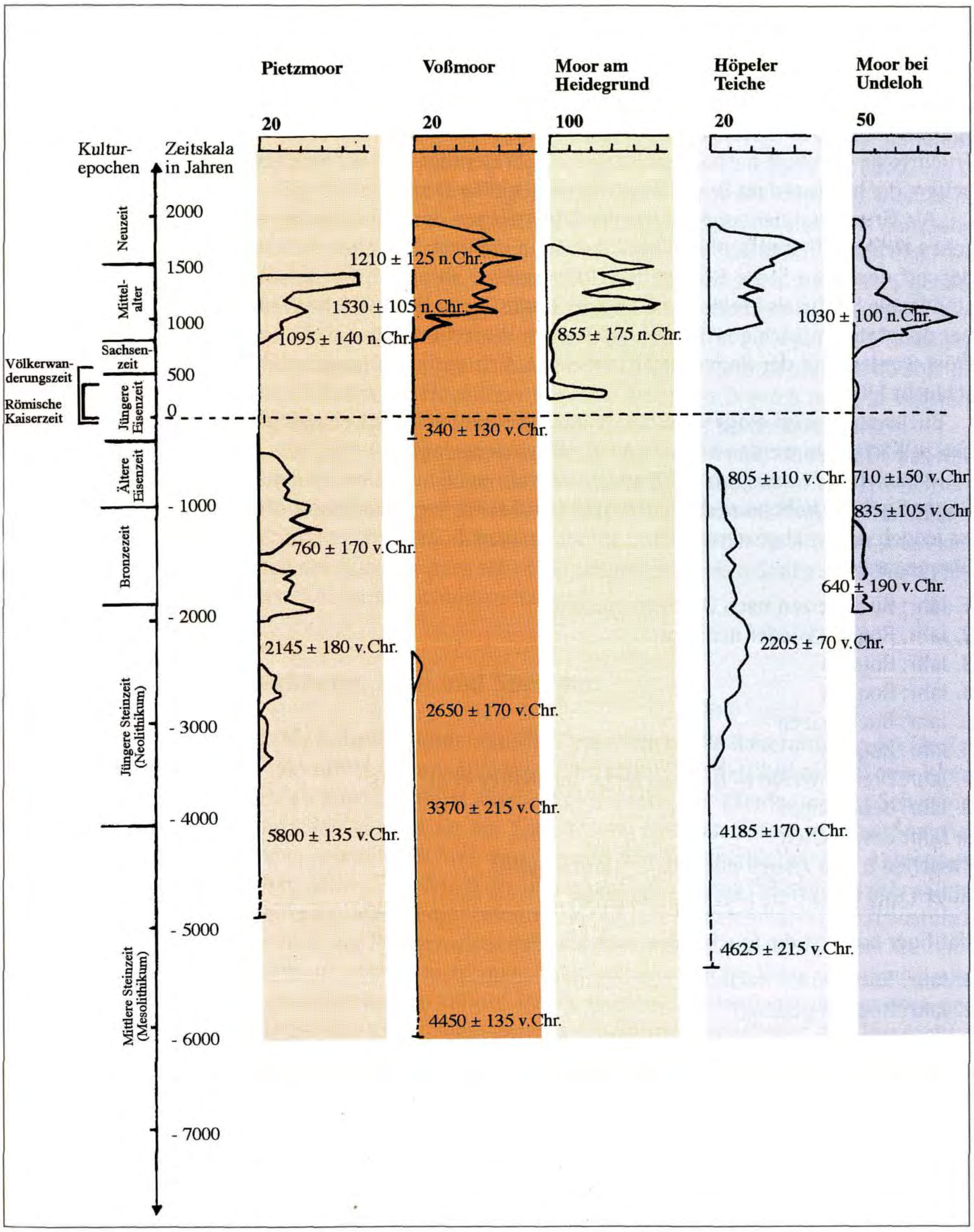


Abb. 3: Lage der Moore im Untersuchungsgebiet
(Die schraffierte Fläche entspricht dem Gebiet des Naturparks Lüneburger Heide).

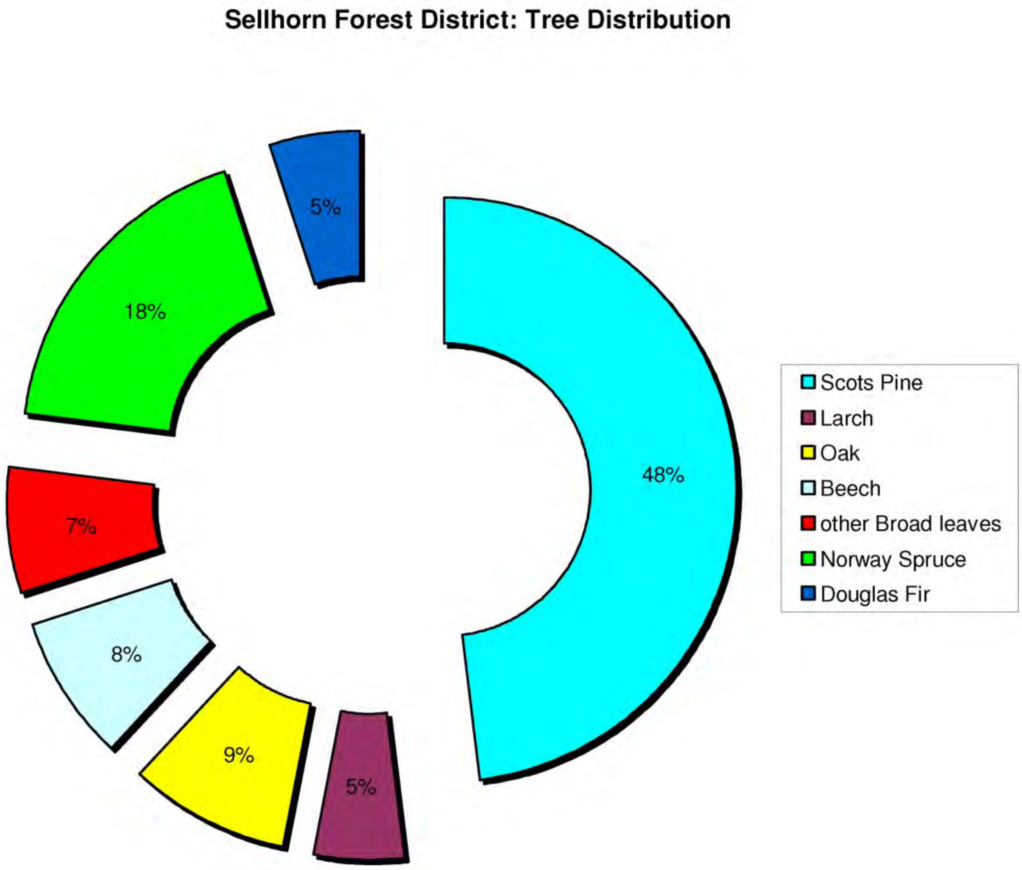

Pietzmoor / Lüneburger Heide
Proben-Nr.
Tiefe in cm
Stratigraphie
Abschn. n. Firbas
Overbeck-Zonen
Salix
Alnus
Betula
Pinus
Quercus
Ulmus
Tilia
Fraxinus
Fagus
Carpinus
Picea
Bäume
Sträucher
Kräuter
Corylus
Cerealia gesamt
Secale
Humulus / Cannabis
Centaurea cyanus
Rumex acetosella
Plantago lanceolata
Calluna
Glühverlust
Artenanzahl
14C-Datierungen
1095 ±140 n.Chr.
760 ±170 v.Chr.
2145 ±180 v.Chr.
5800 ±510 v.Chr.
Analyse: K.Becker 1993
schwach zersetzter Hochmoortorf
stark zersetzter Hochmoortorf
Eriophorum-Fasern
Holz
mäßig zersetzter Hochmoortorf
Sand
Ericac. Reiser
UNIVERSITÄTSBIBLIOTHEK HANNOVER
TECHNISCHE INFORMATIONSBIBLIOTHEK


Voßmoor / Lüneburger Heide
Proben-Nr.
Tiefe in cm
Stratigraphie
Abschn. n. Firbas
Overbeck-Zonen
Salix
Alnus
Betula
Pinus
Quercus
Ulmus
Tilia
Fraxinus
Fagus
Carpinus
Picea
Acer
Bäume
Sträucher
Kräuter
Corylus
Calluna
Cerealia gesamt
Secale
Fagopyrum
Humulus / Cannabis
Centaurea cyanus
Rumex acetosella
Plantago lanceolata
14C-Datierungen
1210 ±125 n.Chr.
1530 ±105 n.Chr.
340 ±130 v.Chr.
2650 ±170 v.Chr.
3370 ±215 v.Chr.
4450 ±135 v.Chr.
Analyse: K.Becker 1993
Übergangstorf
Sand
Holz
Mudde
TECHNISCHE INFORMATIONSBIBLIOTHEK

Becker 1995



116 Die zeitliche Entwicklung der Heiden in der Lüneburger Heide nach Pollenanalysen aus verschiedenen Mooren. Die erfassten Phasen der Heideentstehung sind in eine lineare Zeitskala transformiert; man sieht deutlich den Beginn in der Steinzeit; die räumliche Heideausdehnung in der Bronzezeit und die flächenhafte Ausbreitung seit dem Hochmittelalter. Die Grafik basiert auf Pollenwerten der Besenheide (Calluna vulgaris).



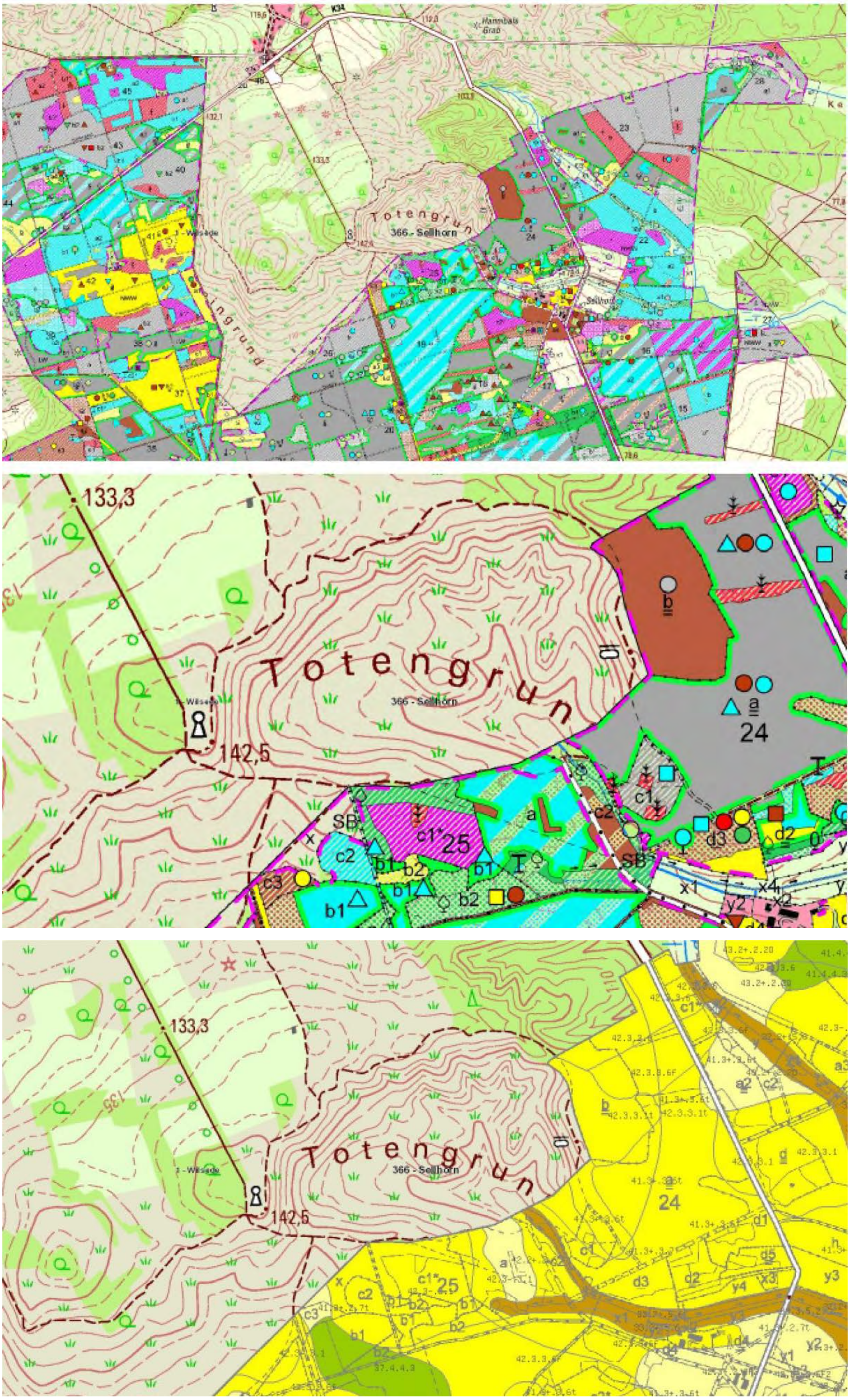
13.220 ha forested area, situated in the “Ost-Heide” and “Hohe Heide” in the SE Lower Saxony lowland

Annual wood growth: 93.000 m^3

Annual wood harvest: 75.000 m^3

Annual increment of growth: 18.000 m^3

	Eastern Heath	**High Heath**
Mean annual precipitation	630 mm	730 mm
Mean prec. during growing season (May - September)	290 mm	330 mm
Mean relative humidity	80%	81%
Mean annual temperature	8.0 °C	8.0 °C
Mean range of ann. temp.	17.3 °C	16.7 °C
Days with frost	90	100

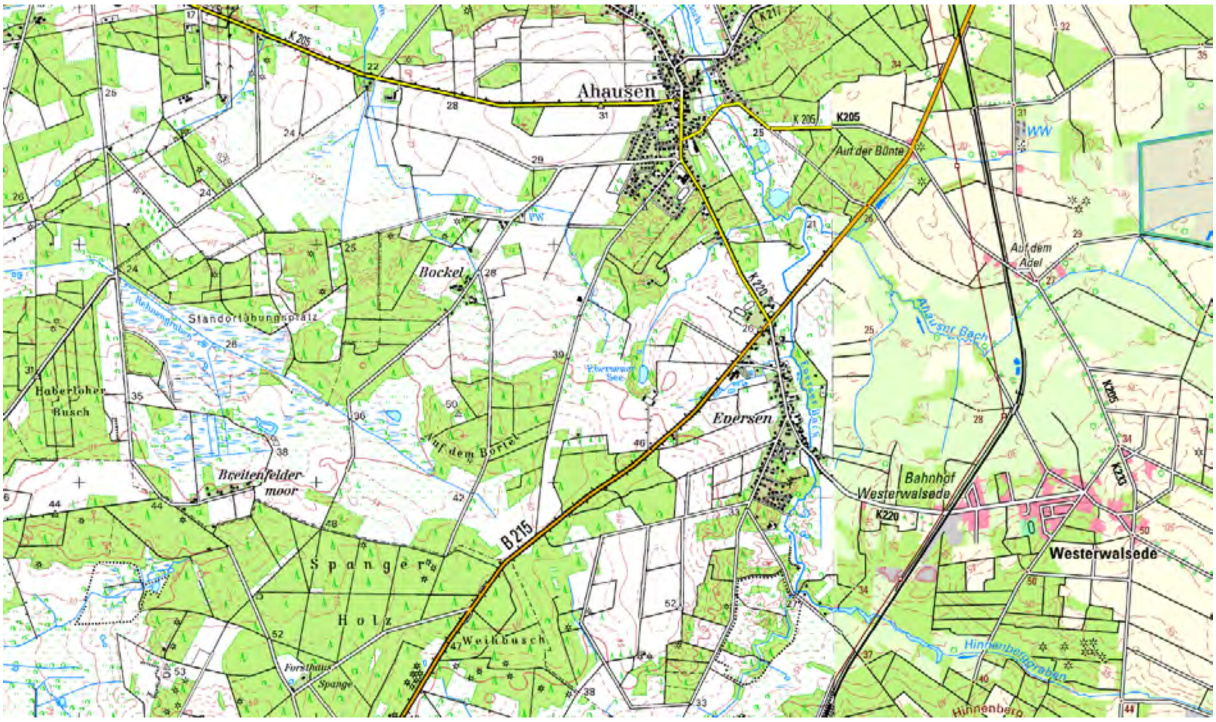


Vegetation and soils of the “Totengrund” area

Multi-proxy evidence of environmental changes related to human land-use from lacustrine sediments of Eversener See

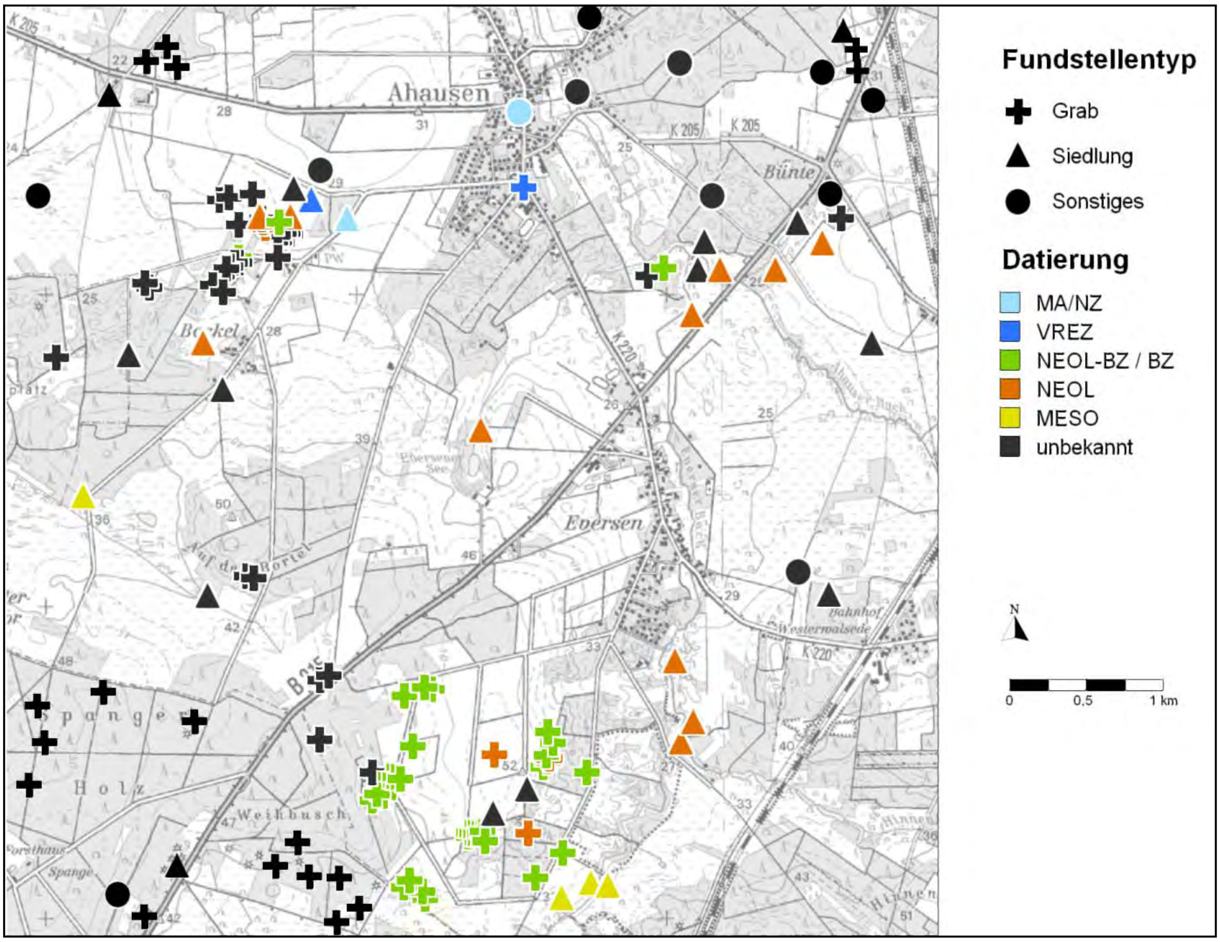
Human land-use has considerably shaped the landscape of northwestern Germany over the past millennia. Deforestation and agriculture created a predominantly open scenery preserved until today with only a few remnants of former landscape elements such as woodlands, peat bogs or heath lands. Lake sediments serve as unique natural archives to reconstruct the extent and timing of prehistoric human impact on the terrestrial environment and lacustrine ecosystems as well as to trace the history of particular landscape elements.

Here we apply a multi-proxy approach to investigate changes in the catchment area of Eversener See using geochemical parameter (element concentrations and stable isotopes) and biological proxies (pollen, diatoms and chironomids). In the vicinity of the lake more than 100 archaeological findings document the prehistoric land occupation since the Neolithic. Sedimentation in the lake basin started during the Late Glacial and thus also allows to document the pre-anthropogenic status of the lake system. The records of K and Ti exhibit distinct peaks starting in Neolithic times. The elevated concentrations of these terrigenic elements are interpreted as result of increased soil erosion caused by logging activities, probably related to a Neolithic shoreline settlement recorded by archaeological artifacts. This also correlates with a higher abundance of settlement indicators in the pollen spectra which coincide with an increased settlement activity during the late Neolithic and Bronze Age. However, the lake seems to be initially insensitive to this catchment disturbance as apparent eutrophication starts not before the Iron Age when human disturbance already seems to decrease. Our data complement the regional archaeological record and will allow – in combination with other paleolimnological sites – to establish a regional pattern of human induced landscape changes and settlement history along a N-S transect from the German North Sea coast to inland areas.

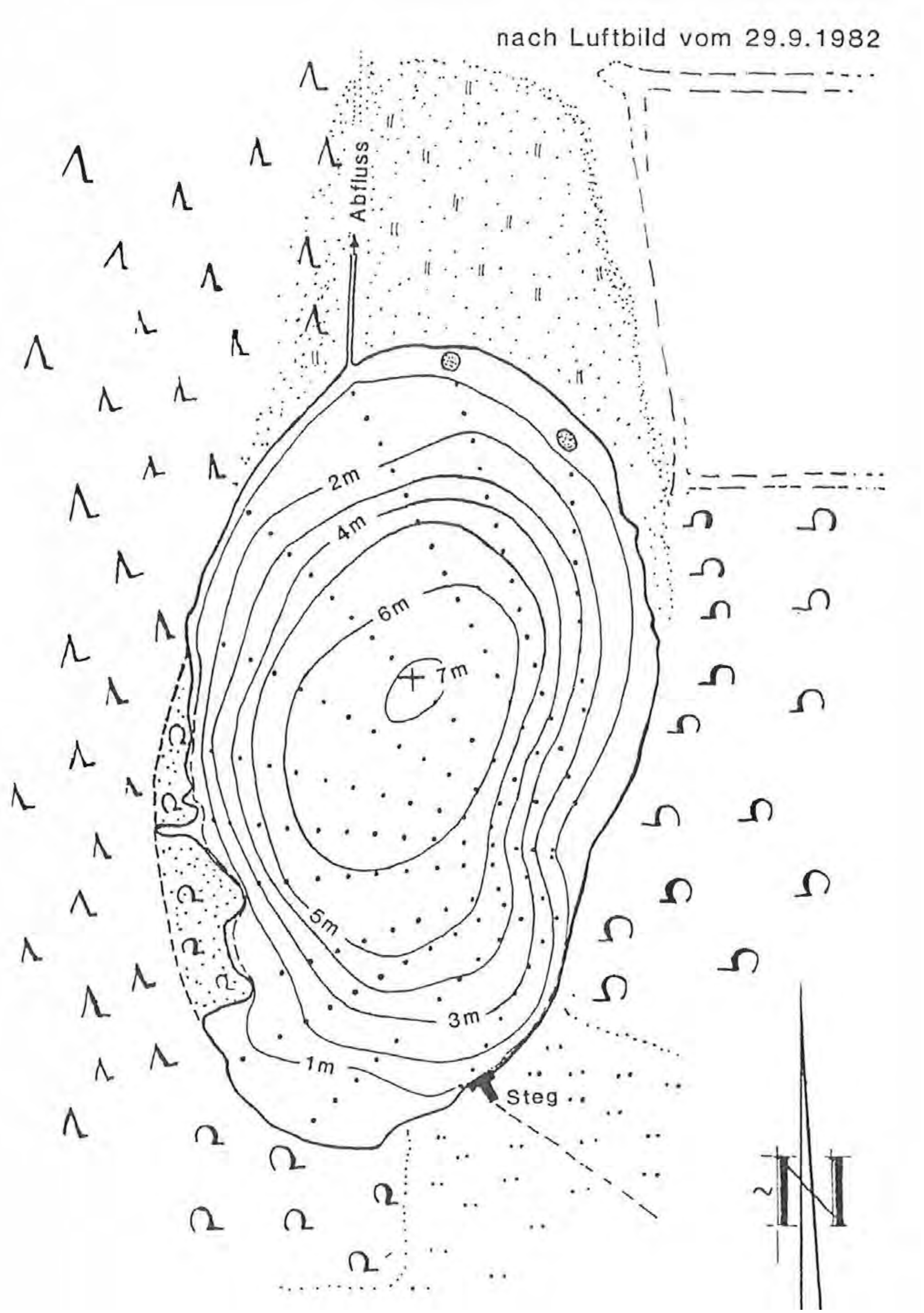


Topographical map of the Eversen area

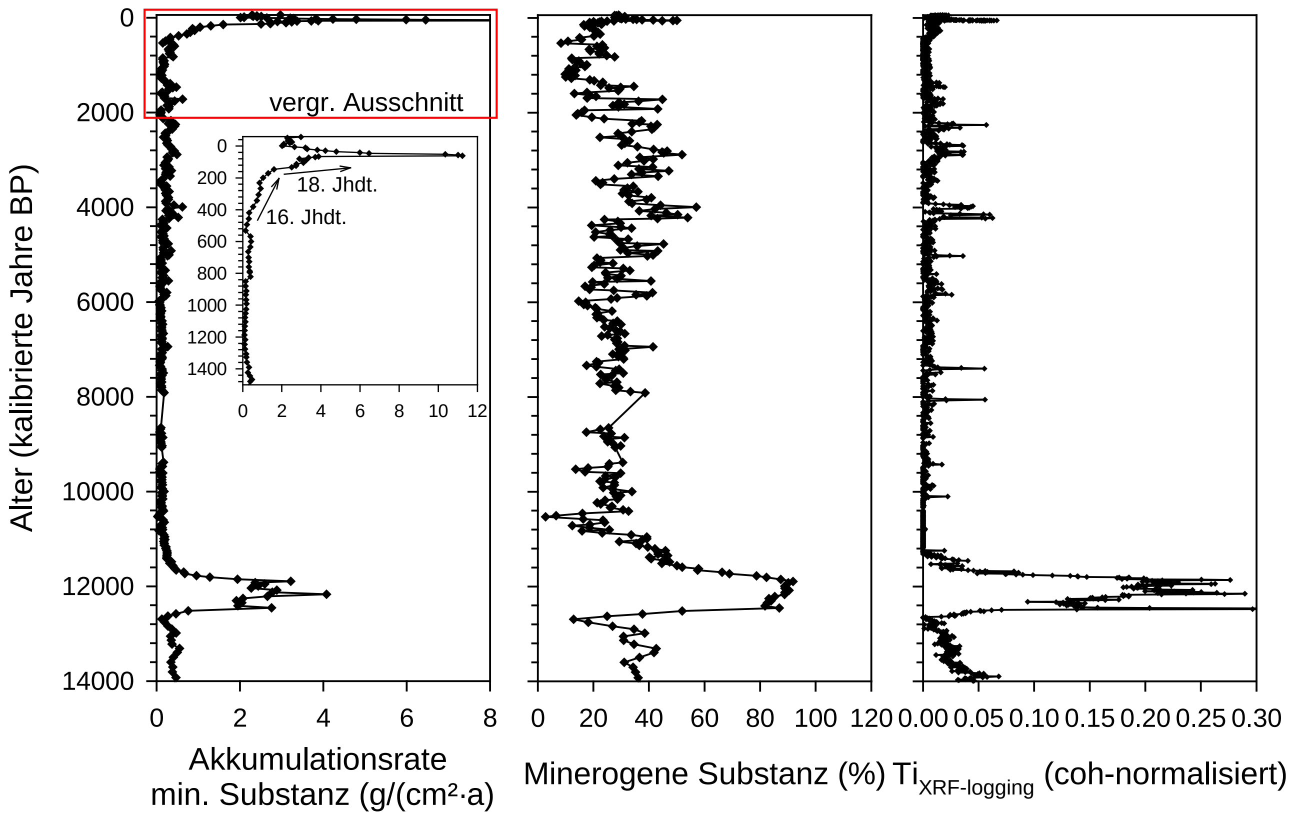
Aerial image of Lake Eversen



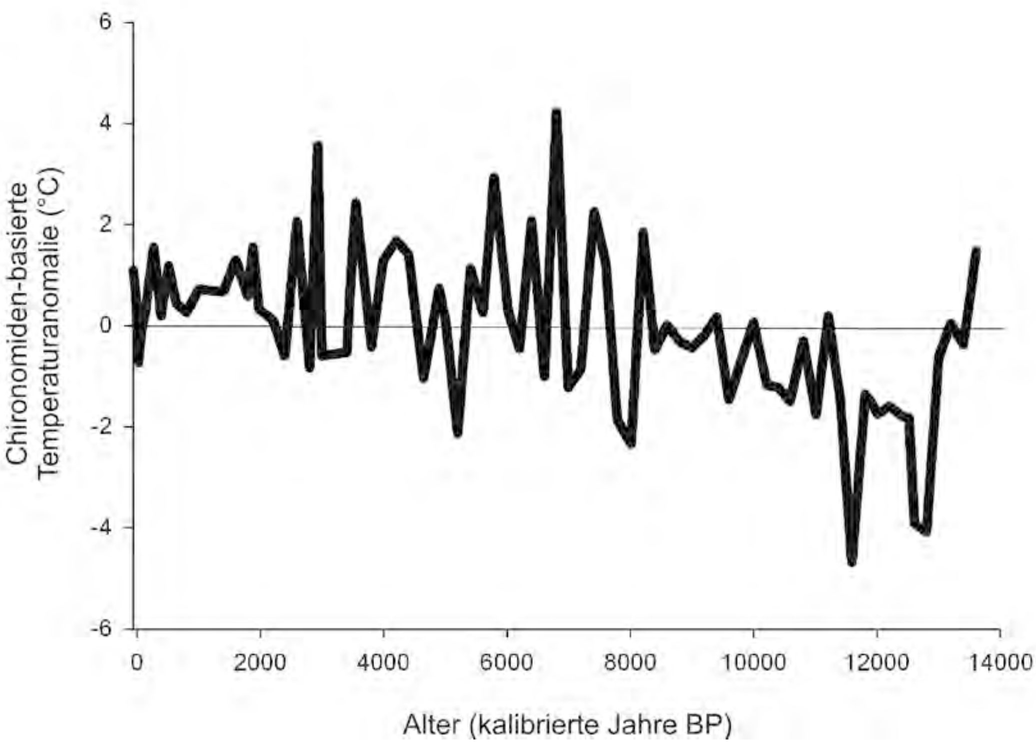
Archaeological records around Lake Eversen



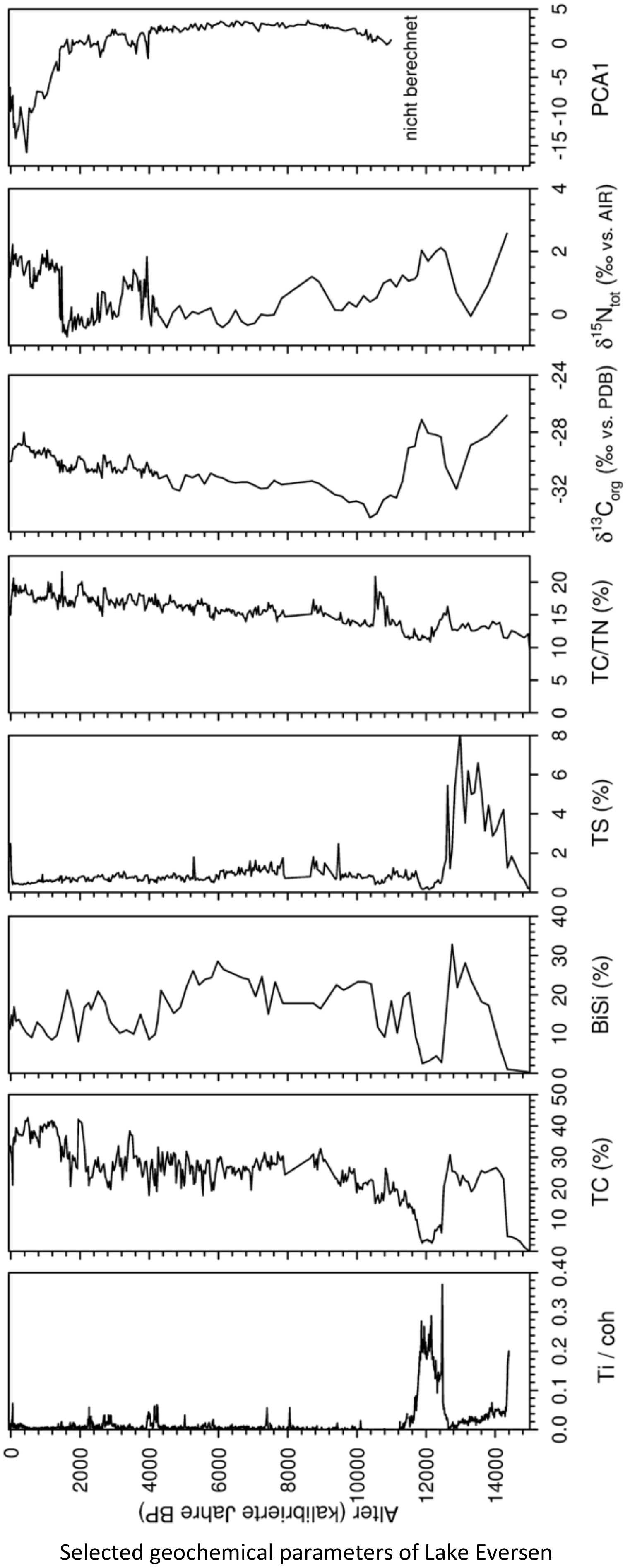
Bathymetry (Merkt 1985)



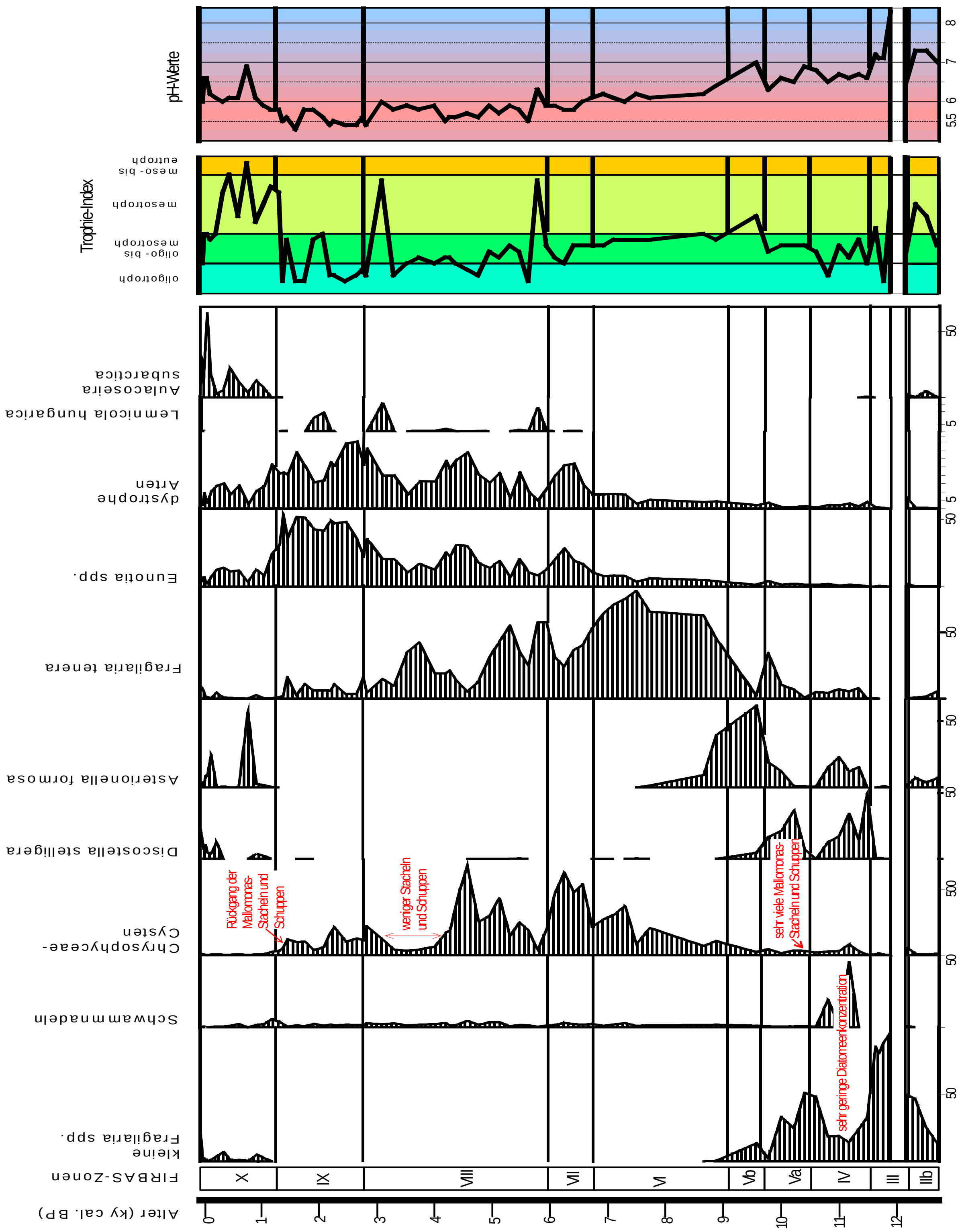
Accumulation rate and percentage of minerogenic material and Ti-curve of Lake Eversen



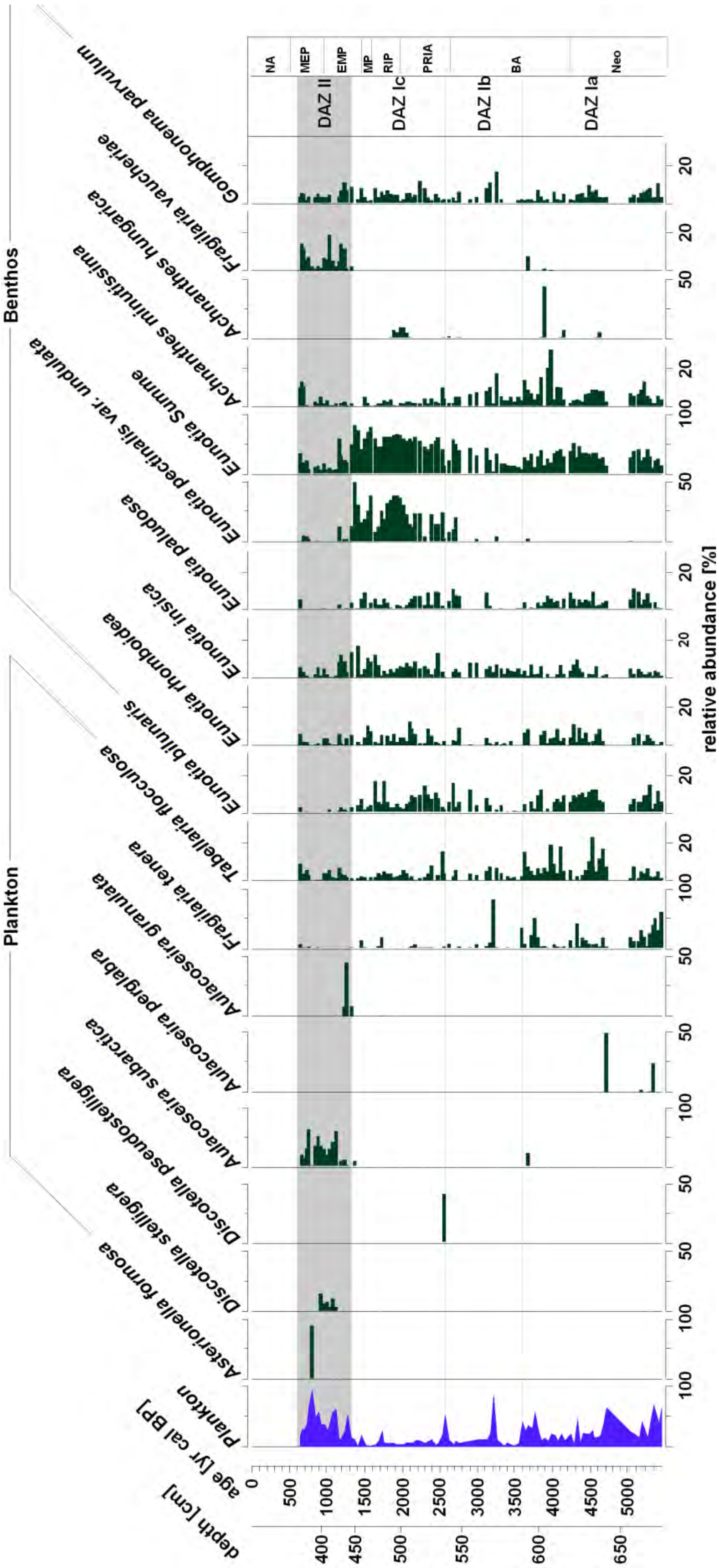
Chironomid inferred temperature anomaly (I. Laroque-Tobler)



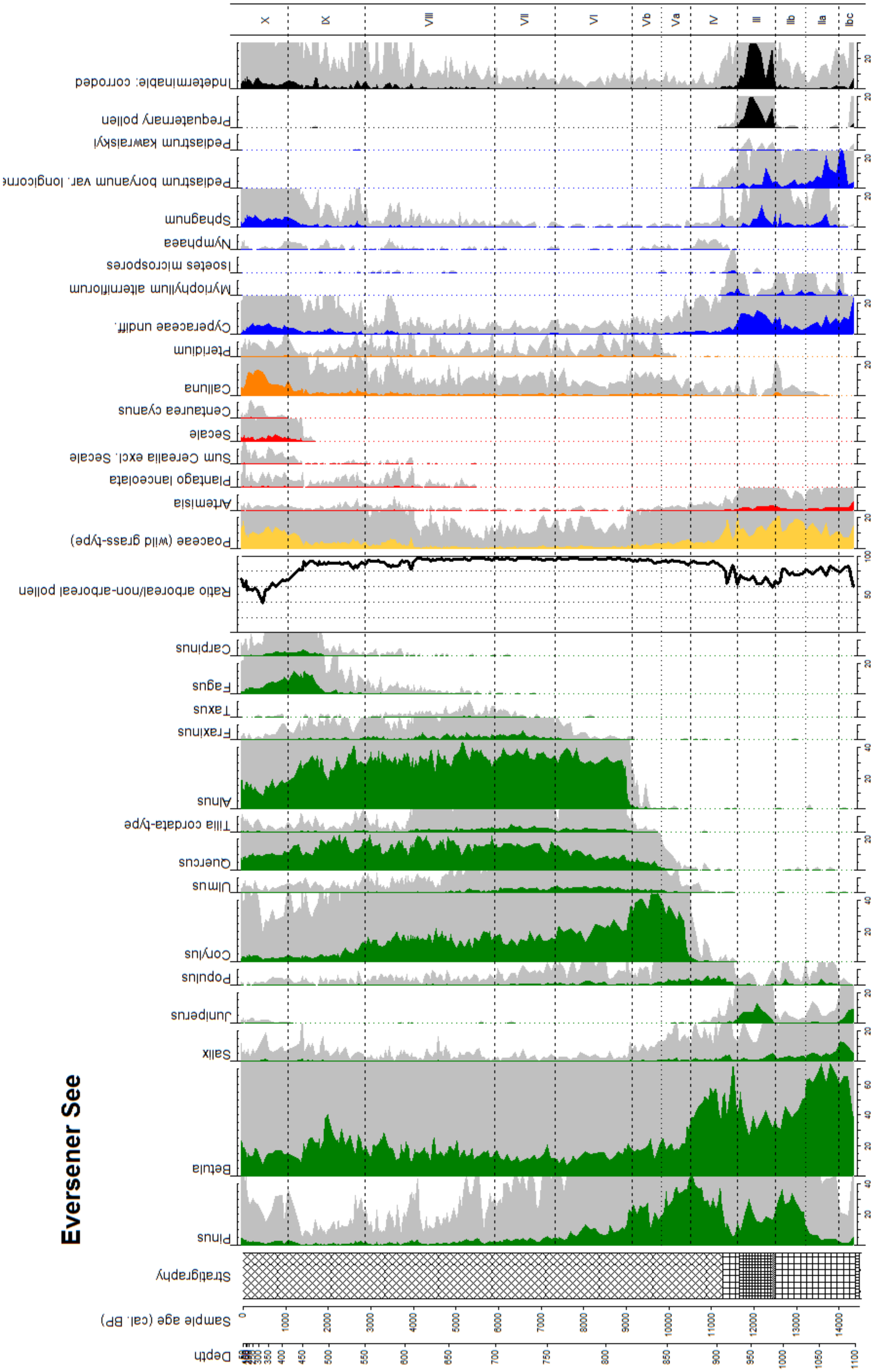
Selected geochemical parameters of Lake Eversen
and sample scores of the 1st PCA axis of pollen analytical data.



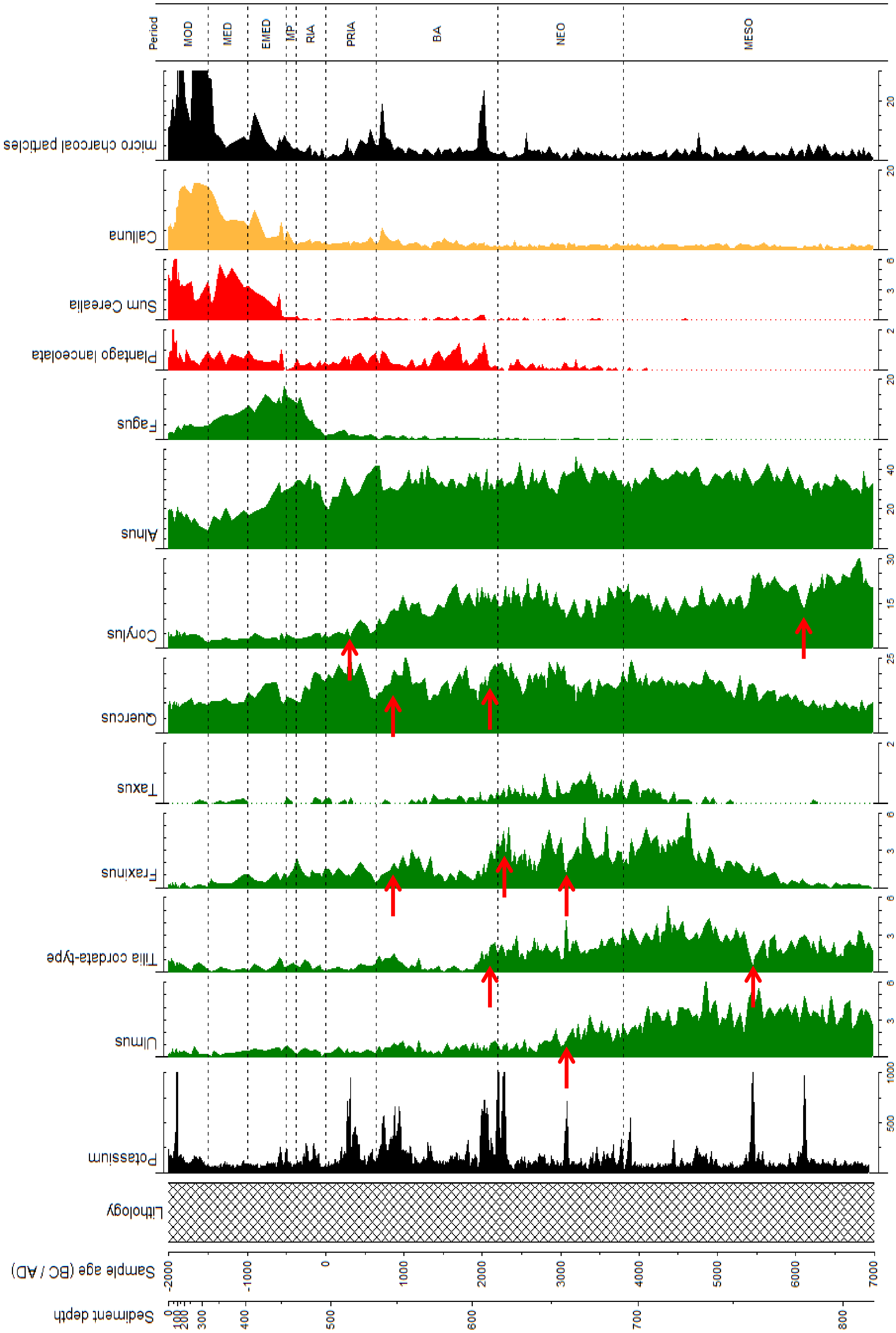
Diatom survey diagram of Lake Eversen (R. Voigt)



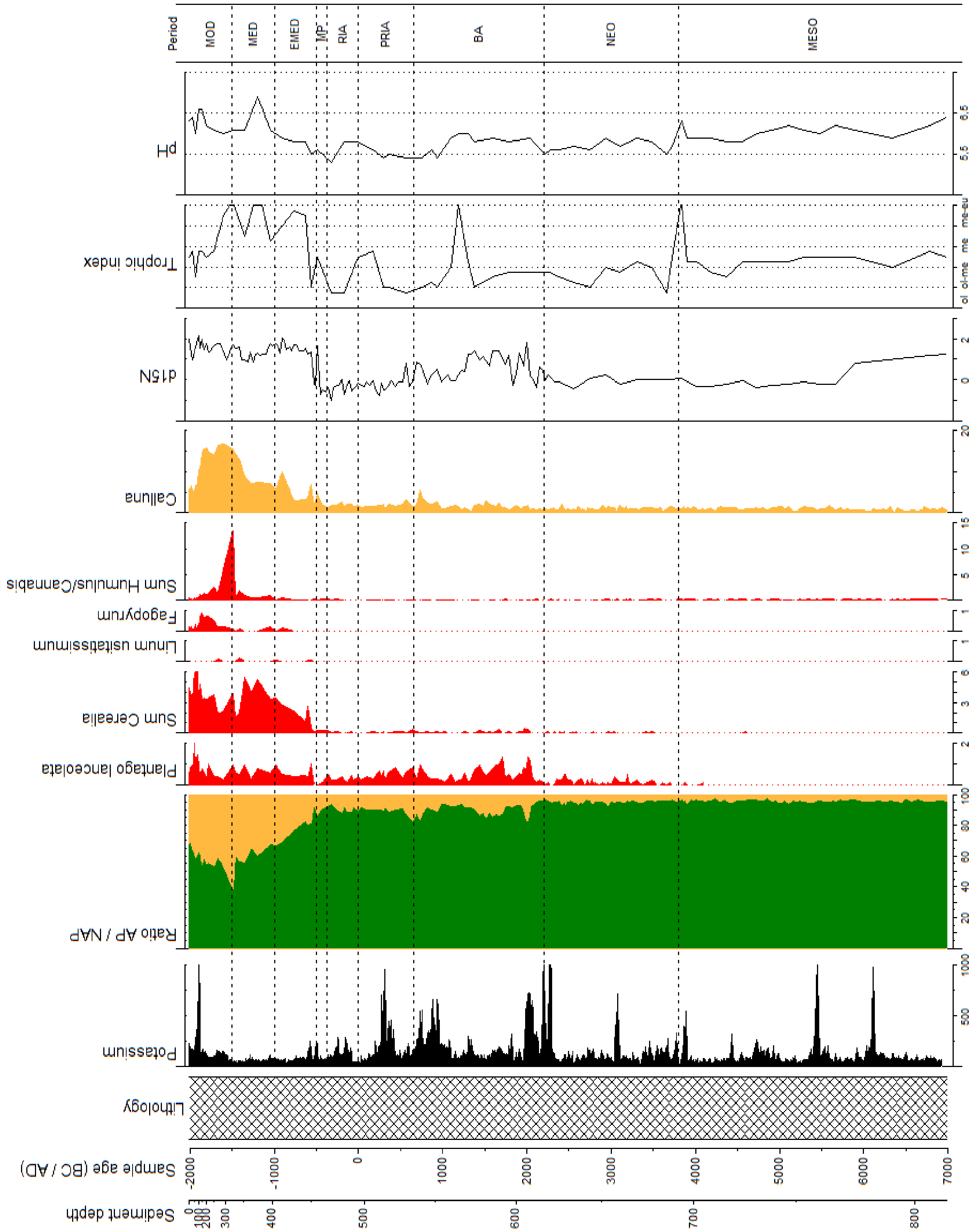
High resolution diatom diagram



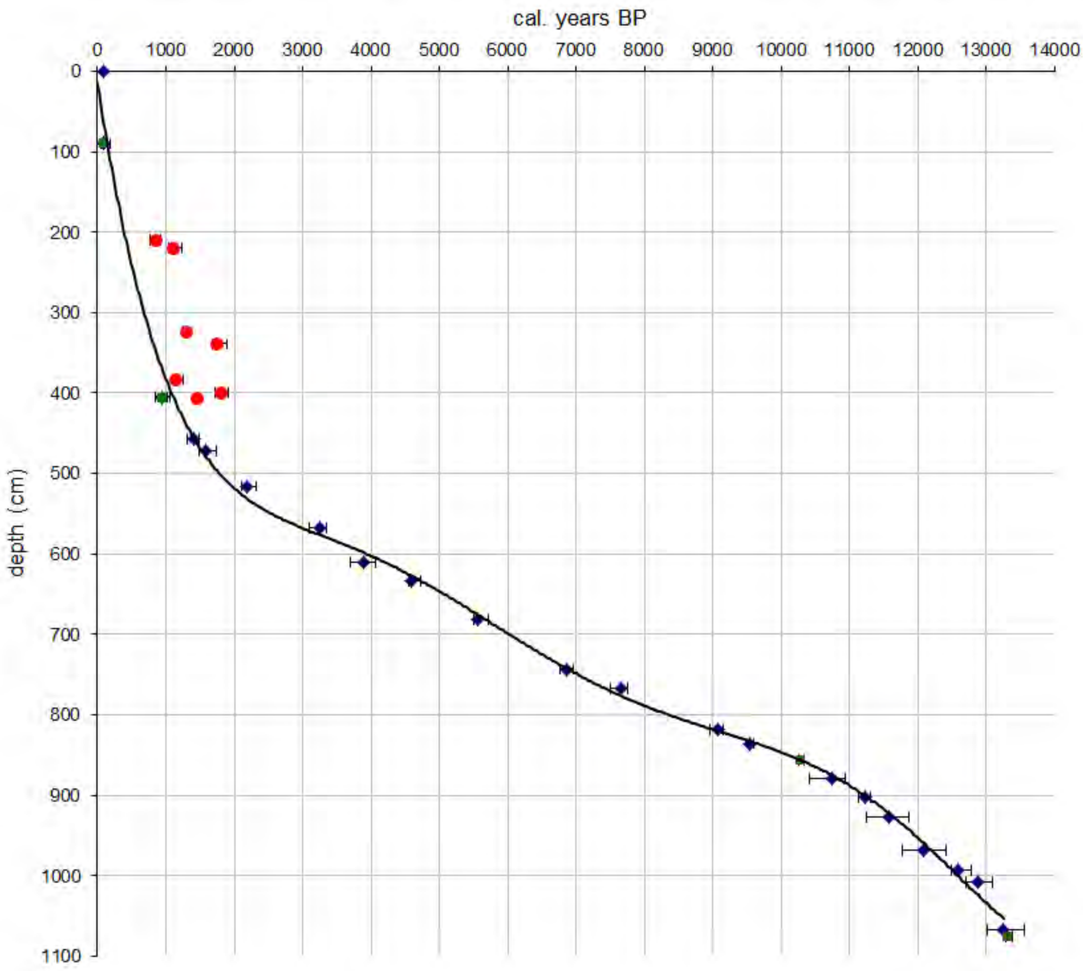
Pollen diagram Lake Eversen (Late Glacial until present)



Pollen diagram Lake Eversen (Woodland clearing and erosion)

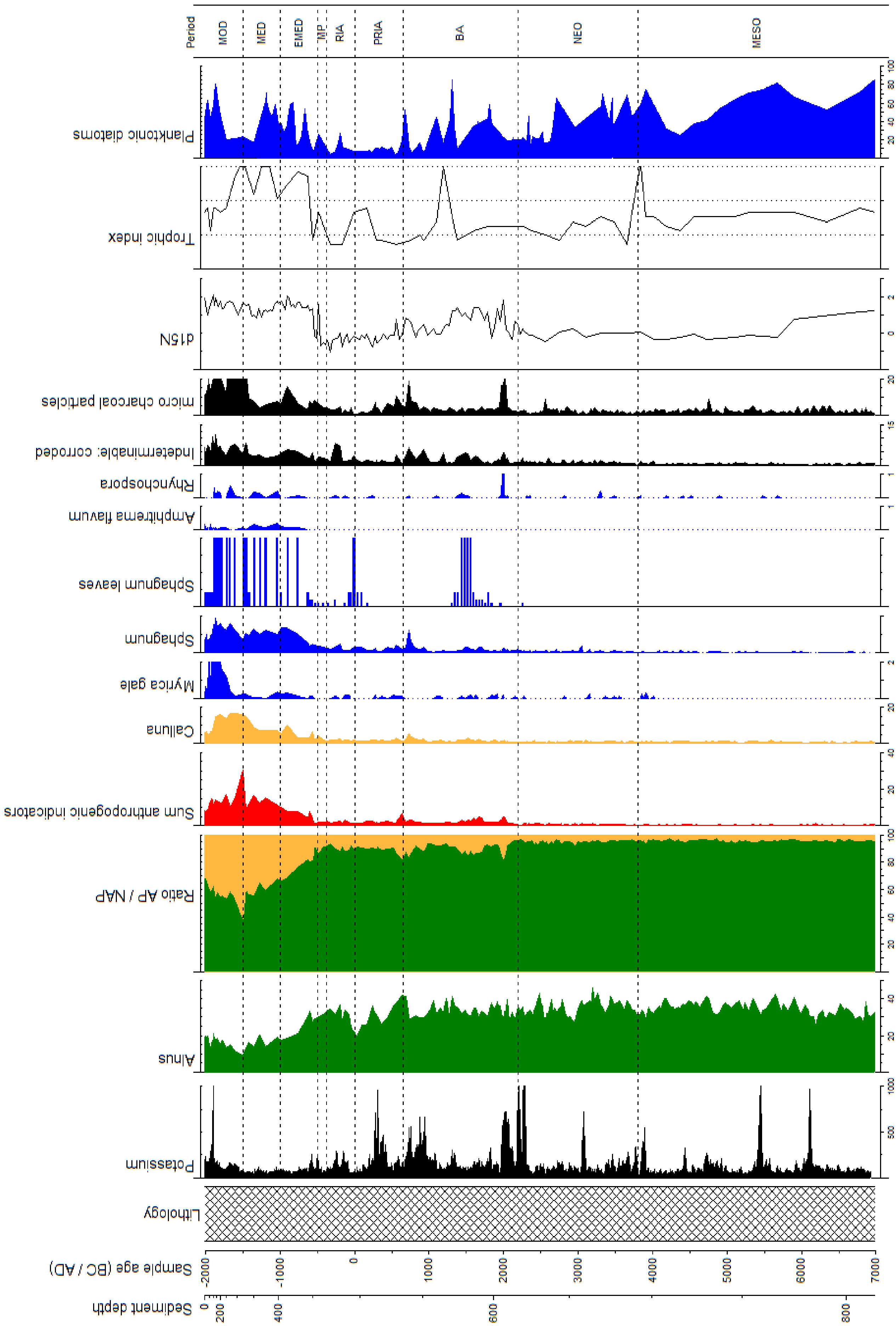


Pollen diagram Lake Eversen (Human impact)



Depth cm	Sample code	Median	Remarks
90	Zn peak	45	
209-210	Poz-55339	855	700 yrs. too old
218-220	Poz-43876	1105	930 yrs. too old
323-324	Poz-40420	1300	840 yrs. too old
338-340	Poz-43877	1755	1200 yrs. too old
383-384	Poz-55340	1160	360 yrs. too old
399-400	Poz-50020	1815	900 yrs. too old
404-408	Poz-43878	1465	500 yrs. too old
405	Centaurea cyanus rise	950	
456-457	Poz-40422	1420	
471-473	Poz-49468	1590	
515-516	Poz-40153	2205	
567-568	Poz-43879	3265	
609,5-610,5	Poz-49469	3905	
633,5-634,5	Poz-43880	4615	
680,5-681,5	Poz-40155	5580	
742,5-743,5	Poz-40156	6880	
766,5-767,5	Poz-43882	7670	
817-818	Poz-43883	9085	
835-836	Poz-40157	9550	
855-856	Saksunarvatn-Tephra	10297	Davies et al. (2012)
878-879	Poz-43884	10750	0,8 mg C
902-903	Poz-40423	11235	
926-927	Poz-55337	11595	
968-969	Poz-40424	12090	0,15 mg C
968-969	Poz-54508		0,12 mg C
991-994	Poz-55338	12600	
1007-1009	Poz-50021	12895	
1066,5-1067,5	Poz-54506	13260	0,2 mg C
1075,5	Paly. trans. OD / BÖ	13325	

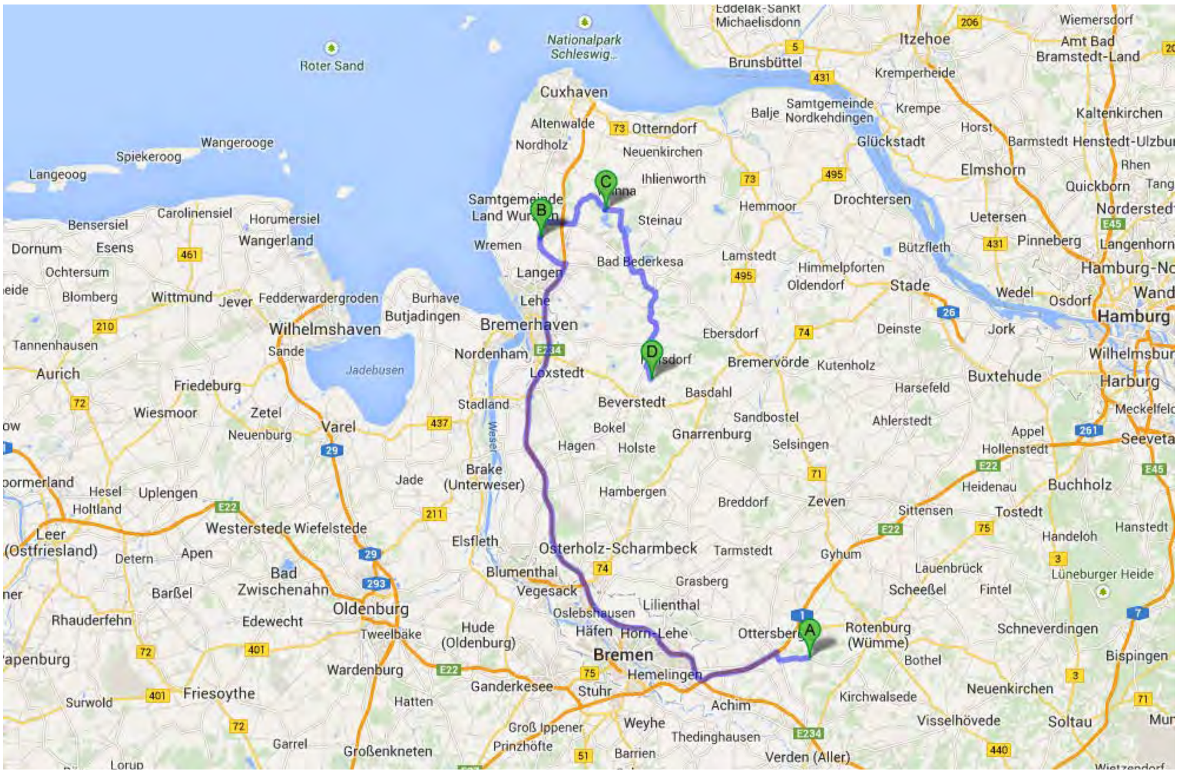
Radiocarbon dating Lake Eversen

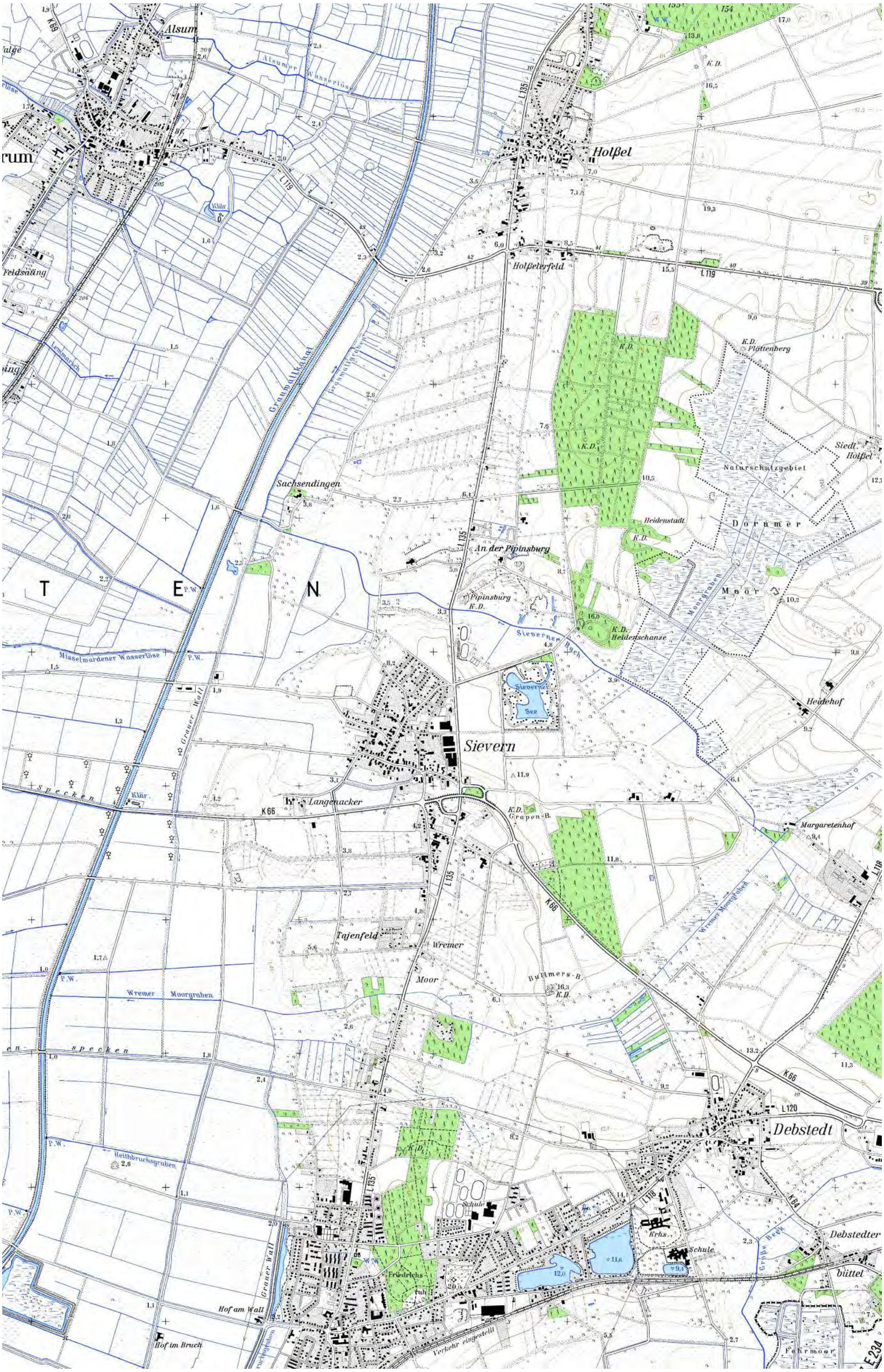


Pollen diagram Lake Eversen (Human impact on wetland sites)

Wednesday, 10.09.2014
Elbe-Weser-Triangle

Palaeotopography and vegetation history at Sievern (I. Brandt, F. Bittmann)
Neolithic settlement and land-use history (A. Kramer, M. Mennenga)
The effects of prehistoric land-use on lake systems (K. Blume, S. Wolters)
Accomodation at Naturfreundehaus Wollingster See

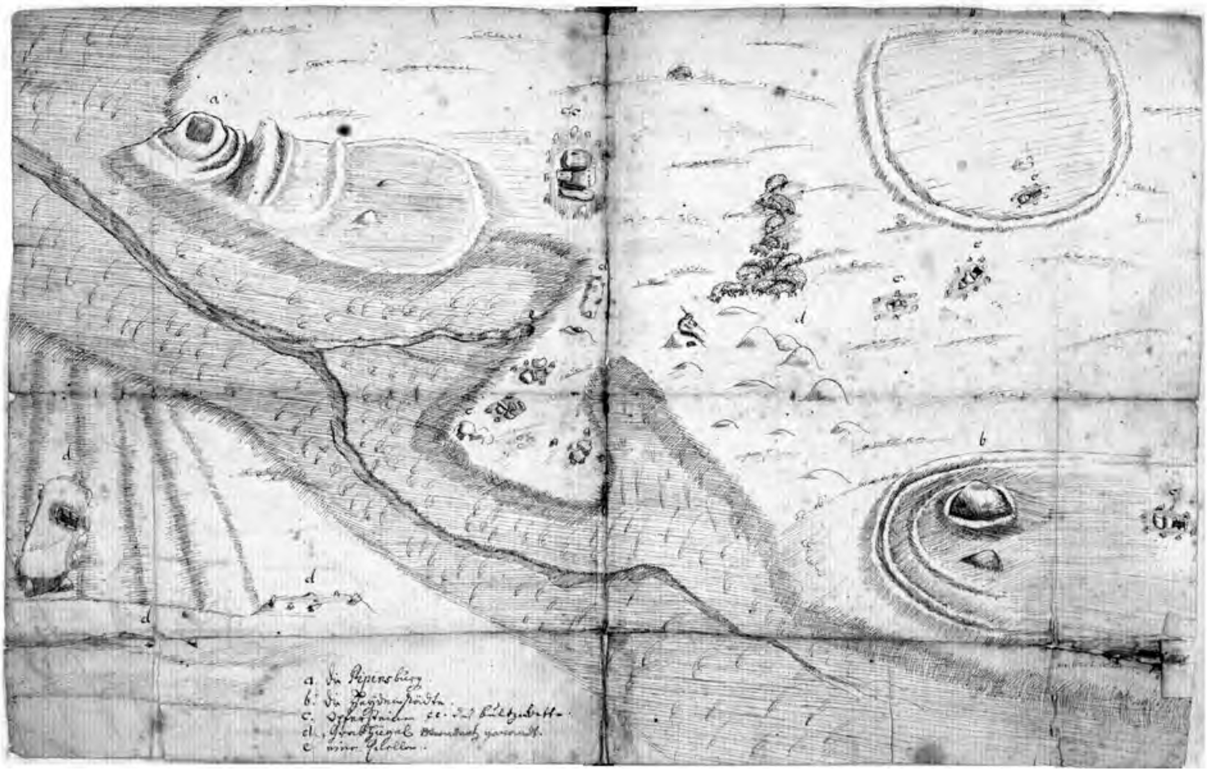




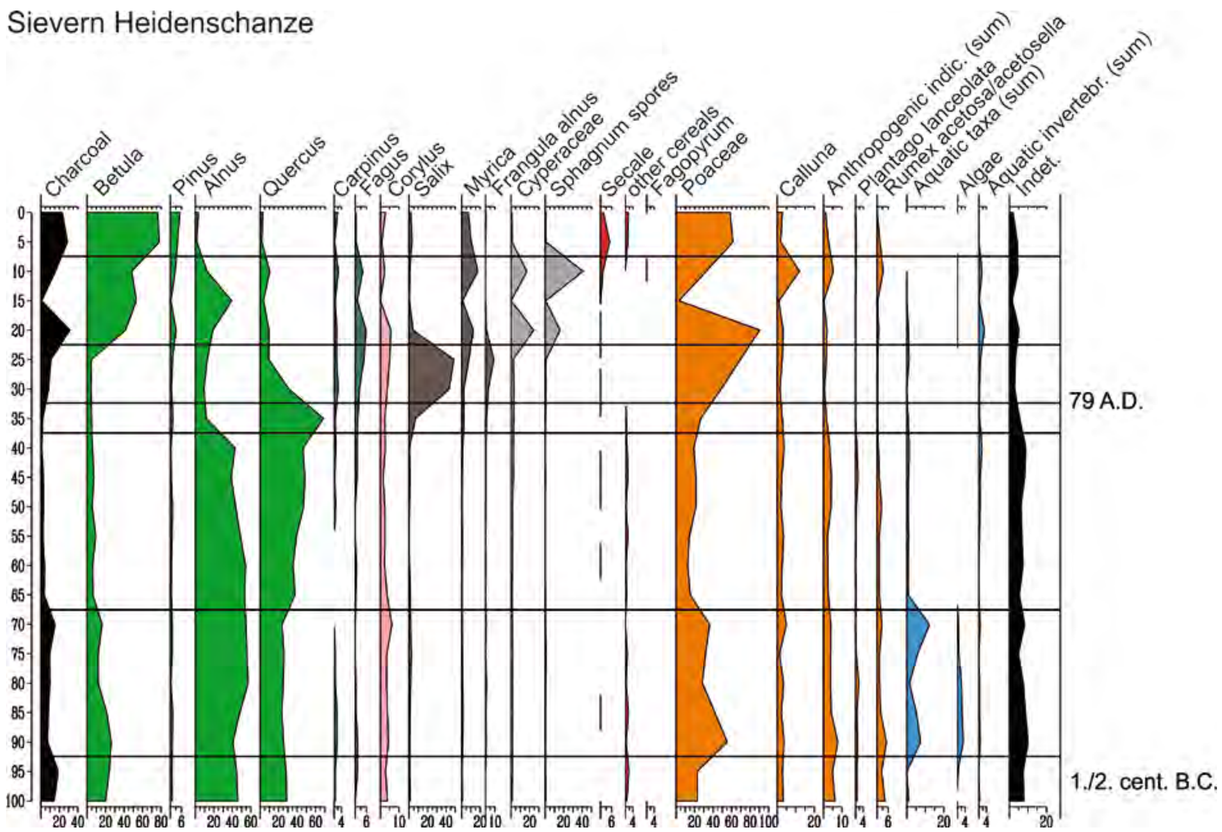
Topographic map of the Sievern area

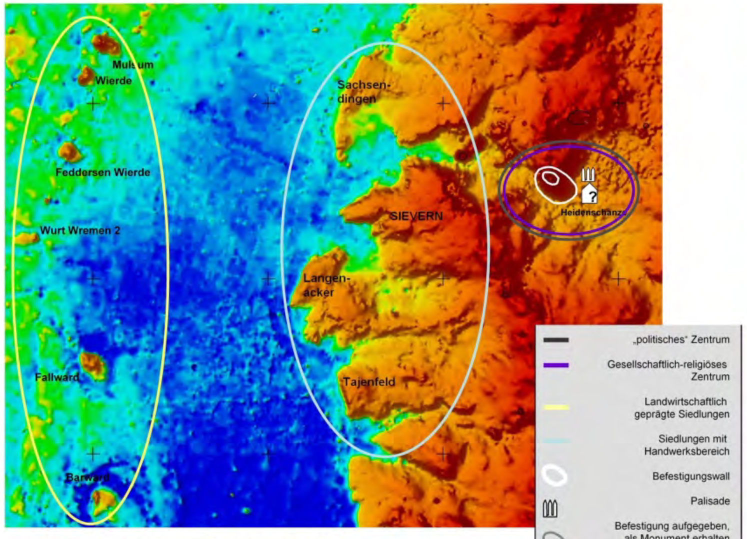
Palaeotopography and vegetation history at Sievern

The Pipinsburg, Heidenschanze, Heidenstadt

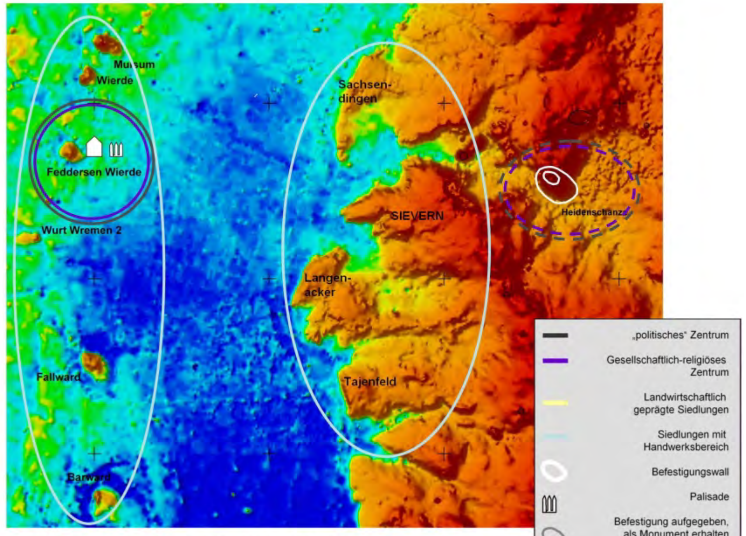


Historical map – after M. Mushard. Palaeogentilismus Bremensis (about 1750)

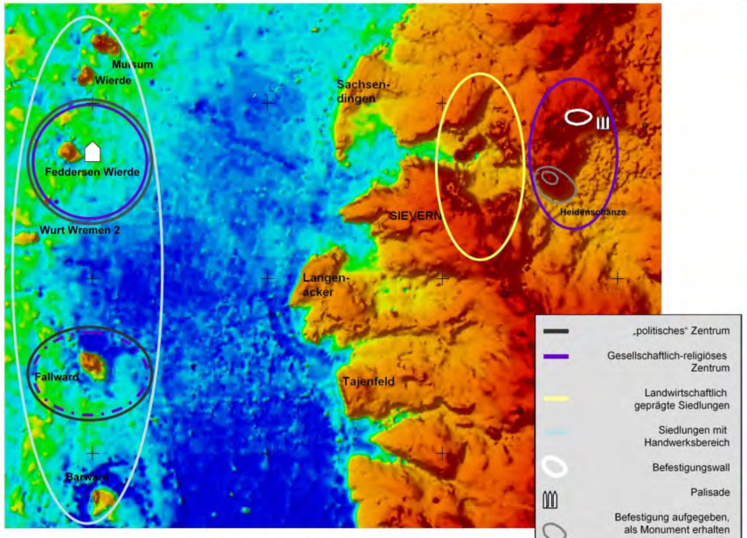




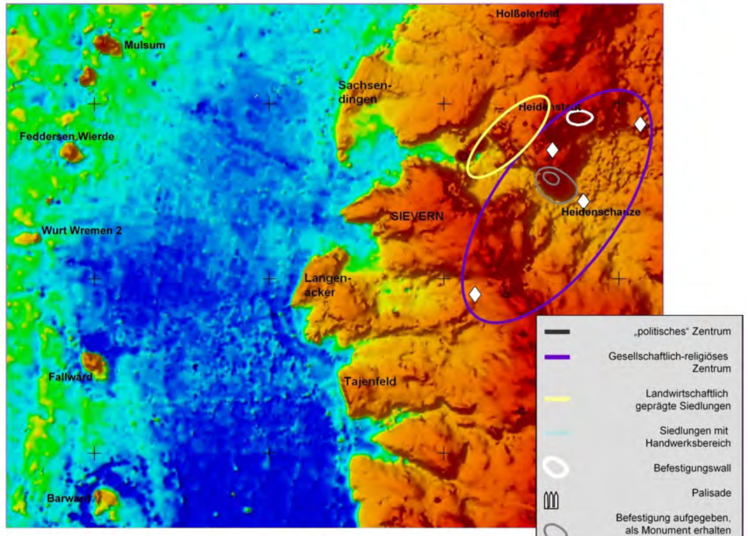
100 vor - 100 nach Chr.



100 - 300 nach Chr.

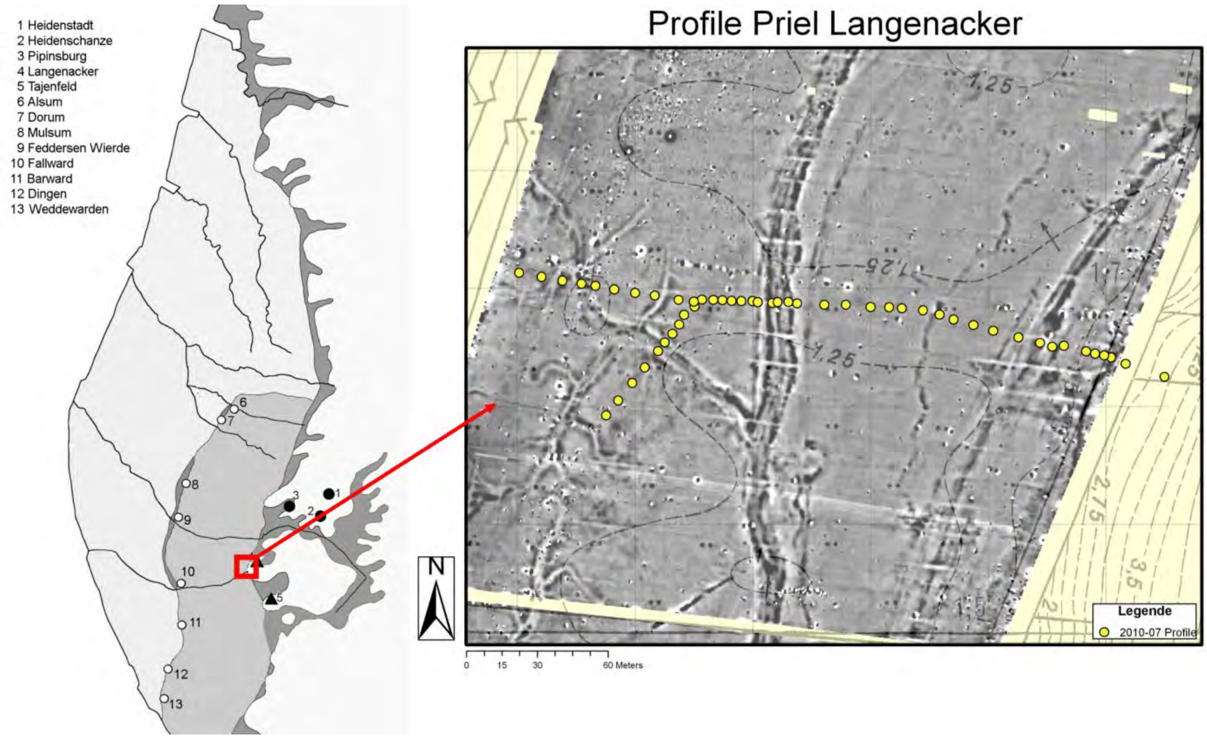


300 - 450 n. Chr,

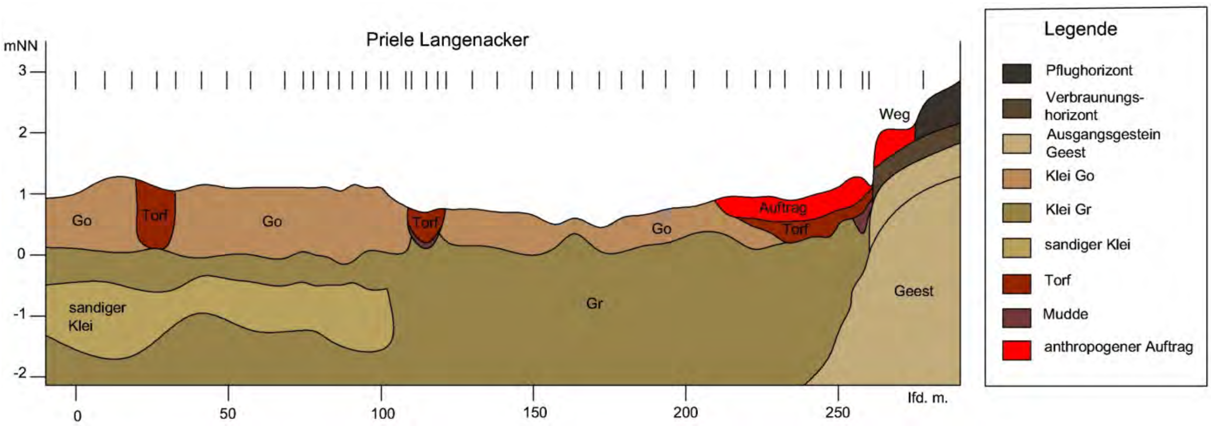


450 - 600 n. Chr.

Langenacker / Priele / Geomagnetik



Geomagnetic measurement Langenacker and coring transect

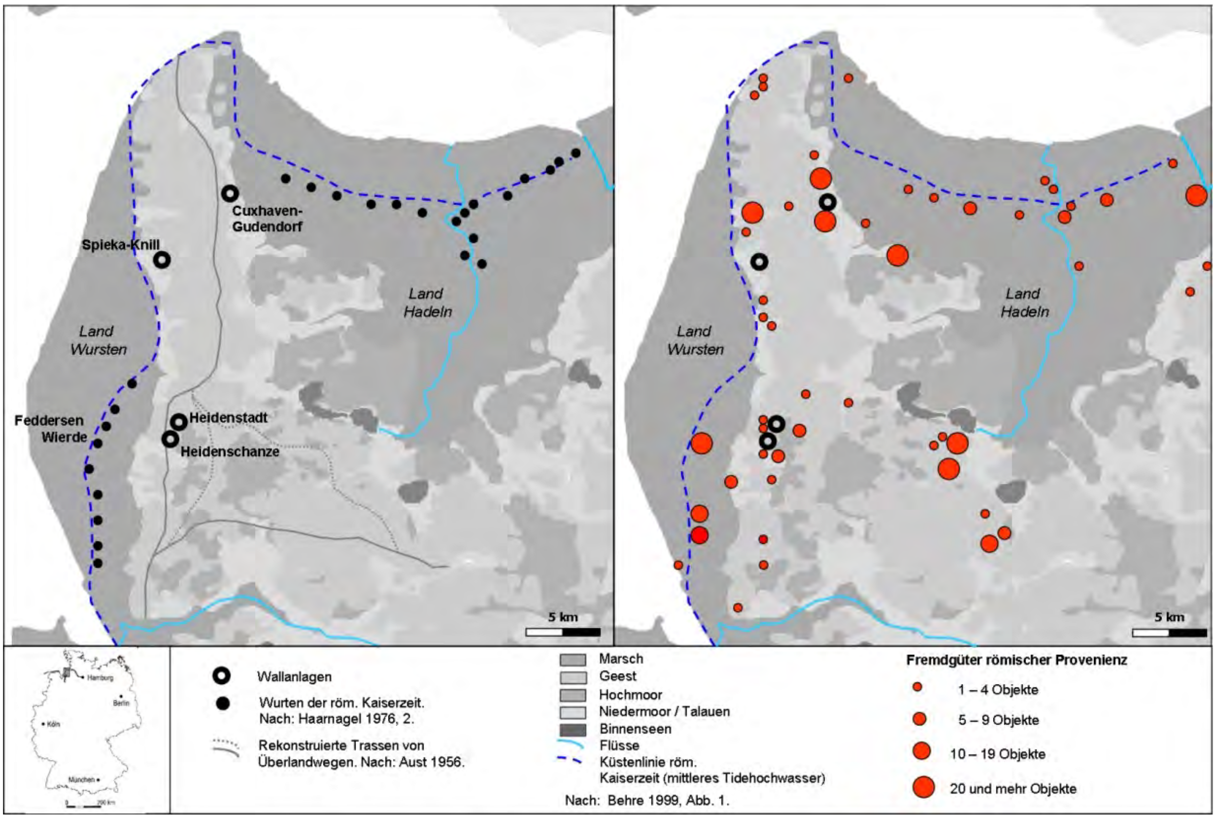


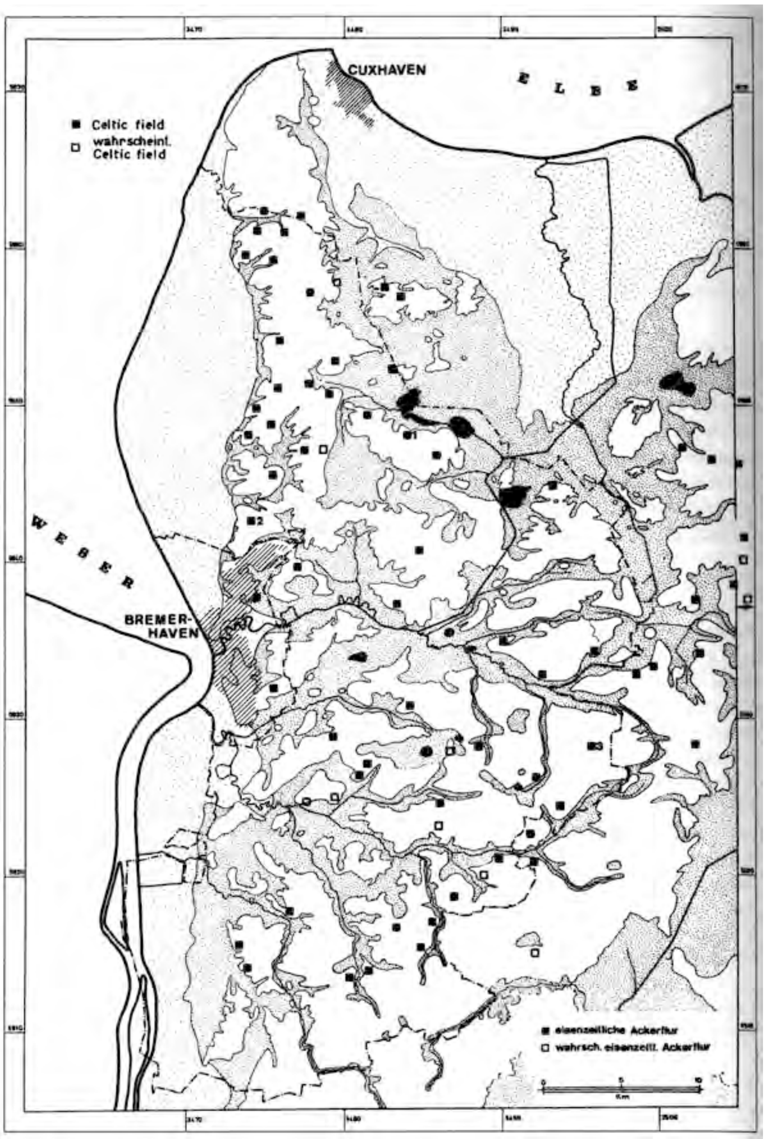
Profile transect Langenacker

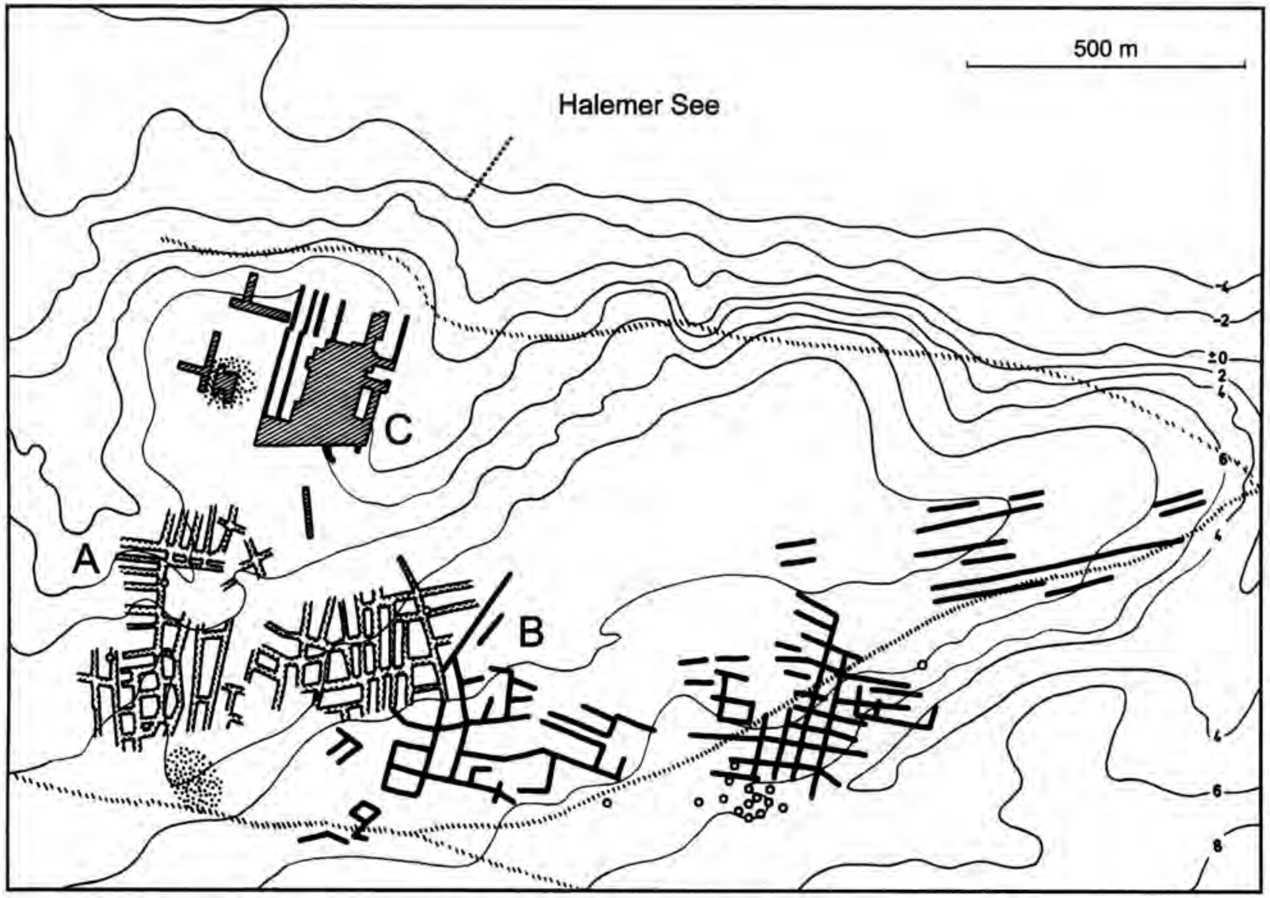
Sievern, Gudendorf and Spieka Knill: Monumental places in the top of Elbe-Weser-triangle and its significance for the Saxon migration

Almost 25 years ago Torsten Capelle argued on the base of the ornamentation of ceramics for close connections between the coastal area of the German Elbe-Weser triangle and Britain. In his eyes this similarities had to be considered not only as evidence of migrating handcrafts traditions from the continent to Britain but also as a prove for the continuous work of a potter from the Elbe-Weser-triangle in his new home in Norfolk. The abandonment of almost all settlements and graveyards in the Northwest-German plain and the palynological evidence of an expansive reforestation during the 6th and 7th century still today support this theory in general, although recent research has proved that there has not been a complete hiatus but an enormous decrease in population. Also the area around Sievern, supraregionally well known for four gold-hoards deposited in the time around 500 AD and the adjacent marshy area "Land Wursten", with the famous dwelling mounds Feddersen Wierde and Fallward suffered at least an enormous decrease of population in the migration period, although there are hints for a continuous settling on the geest ridge until the early medieval period.

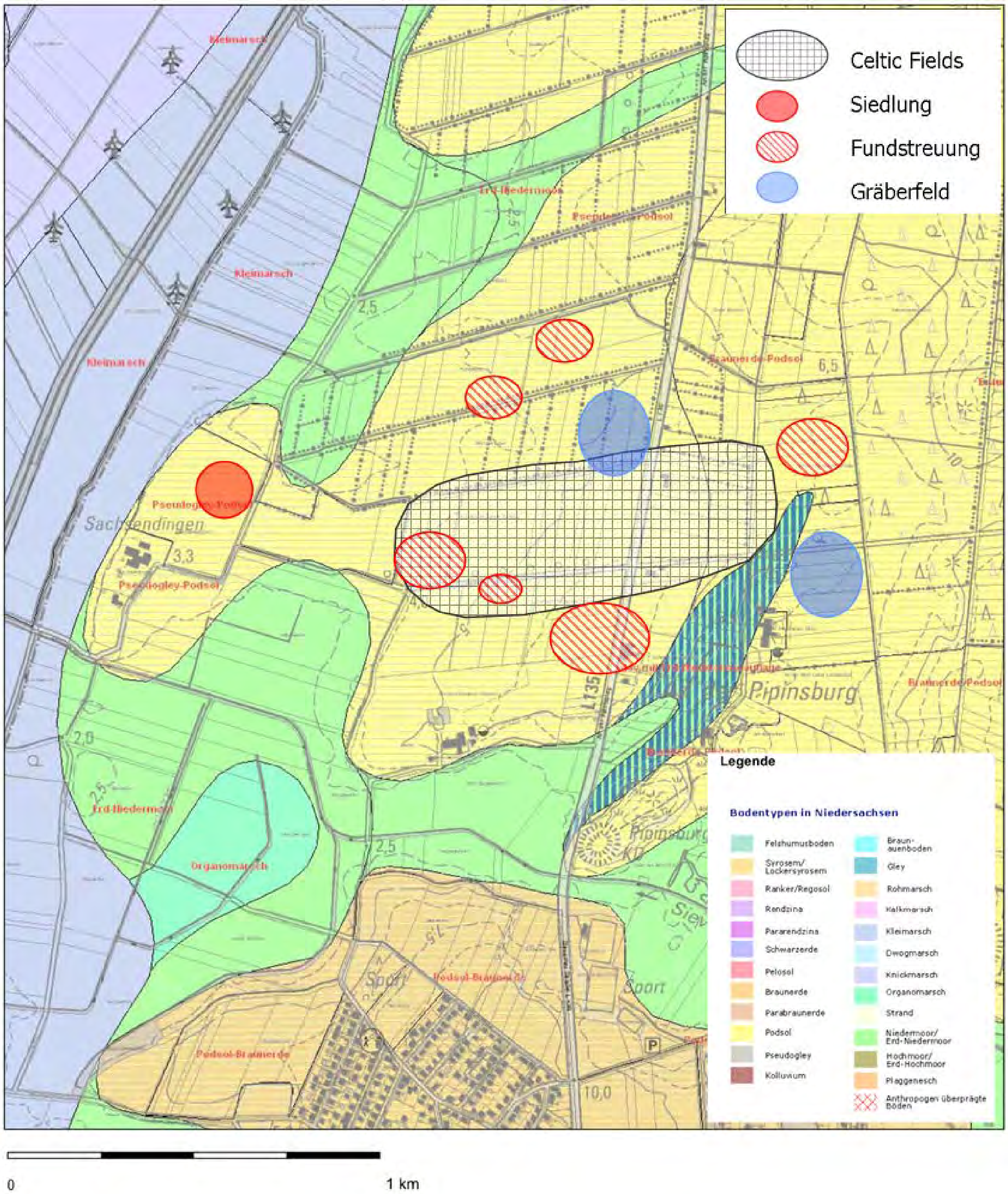
In the last decade new interdisciplinary investigations were done in the area of Sievern and the neighboring areas intending to gather information about the development of settling and landscape during the 1st millennium AD. They comprised geophysical surveys, pedological investigations, trail trenches and excavations on a couple of sites. They prove that the well-known enclosure of Sievern Heidenstadt was constructed during the 4th and 5th century AD. The comparably weak construction of the embankment leads to the conclusion that it functioned rather as a meeting place than as a hill-fort and that it may have played an important role during the sacrifice ceremonies resulting in the deposition of the gold hoards with 11 gold-bracteats from Sievern. Further enclosures presumably dating also to the Roman Iron Age and Migration period have been detected at Gudendorf near Cuxhaven and probably also at Spieka-Knill positioned in the vicinity of the find-spot of another gold-bracteat. The recent state of the art underlines that the north-western part of the top of the Elbe-Weser-triangle played an important role in the social organization of the Saxons, before, during and after their migration to Britain. It is the starting point for a new project (2013-2015) aiming to reconstruct the social and economic organization of the Saxon society in the phase of the Saxon migration.


Cuxhaven-
Gudendorf
Spieka-Knill
Land
Wursten
Land
Hadeln
Feddersen
Wierde
Heidenstadt
Heidenschanze
5 km
Land
Wursten
Land
Hadeln
5 km
Hamburg
Berlin
Köln
München
Wallanlagen
Wurten der röm. Kaiserzeit.
Nach: Haarnagel 1976, 2.
Rekonstruierte Trassen von
Überlandwegen. Nach: Aust 1956.
Marsch
Geest
Hochmoor
Niedermoor / Talauen
Binnenseen
Flüsse
Küstenlinie röm.
Kaiserzeit (mittleres Tidehochwasser)
Nach: Behre 1999, Abb. 1.
Fremdgüter römischer Provenienz
1 – 4 Objekte
5 – 9 Objekte
10 – 19 Objekte
20 und mehr Objekte


CUXHAVEN
E L B E
Celtic field
wahrscheinl.
Celtic field
W E S E R
BREMER-
HAVEN
eisenzeitliche Ackerflur
wahrsch. eisenzeitl. Ackerflur
0
5
10



Das *Celtic Field* von Flögeln-Haselhörn, Lkr. Cuxhaven: A Erhaltene Wälle; B Ehemalige Wälle, nach Luftaufnahmen; C Grabungsfläche Eekhöltjen (nach Zimmermann 1976).


Celtic Fields
Siedlung
Fundstreuung
Gräberfeld
Kleimarsch
Erd-Niedermoor
Pseudogley-Podsol
Braunerde-Podsol
Sachsendingen
Pipinsburg
Organomarsch
Podsol-Braunerde
L135
Legende
Bodentypen in Niedersachsen
Felshumusboden
Syrosem/
Lockersyrosem
Ranker/Regosol
Rendzina
Pararendzina
Schwarzerde
Pelosol
Braunerde
Parabraunerde
Podsol
Pseudogley
Kolluvium
Braun-
auenboden
Gley
Rohmarsch
Kalkmarsch
Kleimarsch
Dwogmarsch
Knickmarsch
Organomarsch
Strand
Niedermoor/
Erd-Niedermoor
Hochmoor/
Erd-Hochmoor
Plaggenesch
Anthropogen überprägte
Böden
0
1 km

Zentralorte

Für das 1. Jahrtausend v. Chr. und das 1. Jahrtausend n. Chr. sind in Nord- und Mitteleuropa so genannte Zentralorte bekannt geworden. Dies sind Plätze, die innerhalb des sie umgebenden Siedlungsgefüges offenbar eine Rolle als wirtschaftliches, politisches und/oder kulturelles Zentrum wahrnahmen. Obwohl sie jeweils individuelle Züge aufwiesen, lassen sich gemeinsame Charakteristika benennen:

- Es kann mittlerweile als gesichert gelten, dass diese Plätze unter der Kontrolle einer ortsansässigen Elite standen, die sich im archäologischen Befund durch prestigeträchtige Güter und Bauten manifestierte.
- Die landwirtschaftliche Produktion stellte auch für die Zentralorte die wirtschaftliche Basis dar, von nahezu allen bekannten Plätzen liegen jedoch auch Hinweise auf spezialisierte Handwerkszweige vor.
- Ein weiterer gemeinsamer Faktor ist die verkehrsgünstige Lage an Land- und Wasserwegen. Diese Infrastruktur bildete nicht nur die Grundvoraussetzung für die regionale Kommunikation sondern auch für überregionale Kontakte, die sich archäologisch in Form von Fremd- und Importgütern im Umfeld des Zentralortes niederschlugen.
- Zudem hatte eine Vielzahl dieser Plätze offenbar auch eine Funktion im Ritus.

Die Bedeutung der Mikroregion Sievern, Ldkr. Cuxhaven

Für den Bereich der nordwestdeutschen Tiefebene sind vergleichbare Plätze bisher weitestgehend unbekannt. Dem Raum um die heutige Ortschaft Sievern im westlichen Elbe-Weser-Dreieck wird in der Siedlungsforschung aufgrund einer für den norddeutschen Raum einzigartigen Verdichtung von Funden und Geländedenkmälern jedoch eine besondere Bedeutung eingeräumt.

Dazu zählen insbesondere die Wallanlagen der späten vorrömischen Eisenzeit und römischen Kaiserzeit beziehungsweise der Völkerwanderungszeit, die als „Heidenschanze" und „Heidenstadt" in die Literatur eingegangen sind (Abb. 1, 2).

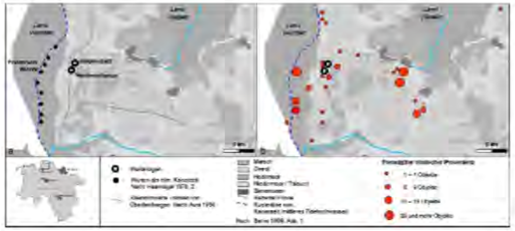


Abb. 2: a) Wallanlagen und Marschensiedlungen sowie der nach Aust (1956) rekonstruierte Verlauf von Überlandwegen im westlichen Elbe-Weser-Dreieck. – b) Verbreitung von Fremdgütern römischer Herkunft im westlichen Elbe-Weser-Dreieck. Abbildung: Aufderhaar, NIhK, Kartengrundlage nach Behre 1999, Abb. 1.

Auch die im Umfeld von Sievern gefundenen Edelmetalldepots des 5. und 6. Jh. n. Chr. sind in ihrer Häufung im deutschen Küstengebiet singulär: Neben fünf geösten oströmischen Goldsolidi wurden mit einem Halsreif und vierzehn Goldbrakteaten zahlreiche Gegenstände skandinavischer Herkunft (Abb. 3, 5) in der Umgebung von Sievern gefunden, die insgesamt für weit reichende Kontakte der ortsansässigen Bevölkerung sprechen.

Diese Verdichtung außergewöhnlicher Befunde und Funde führte zu der Hypothese, dass in der Region Sievern während der ausgehenden vorrömischen Eisenzeit, der römischen Kaiserzeit und Völkerwanderungszeit ebenfalls ein Zentrum bestanden hat, das mit den Zentralorten gleicher Zeitstellung in Mittel- und Nordeuropa vergleichbar war.

Neue Forschungen in Sievern (2007 – 2010)

Im Rahmen des von der Deutschen Forschungsgemeinschaft (DFG) geförderten Projektes „Der eisenzeitliche Zentralplatz von Sievern, Ldkr. Cuxhaven – Prospektion und Sondagen" wurden zwischen 2007 und 2010 großflächige geophysikalische Prospektionsarbeiten, Bohrungen und archäologische Sondagen an zahlreichen Siedlungsplätzen im Raum Sievern vorgenommen.

Durch die vergleichende Auswertung aller eingesetzten Methoden (Abb. 4) wurden weit reichende Einblicke in die innere Struktur der unterschiedlichen Bestandteile des Siedlungsgefüges im Raum Sievern vor allem während der ersten Hälfte des 1. Jahrtausends n. Chr. gewonnen. So erbrachten sie neue Erkenntnisse zu den Befestigungsanlagen und deren näherem Umfeld sowie zu einigen Siedlungen, die aufgrund ihrer Lage am Randbereich der Geest mit guten Zugangsmöglichkeiten zur Marsch ebenso wie die in der Marsch gelegenen Wurtensiedlungen als Bootslandeplätze in Betracht gezogen werden können (vgl. Abb. 1).

Abb. 3: Goldfunde aus der Umgebung von Sievern
Nach: Hässler 2003, Abb.45; Hauck 1970, Abb. 3a,2; 6,4; 8.)

Das Projekt wurde vom Niedersächsischen Institut für historische Küstenforschung Wilhelmshaven (NIhK) gemeinsam mit der Abteilung Geophysik des Instituts für Geowissenschaften der Christian-Albrechts-Universität zu Kiel in Kooperation mit der

Archäologischen Denkmalpflege des Landkreises Cuxhaven durchgeführt.

Abb. 4: Forschungen zur Entwicklung des Siedlungsgefüges und der Landschaft durch geomagnetische Prospektionen (a-b), archäologische Ausgrabungen (c) und bodenkundliche Profilaufnahmen (d-f). Aufderhaar u. Brandt 2011, Abb. 3.

Zudem erfolgten die Forschungen in enger Kooperation mit dem durch das Niedersächsische Ministerium für Wissenschaft und Kultur (MWK) geförderten Projekt „Untersuchungen zur Rekonstruktion der Paläotopographie im Umfeld des eisenzeitlichen Zentralplatzes von Sievern, Ldkr. Cuxhaven", das von Imke Brandt M. A. am NIhK durchgeführt wird.

Abb. 5: Zwei neu gefundene Brakteaten aus Sievern, Ldkr. Cuxhaven; Foto: Kiepe, NIhK.

Derzeit werden die Ergebnisse des Projektes „Der eisenzeitliche Zentralplatz von Sievern, Ldkr. Cuxhaven Prospektion und Sondagen" von I. Aufderhaar im Rahmen einer Dissertation ausgewertet. Der Abschluss dieser Arbeit wird vom MWK im Umfang des Programms Projekt Promotion Plus gefördert.

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Niedersächsisches Institut
für historische Küstenforschung Wilhelmshaven

Der eisenzeitliche Zentralplatz von Sievern, Ldkr. Cuxhaven – Prospektion und Sondagen –

Iris Aufderhaar M.A.

Abb. 1: Zeichnung der archäologischen Denkmäler aus den Gemarkungen Sievern und Holßel im Ldkr. Cuxhaven nach M. Mushard, Palaeogentilismus Bremensis (um 1750) Veröffentlicht im Jahrbuch des Provinzialmuseums Hannover 1927, Taf. 2

DFG Deutsche Forschungsgemeinschaft

Niedersächsisches Ministerium für Wissenschaft und Kultur

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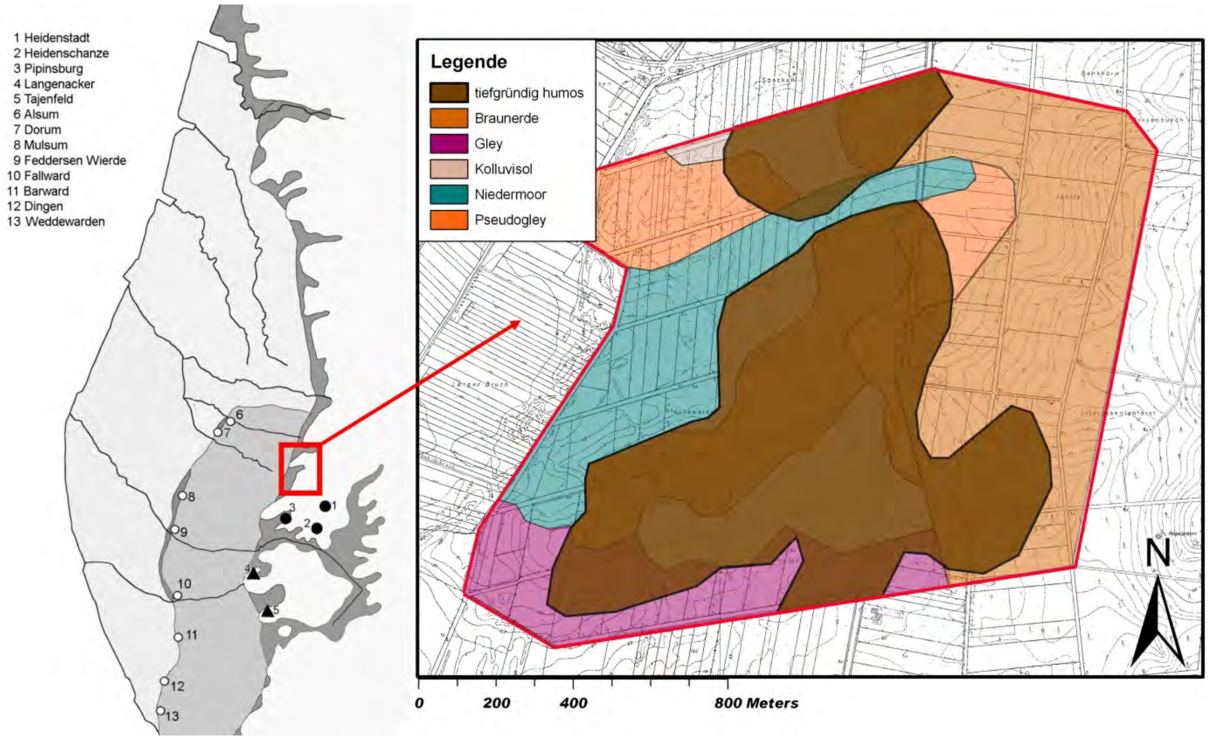
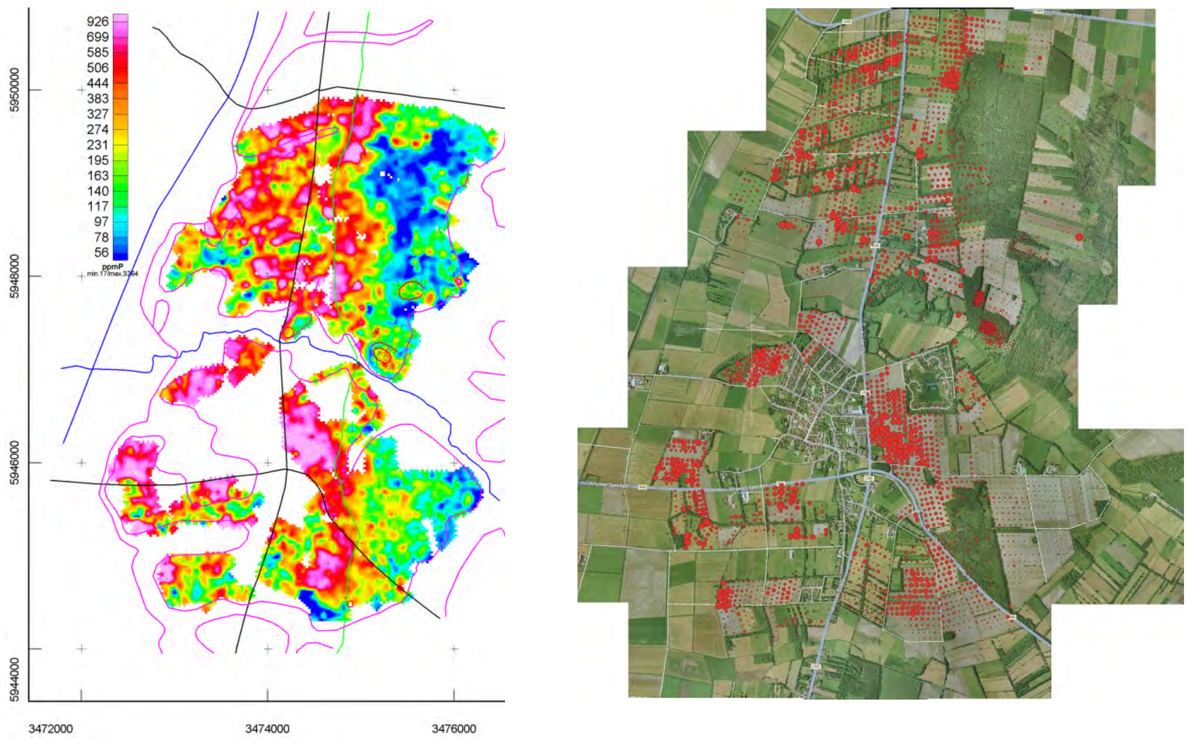
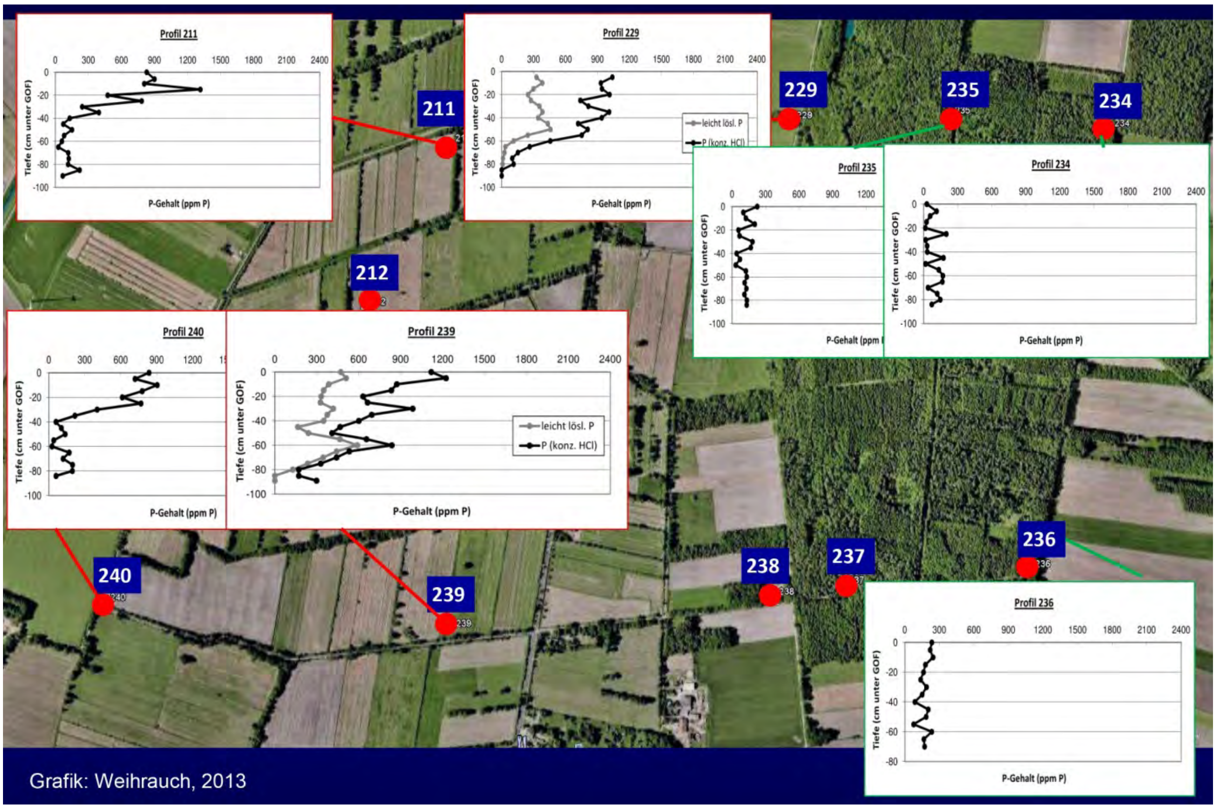
Pferdeweide

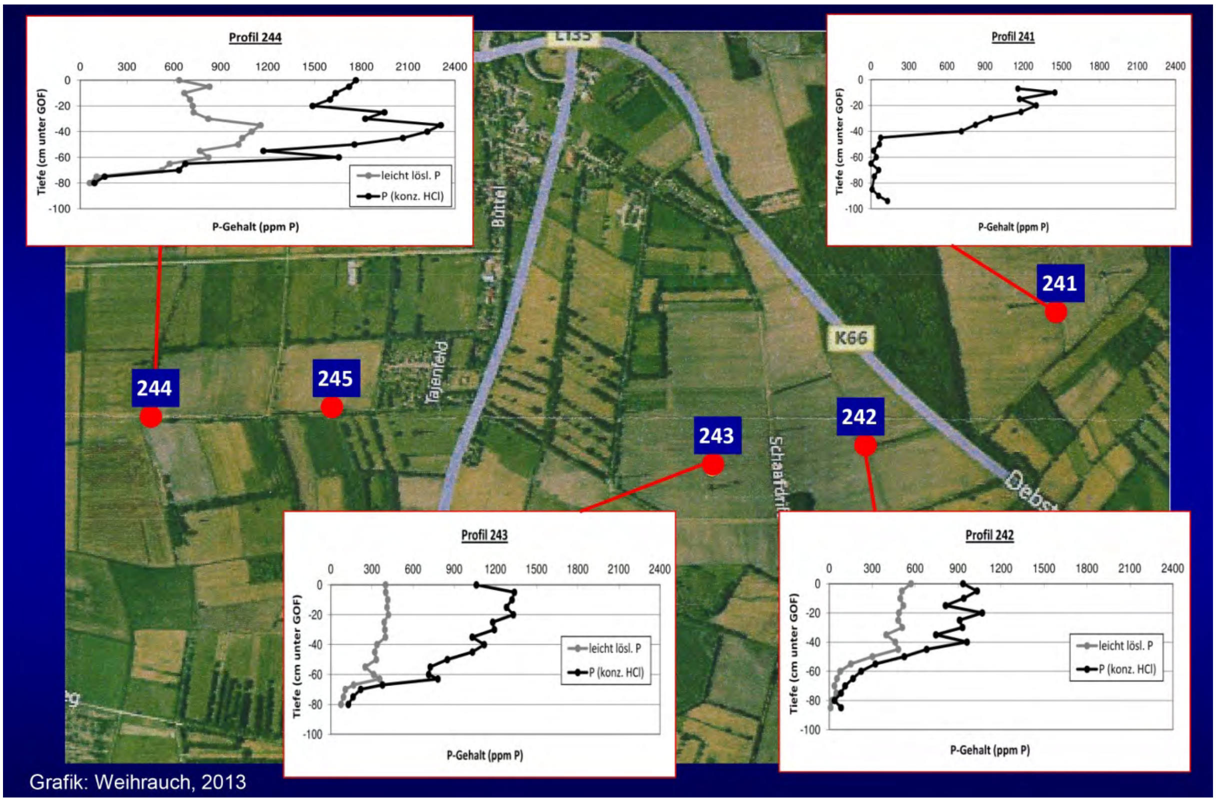


Simplified soil map of the investigated area



Interpolation vs. measurements of phosphates

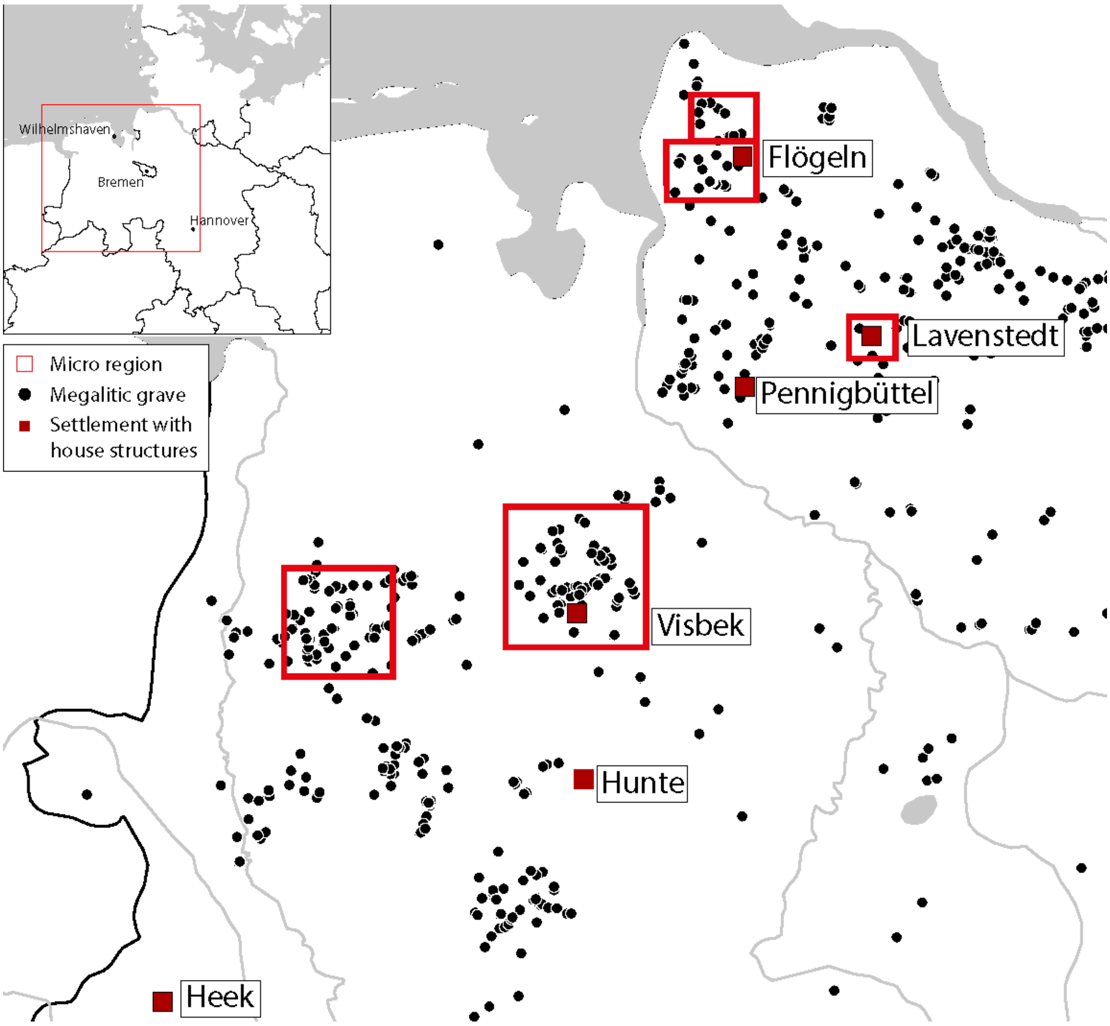




Vertical displacement of phosphates in soils

Neolithic settlement and land-use history in northwestern Germany

Northwest Lower Saxony was settled by people belonging to the west group of the Funnel Beaker (TRB) and the succeeding Single Grave Culture (SGC) during the 4th and the second half of the 3rd millennium before Christ (BC). Numerous megalithic tombs and grave mounds, as well as finds of settlements and hoards document the presence of theses cultures in the area. Therefore, the region provides an ideally suited environment for investigations into relationships between different find spot ensembles and about the nature and extent of human influence on the surrounding landscapes. A multidisciplinary study involves archaeological excavations and palynological investigations to shed further light on the Neolithic revolution in northwest Germany (Kramer et al., 2012; Kramer et al., 2014). The on-going project is realised within the Priority Program 1400: "Early Monumentality and Social Differentiation", funded by the German Research Foundation.



Overview working area with distribution of megalithic tombs and yet known settlements

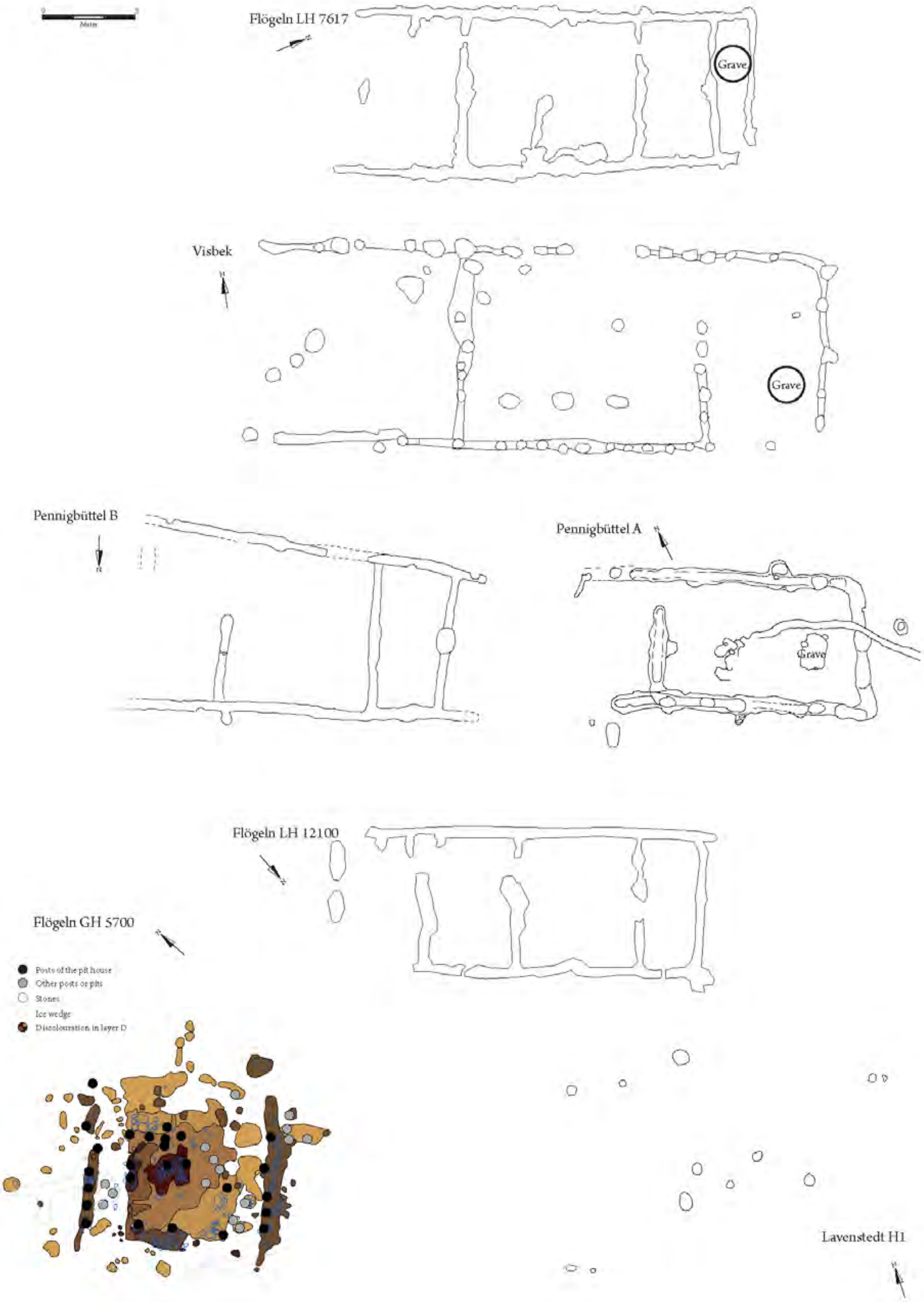
In the area between the rivers Elbe and Ems, almost 17,000 megalithic graves are known while probably much more have been already destroyed. The spatial distribution of these tombs provides an idea of how well populated the area was during the middle and young Neolithic which demonstrates a very poor state of research for the known settlements. Up to now, only six settlements with building structures have been documented. Therefore, particular attention is given to the investigation into settlements and settlement structures.

The known settlements are often spatial connected to flat graves and megalithic tombs which is typical for the TRB west group but, uncommon for other TRB regional groups. In three cases, Flögeln (Zimmermann, 2000), Visbek (Mennenga et al., 2013) and Pennigbüttel (Assendorp, 2000), flat graves were also found inside the houses. In the west group, most of the known houses were constructed with wall foundation trenches, which provided the opportunity to better understand the internal structures of the buildings. Only some houses from the settlements in Flögeln and Lavenstedt show different construction types. In Flögeln, additional to two wall foundation trench houses, a pit house, postulated as a "cult-house", was found in 1985 (Zimmermann, 1995). In Lavenstedt (Mennenga, in press) important and interesting contributions for the TRB research in this area were revealed during recent years. The documented house construction includes traditions from the TRB west as well as from the north group which possibly point to some kind of social exchange between these groups. Results from Lavenstedt further provide new information about the absolute dating of the TRB which have been determined so far to 3400 cal BC (Brindley, 1986). The botanical macro remains which were sift out of the posts and a well fillings, were radiocarbon dated and indicate an earlier establishment, as it was previously known, of the TRB in the area. Thereby, it is possible to close a time gap to the neighbouring regional groups and to see over-regional developments as nearly parallel processes.

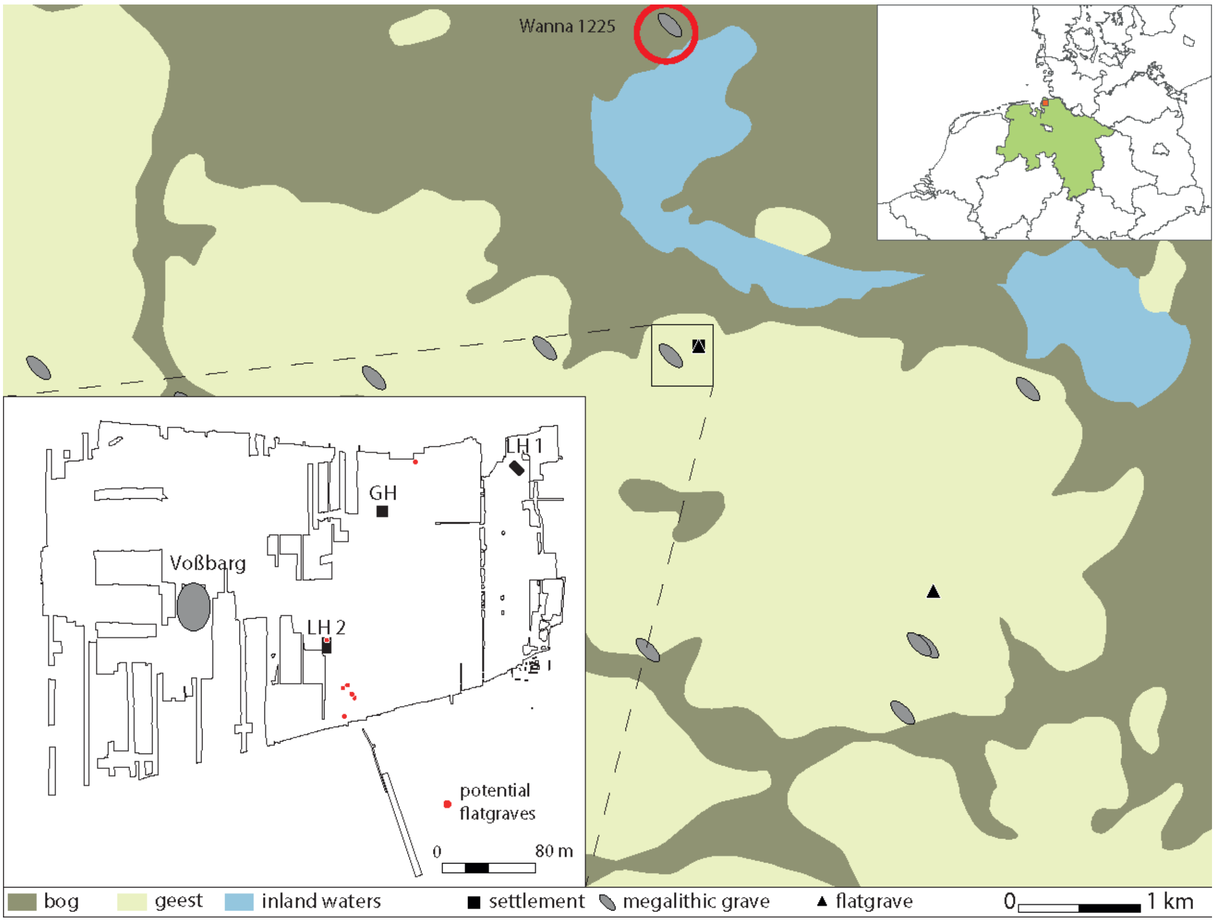
Apart from the investigated settlement structures in Flögeln, most of the information about the vegetation and settlement history during the Neolithic was gained by detailed palynological investigations on twelve peat profiles from the geest island Flögeln (Behre and Kučan, 1994). The results suggested a first moderate human influence on the vegetation on start with the elm decline that was later more pronounced and went together with significant increases of settlement indicator pollen types. It was also possible to identify areas with high and low settlement activities by means of the data (ibid).

Based on these information, current palynological research on the geest island Flögeln focuses on the establishment of an improved age-depth model for the vegetation development reconstructed by Behre and Kučan (1994) to better distinguish between different stages of Neolithic landscape changes. Up to now, the peat profile from the kettle-hole bog "Swienskuhle" is the most significant profile from Flögeln as Neolithic vegetation and land use history are best visible here. A parallel profile from the "Swienskuhle" was recovered to avoid problems that might arise when dating material from longer-term storage (Wohlfahrt et al., 1998). The pollen events discovered in the original profile, such as the elm and lime declines, a strong increase in anthropogenic indicators, the following spread of heather, and the subsequent generation period (cf. Behre and Kučan 1994) have been connected to the new profile. However, new dating results revealed a different age regime for the Swienskuhle, which point to high vegetation heterogeneity in the area and to distinct differences between local and regional vegetation changes in response to human induced disturbances . (Kramer et al., in prep).

Theories about the abandonment of the settlement areas in the Elbe-Weser triangle include the idea that the Neolithic settlers (TRB and SGC) probably had to face a progressive reduction in their habitation area (Behre 2005). The reduction bases on rising sea level of the North Sea (Behre, 2007; Bungestock and Schäfer, 2009) which led to the expansion of peatlands. Manifestations of this development had been seen in the presence of several megalithic tombs that have been rediscovered beneath a bog layer during recultivation measures. Recent investigations on the basal peat layers of five bog-overgrown megalithic tombs gave no direct indication for this phenomenon because the tombs were probably not covered by bogs before the 1st millennium BC (Kramer et al., 2012, p 325).



TRB house floor plans from NW Germany



Site map of Flögeln area with Neolithic settlement sites and graves

Examples of megalithic tombs over grown by bog in Elbe-Weser Triangle (photos: D. Nösler)

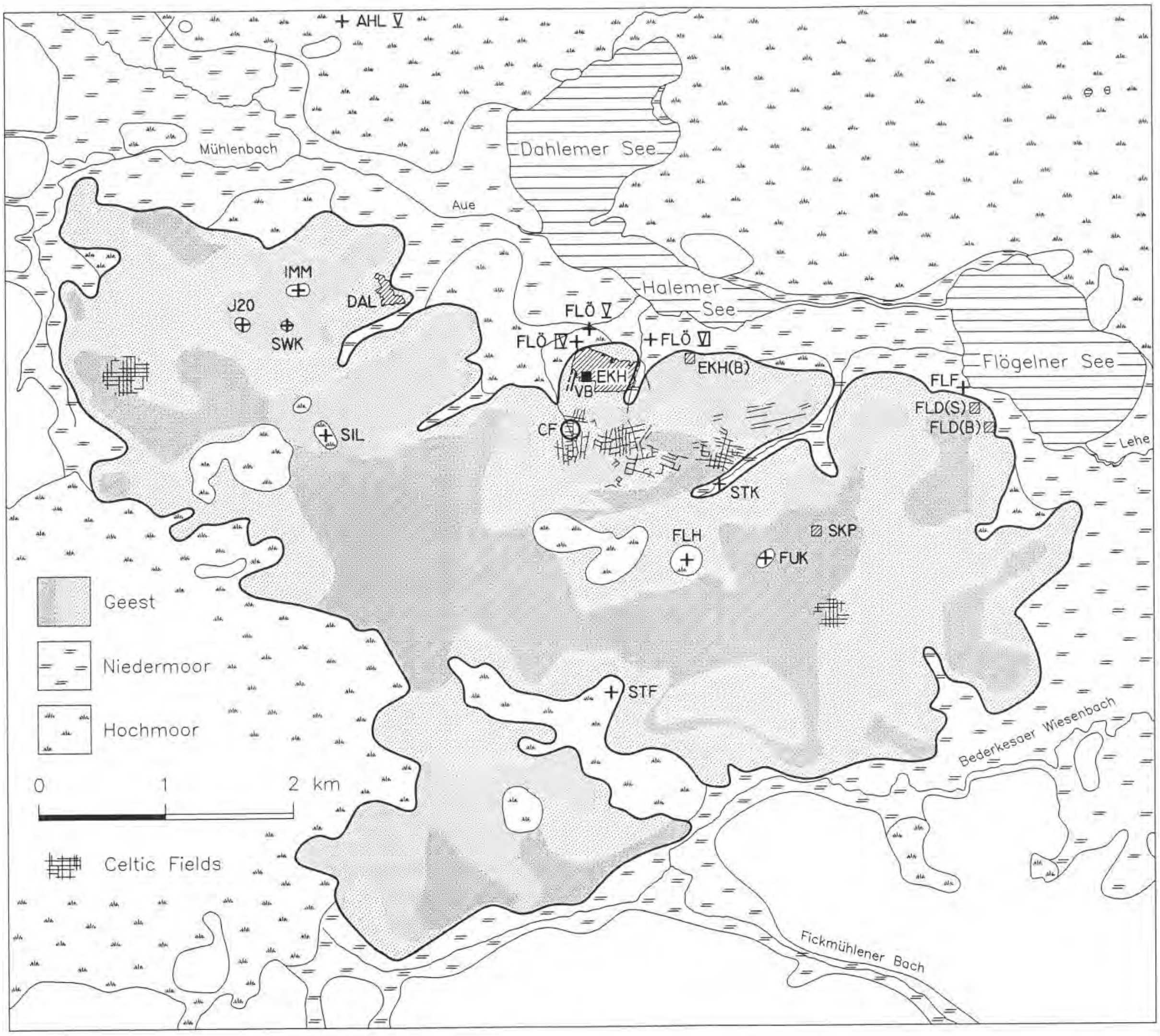
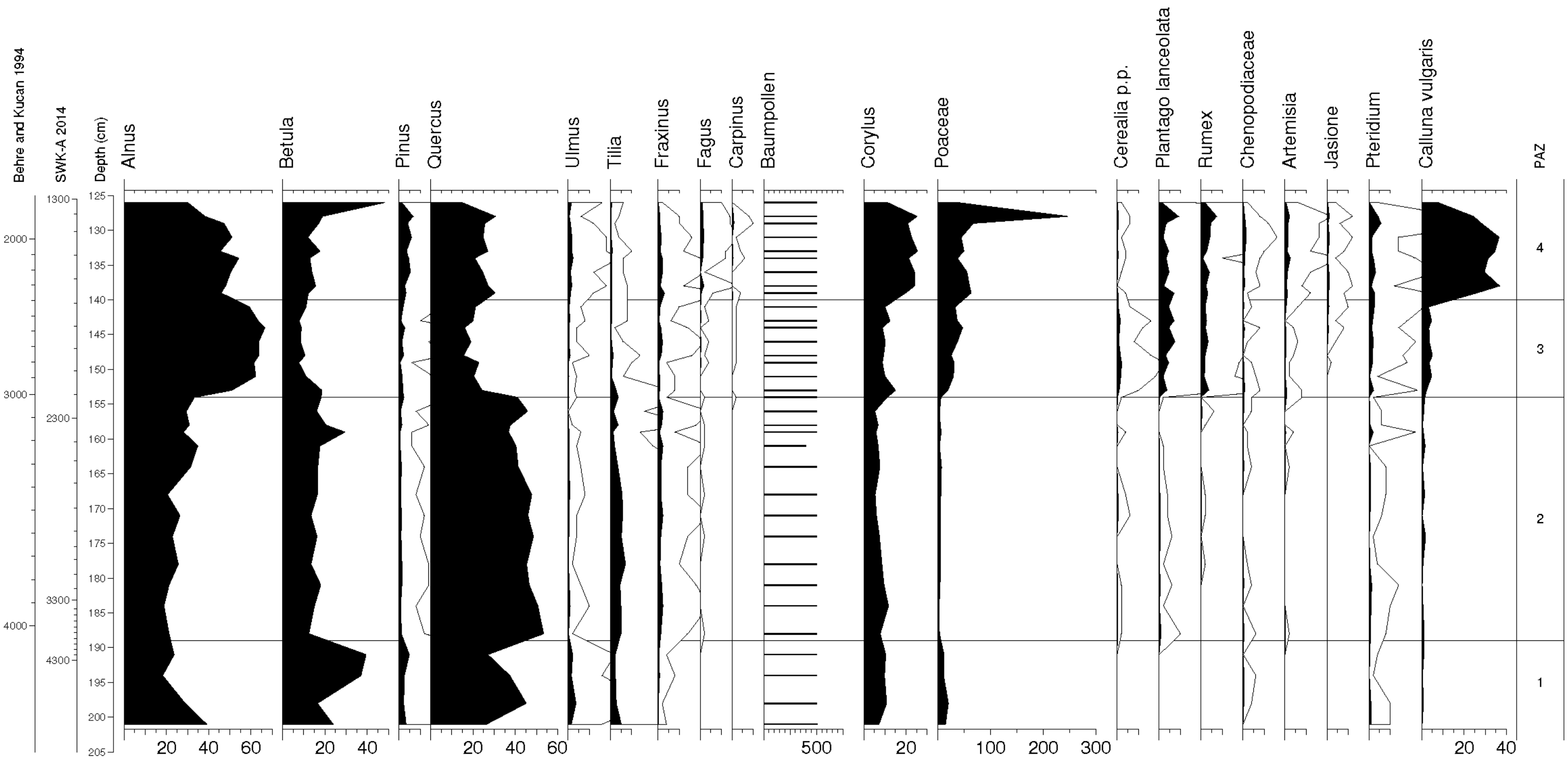


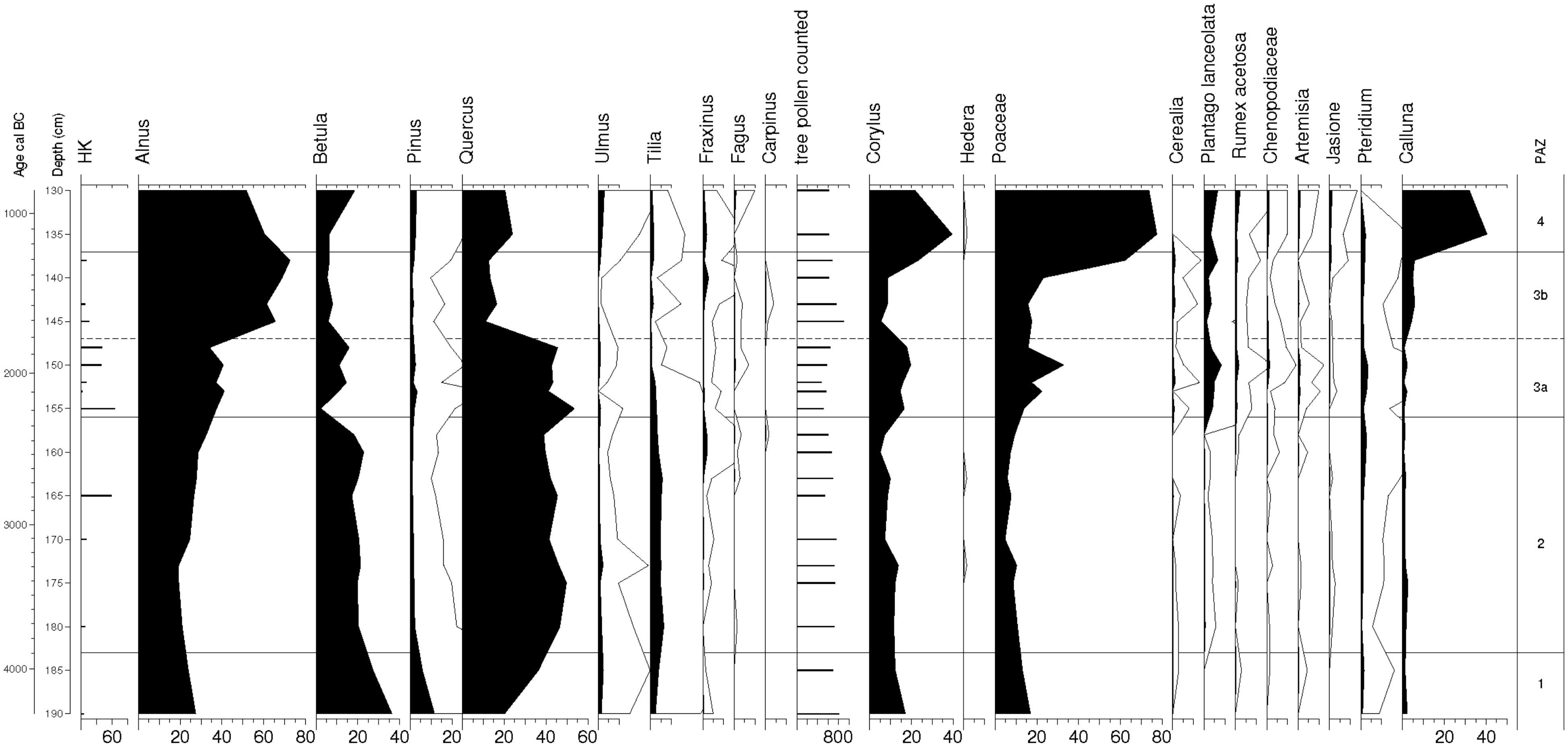
Abb. 71. Karte der Pollendiagramme und Makrorestfundstellen in der Siedlungskammer Flögeln.
Moorprofile (Kreuze):
AHL V = Ahlenmoor V, J20 = Jagen 20, SWK = Swienskuhle, IMM = Immenmoor, SIL = Silbersee, FLÖ IV-VI = Flögeln IV-VI, STK = Steinkiste, FLH = Flögelner Holz, FUK = Fuhrenkamp, FLF = Flögeln Fischer, STF = Steertmoor Fickmühlen.

Celtic Fields Profile (Kreis):
CF = Profile 8, 10, 70, 80, 105
Makrorestfundstellen: DAL = Dalem (Mittelalter)
EKH = Eekhöltjen (Neolithikum, Römische Kaiserzeit, Völkerwanderungszeit)
EKH (B) = Kringler (späte Bronzezeit)
VB = Gräberfeld Voßbarg (Völkerwanderungszeit)
SKP = Schmidts Kamp (späte Bronzezeit)
FLD (S) = Flögeln-Dorf, Hof Sengstaken (Neuzeit)
FLD (B) = Flögeln-Dorf, Hof Bellgardt (Mittelalter)
Auf der Geestinsel sind unterschieden (nach der geologischen Karte, Blatt 2318 Neuenwalde):
dunkles Raster = Geschiebelehm (Grundmoräne)
mittleres Raster = Geschiebedecksand über Geschiebelehm
helles Raster = glazifluviatiler Sand

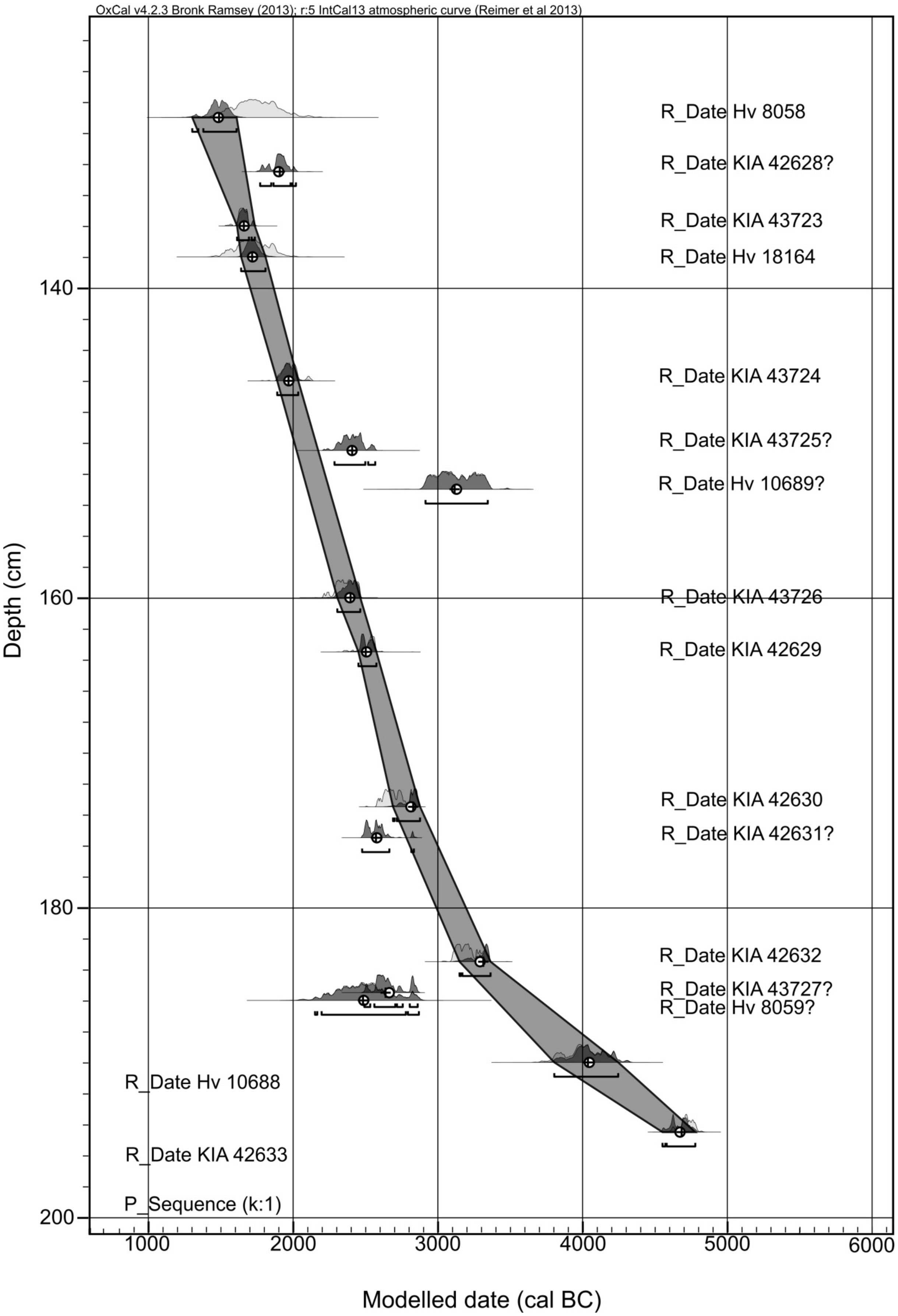
Site map of Flögeln area with investigated pollen profiles from Behre and Kučan (1994, p. 166)



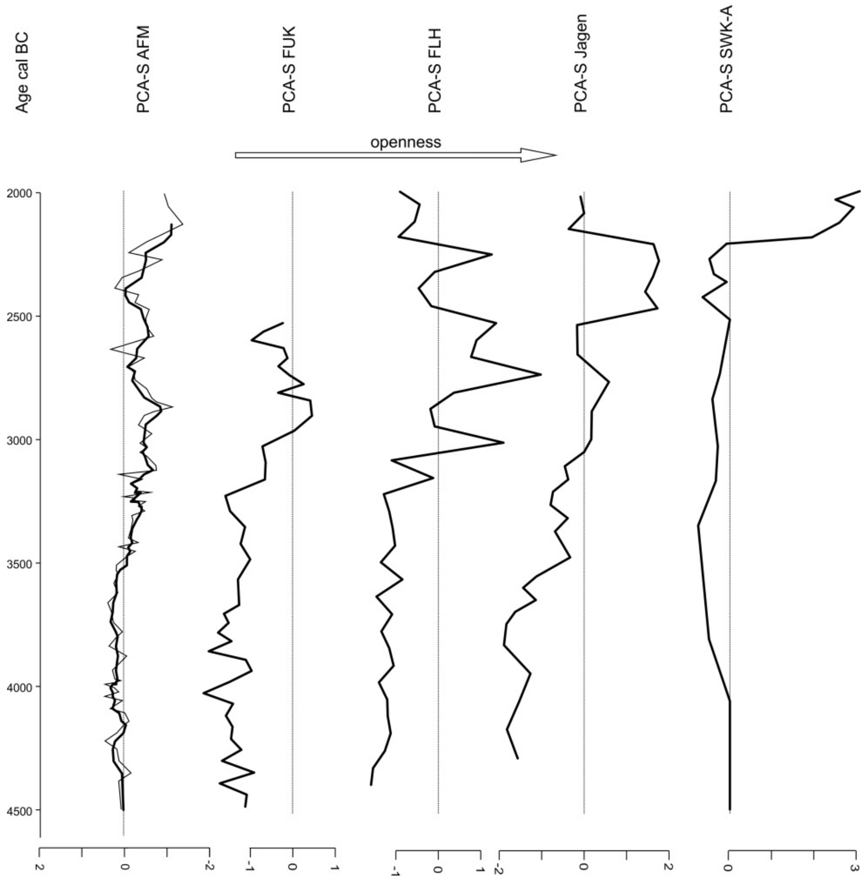
Pollen diagram (SWK-A) from Swienskuhle (Behre and Kučan, 1994) with old and new age-depth models. Percentages base on AP sums (magnification tenfold)



Newly obtained pollen profile (SWK-N) from Swienskuhle. Percentages base on AP sums (magnification tenfold)



Age-depth model for SWK-A and SWK-N



First PCA axes from five pollen profiles from Flögeln area. The axes are interpreted as semi-quantitative measurements of human impact in the region.

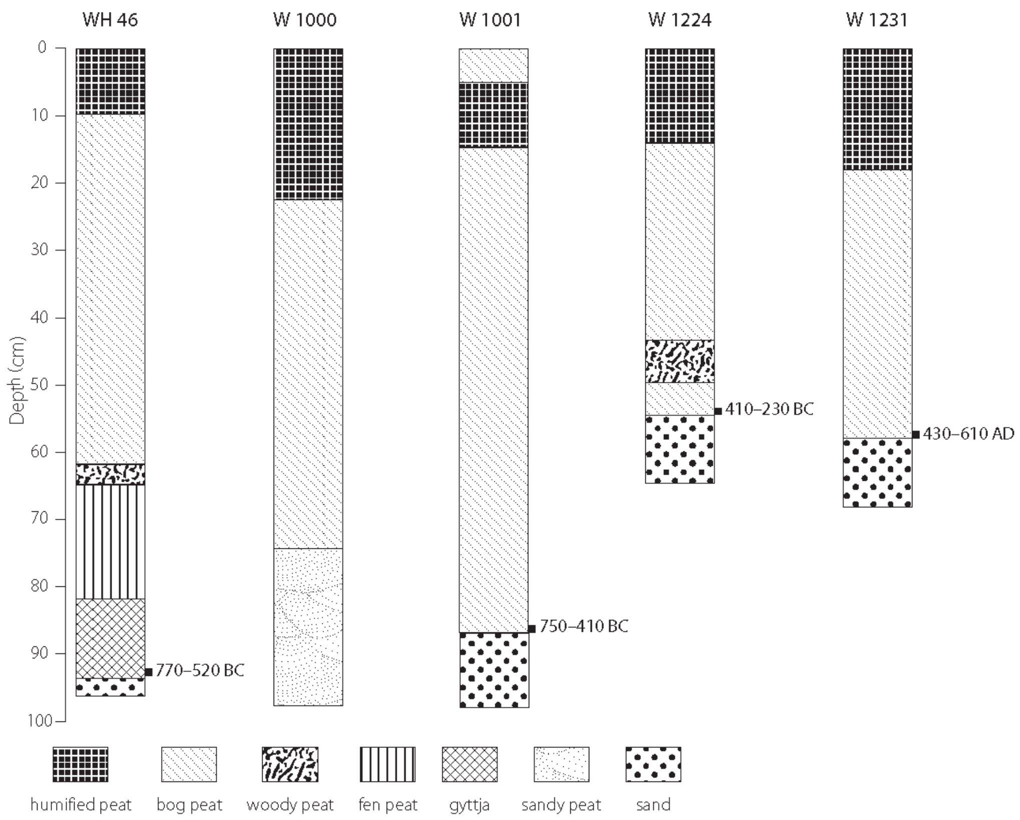
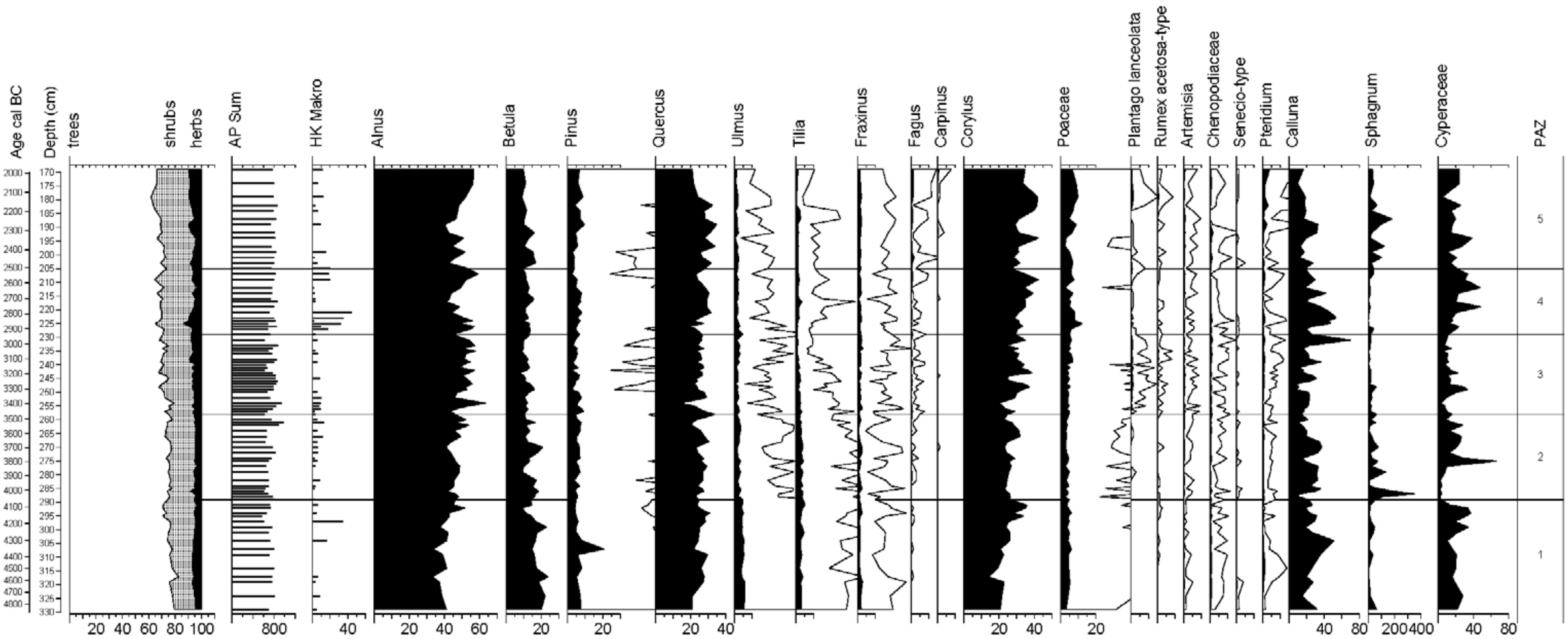
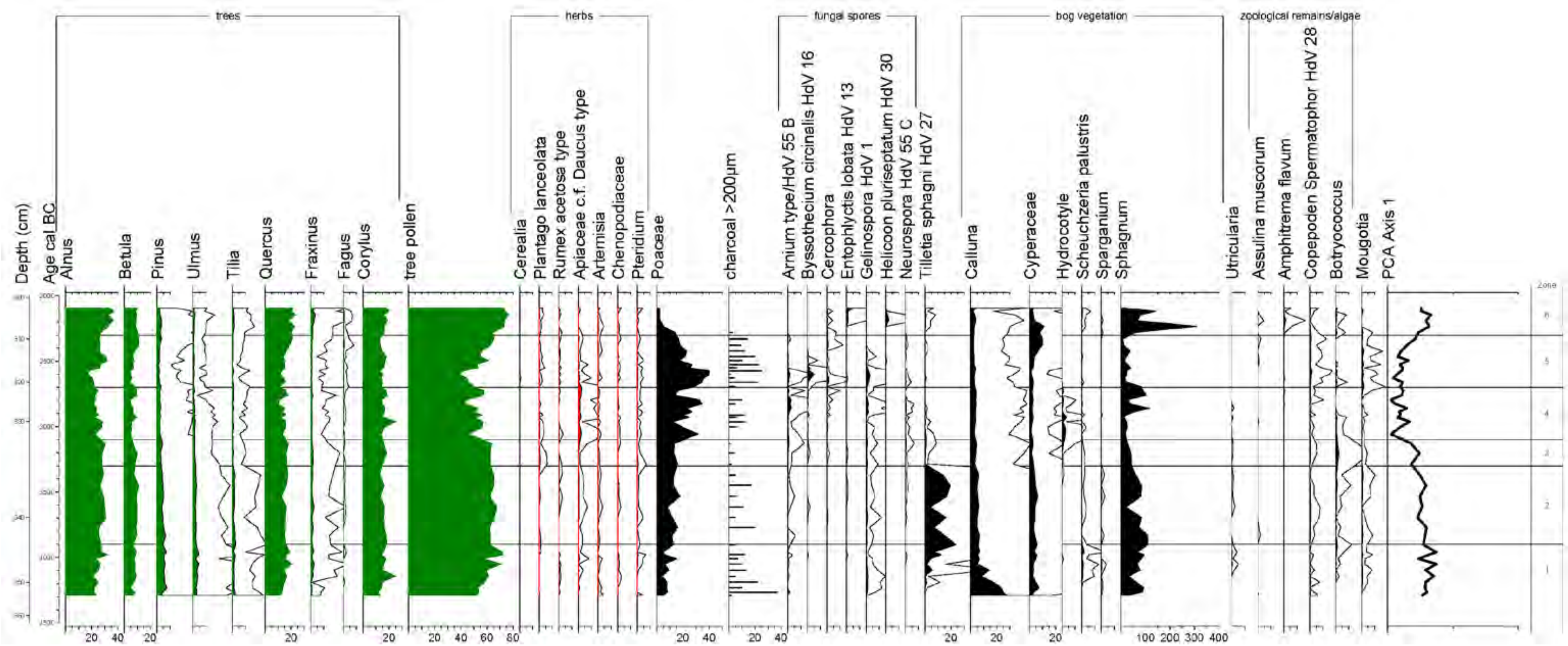


Fig. 6. Peat profiles from bogs covering megalithic tombs at Wanna. On the right of the profiles ^{14}C dates (Leibniz Labor Kiel) are given as calibrated ages (2-σ-range). Profiles are named according to the respective field sector number (WH: Wanhöden, W: Wanna). According to Nösler *et al. 2011, Fig. 13.*



Pollen profile Ahlen-Falkenberger Moor (AFM) Percentages base on AP sums (magnification tenfold)



Pollen and NPP profile “Huvenhoopsmoor” from Lavenstedt area. Percentages base on TTP (magnification tenfold)

Neolithic Settlement and Land Use History in Northwestern Germany – First Results from an Interdisciplinary Research Project

Annette Kramer, Moritz Mennenga, Daniel Nösler, Hauke Jöns, and Felix Bittmann

Zusammenfassung

Zur Klärung der neolitischen Siedlungs- und Landnutzungsgeschichte Nordwestdeutschlands werden umfangreiche archäologische und palynologische Untersuchungen im Rahmen des DFG-Schwerpunktprogramms: „Monumentalität und soziale Differenzierung – Zur Entstehung und Entwicklung neolithischer Großbauten und erster komplexer Gesellschaften im nördlichen Mitteleuropa" durchgeführt. Zahlreiche Großsteingräber, Grabhügel und Oberflächenfunde belegen die Siedlungstätigkeit der Trichterbecherkultur (Westgruppe) und der nachfolgenden Einzelgrabkultur im Untersuchungsgebiet. Trotz der Sichtbarkeit dieser Fundgruppen, ist bislang noch relativ wenig über die Siedlungsstruktur sowie die damalige Umwelt und Umweltentwicklung in Nordwestdeutschland während des vierten und dritten Jahrtausend vor Christus bekannt. Daher wurden fünf Kleinregionen beispielhaft ausgewählt, in denen eine gute Ausgangslage für die erfolgreiche Untersuchung des strukturalen Zusammenhangs zwischen Gräbern und Siedlungen, der chronologischen und räumlichen Muster der neolithischen Siedlungstätigkeit sowie des menschlichen Einflusses auf die Umwelt gegeben ist. Die Kleinregionen befinden sich alle in Niedersachsen auf Geestinseln des Elbe/Weser Dreiecks (Flögeln / Sievern, Wanna und Lavenstedt), auf dem Geestrücken des Hümmlings im Emsland und auf der Wildeshauser Geest.

Für die palynologischen Untersuchungen liegt nun mindestens ein Profil aus jeder der Regionen vor, das in den dort anzutreffenden Mooren geborgen wurde. Erste Analysen an verschiedenen Profilen zeigen Unterschiede im zeitlichen Verlauf und der Intensität des menschlichen Einflusses auf die Vegetation. Möglicherweise ist dies durch die unterschiedliche regionale Lage oder aber durch den Einfluss der verschiedenen Fundkategorien (Gräber oder Siedlungen), die sich in der Nähe der Bohrlokalität befinden, zu erklären.

Nach den Prospektionsmaßnahmen konzentrieren sich die archäologischen Untersuchungen vorrangig auf drei Kleinregionen. In der Wildeshauser Geest bei Holzhausen wurde während geomagnetischer Prospektionsarbeiten eine Struktur entdeckt, die als Hinweis Überreste eines Erdwerks gewertet werden könnte. Außerdem wurden zwei viel versprechende Siedlungsplätze in Sievern und Lavenstedt entdeckt. Die Lage der Siedlung in Lavenstedt bietet durch die Nachbarschaft zu mehreren neolithischen Gräbern hervorragende Bedingungen, um Fragen zu trichterbecherzeitlichen Siedlungsstrukturen zu klären. In Sievern deuten erste Datierungsergebnisse auf die bislang älteste entdeckte neolithische Siedlung in Nordwestdeutschland. Dies konnte auch durch Pollenanalysen und Radiokarbondatierungen an einem Torfprofil aus dem benachbarten Dorumer Moor bestätigt werden. Wir erwarten daher einen deutlichen Erkenntniszugewinn über den Prozess der Neolitisierung in Nordwestdeutschland.

Abstract

The Neolithic settlement and land use history in northwestern Germany is subject to detailed archaeological and palynological investigations that are carried out within the framework of the DFG priority program "Early Monumentality and Social Differentiation –the Emergence of Neolithic Monuments and Early Complex Societies in Northern Central Europe". Up to now, only little is known about the settlement structure and the environmental conditions and changes in northwestern Germany during the 4th and 3rd millennium BC, although various megalithic monuments, grave mounds as well as surface finds indicate that the area was settled by the West Group of the Funnel Beaker and the subsequent Single Grave Cultures. Therefore, five local research areas were selected that bear high po-

In: M. Hinz / J. Müller (Hrsg.), Siedlung, Grabenwerk, Großsteingrab. Studien zu Gesellschaft, Wirtschaft und Umwelt der Trichterbechergruppen im nördlichen Mitteleuropa. Frühe Monumentalität und soziale Differenzierung 2 (Bonn 2012) 317 – 336.

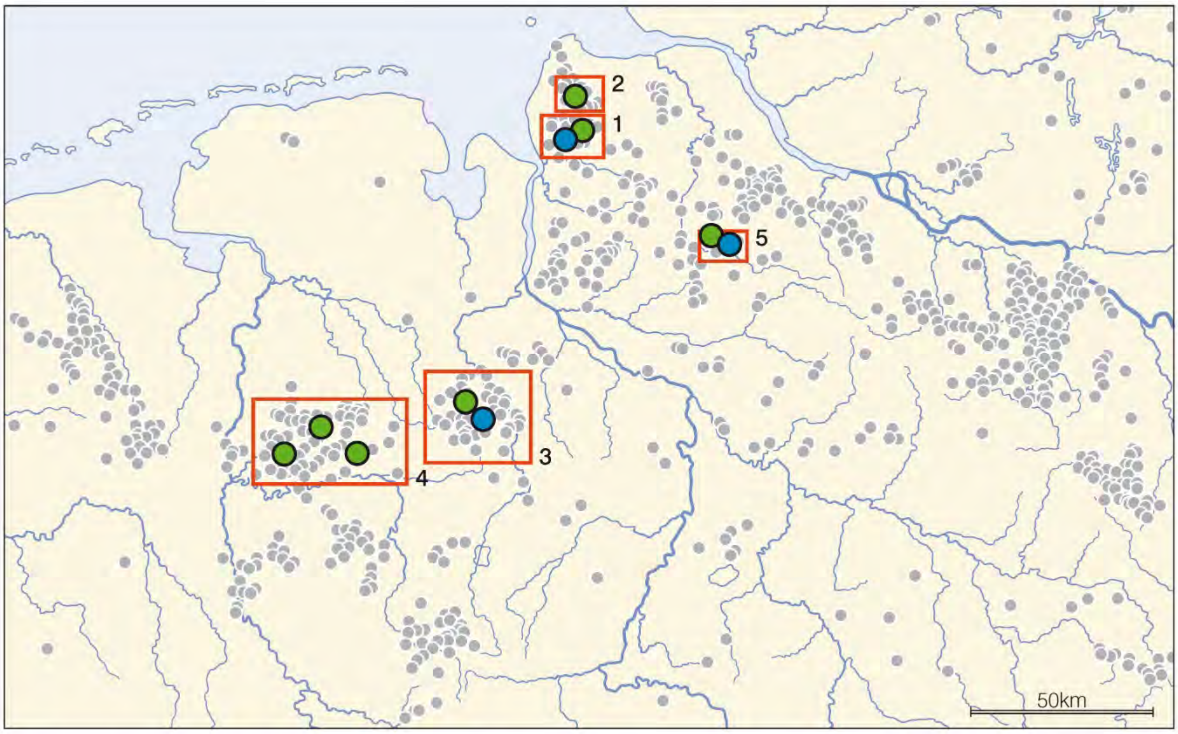


Fig. 1. Distribution of megalithic tombs in northwestern Germany. (according to Fritsch *et al. 2009, Fig. 1 with addenda). The local research areas are highlighted. 1 Area of Flögeln/Sievern; 2 Wanna; 3 Wildeshauser Geest; 4 Hümmling; 5 Lavenstedt. The megalithic tombs are indicated by grey circles, the investigated settlement sites by blue circles and recovered pollen profiles by green circles. Graphic modified according to* Nösler *et al. 2011, Fig. 1.*

tential for interdisciplinary investigations into the structural context between graves and settlements, the temporal and spatial patterns of the Neolithic occupation period, and on the human impact on the landscape. The research areas are located in the Elbe/Weser Triangle (Flögeln / Sievern, Wanna and Lavenstedt), in the Emsland (Hümmling) and the Wildeshauser Geest on sandy geest islands, all in the federal state of Lower Saxony.

At least one pollen profile from each local research area was recovered from bogs and fens to work on the landscape reconstruction of Northwestern Germany. First results imply differences in the chronological development and intensity of the human impact on the vegetation possibly depending on regional differences or on the profile's vicinity to different find categories like settlements or graves.

The archaeological investigations will focus on three of the local research areas where promising sites were identified. At Holzhausen in the Wildeshauser Geest, geomagnetic surveys generated a structure that might be evoked by remains of a causewayed enclosure. In addition, two promising TRB settlements were discovered at Sievern and Lavenstedt. The close connection of the settlement at Lavenstedt to various Neolithic tombs provides the opportunity for working on questions concerning TRB settlement structures. At Sievern, the site was yet dated to the oldest Neolithic settlement in Northwestern Germany which is supported by results from pollen analysis and radiocarbon dating of the profile from the neighbouring bog "Dorumer Moor". Therefore, we expect gain of knowledge about the Neolithic transition in the area.

Introduction

The research project "The Funnel Beaker Culture in Northwestern Germany" is embedded in the framework of the DFG priority program "Early Monumentality and Social Differentiation – the Emergence of Neolithic Monuments and Early Complex Societies in Northern Central Europe" (SPP 1400), first launched in 2008. The program is designed to work on unsolved questions about the origins and reasons for the establishment of monuments, such as megalithic tombs and causewayed enclosures, in order to shed light on the cultural context of Neolithic societies in Northern Europe since 4100 BC (compiled by Müller 2009; 2011).

In Northwestern Germany, the distribution area of the west group of the Funnel Beaker Culture (TRB) and the Single Grave Culture (EGK) is to be investigated. Several traces were left by both cultures in the areas between the Elbe and Ems rivers. The most prominent features are the numerous megalithic tombs that – at least partly – still shape today's landscape (Fig. 1). They have often been objects of scientific research as their architecture and distribution reveal regional differences in settlement intensities and land use. In addition, a few flat graves, hoards, and settlements with building features are known (complied by Assendorp 1999; Kossian 2005; Laux 1995; Strahl 1990), while no causewayed enclosures have yet been identified from the mentioned area (compiled by Richter 2002, 3 pp.).

Therefore, this setting is ideally suited for investigations into the Neolithic colonisation history of the 4[th] and the early 3[rd] millennia BC. The research project of the Lower Saxony Institute for Historical Coastal Research (NIhK) commences here. Within the project it is necessary to explore whether the rare TRB settlement features can be considered to be characteristic for this epoch and which settlement pattern might be presumed. Hence, the localisation and the extensive examination of well-preserved TRB and EKG settlements are of great significance (Nösler et al. 2011). The relationships between graves and coexistent settlements and the existence of hierarchical structures among single settlements and graves, respectively, are important topics that will be addressed within the examinations.

It is also of great importance to know which natural preconditions the Neolithic settlers had to deal with and which climatic and ecological changes they had to face. Palynological investigations will give insights into these developments. A number of further questions are to be investigated. For example, when was the TRB established on the Northwestern German Plain? From which cultures (Ertebølle, Swifterband, Rössen / Bischheim) did the TRB evolve? Which culture(s) influenced the TRB, and what reasons were crucial for this development? The transition from the TRB to the EGK, including when and why it took place, will also be analysed. The state of the art prior to the project's commencement and its first results shall be presented in the following.

Current State of Research

The landscape in Northwestern Germany is characterised by sandy moraines (geest), marshes, tidal flats and expansive swamps and bogs. While only few pottery and stone artefacts from the TRB and EGK were found in the marsh and on the tidal flats, most finds from this region were recovered on the sandy geest and the area that is nowadays covered with bogs. Bog growth started around 6000 BC. The expansion was triggered by the transgression of the North Sea resulting in more pronounced oceanic climate conditions (Behre 2005; Behre et al. 2001). Bog expansions successively displaced the closed mixed oak-lime forests that dominated the geest before the onset of the Neolithic. The higher geest areas became islands enclosed by bogs (cf. Behre / Kucan 1994). This development did not only causes changes in vegetation but possibly reduced the potential settlement area of the Neolithic inhabitants and overgrew graves and already established settlement sites (Behre 2005). In addition to the expansion of bogs, the landscape and vegetation were also shaped by the invention of husbandry. The elm decline, which is observed synchronously in Northwestern Germany, marks the transition to a Neolithic economy in the area. The decline was probably triggered by the elm disease – an Ascomycota infection – that is transferred by the elm bark beetle (*Scolytus scolytus*). The synchronous character of the decline points to further factors which may have promoted the spreading of the infection. It is assumed that human activity, such as cutting twigs for leaves, facilitated the establishment of the infection (cf. compilation Heider 1995, 91 f.).

Important insights into Neolithic vegetation history were inferred from the geest island of Flögeln (Behre / Kučan 1994). Within the archaeologically inspired project, ten kettle-hole bogs were examined to reconstruct the vegetation and settlement history of the area. The detailed palynological analyses suggest a first moderate influence on the vegetation that was later more pronounced. Behre and Kučan (1994) assume that the subsistence strategy of the first Neolithic people focused on animal husbandry. They interpreted the elm decline and high total tree pollen as well as low grass pollen as indicators of leaf fodder management, while wood pasture was excluded. This subsistence strategy is still found today in some regions in the Alps, the Black Forest and the Mediterranean. Alternative interpretations of the consequences of human impact on vegetation are currently under debate, considering that forest clearance as an effect of wood pasture is difficult to evaluate from palynological data (cf. Groenman-van Waateringe 1993; Kreuz 2008).

A marked interference of humans on vegetation is evidenced, on the one hand, by declining tree pollen

Veget Hist Archaeobot (2014) 23:461–478
DOI 10.1007/s00334-013-0409-z

ORIGINAL ARTICLE

New insights into vegetation dynamics and settlement history in Hümmling, north-western Germany, with particular reference to the Neolithic

Annette Kramer · Felix Bittmann · Daniel Nösler

Received: 2 October 2012 / Accepted: 6 June 2013 / Published online: 10 July 2013

Abstract Palynological investigations on two well-dated peat profiles provide insights into Neolithic vegetation and settlement history from Hümmling in north-western Germany. The site selections allow comparisons between local and regional vegetation changes and are used to estimate the extent of Neolithic influence on the vegetation. The interpretation of the fossil spectra relied on radiocarbon dating, evaluation of pollen indicator taxa, non-pollen palynomorphs and multivariate techniques. During the late Mesolithic the vegetation was dominated by mixed oak forests while openings in forest cover were detected, with a decline in elm reflected in the regional pollen record around 4250 cal. B.C. The presence of humans is shown by settlement indicators that are first recorded at ca. 3800 cal. B.C. Vegetation changes were small between 4300 and 3600 cal. B.C. This suggests that regional vegetation was relatively resilient to small-scale disturbances. Possible indications of grazing were recorded in the spectra of the local pollen profile but there is no clear-cut evidence for Neolithic activity. Between 3520 and 2260 cal. B.C. decreases in forest cover were inferred from both profiles and increases in settlement indicators reflect farming activity. These changes coincide with the emergence in the area of the Funnel Beaker Culture and the subsequent Single Grave Culture. Both profiles suggest that settlement probably ceased between ca. 3230 and 3050 cal. B.C. This lull or cessation in activity was probably regional in character. After 2260 cal. B.C. human impact on the vegetation decreases and woodlands regenerate. The longevity of the regeneration phase—ca. 690 years—was probably connected with the low resilient capability of the vegetation on the poor soils.

Keywords Neolithic · Pollen analysis · Human impact · Northern Germany · Funnel Beaker Culture · Single Grave Culture

Communicated by M. O'Connell.

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Introduction

Today, the Hümmling, an old morainic ridge in the Emsland, is characterised by cultivated land and parcels of semi-natural mixed oak–birch forests. This is largely the result of prolonged farming activity. Farming was introduced by Neolithic settlers in northern Germany ca. 4100 cal. B.C. (Kalis and Meurers-Balke 1998; Hartz et al. 2000; Müller et al. 2010) while intensification of farming took place between ca. 3600 and 3400 cal. B.C. during the phase of megalithic tomb construction (Hartz et al. 2007; Kirleis et al. 2012). The megalithic tombs of the Hümmling are assignable to the west group of the Funnel Beaker Culture (Trichterbecherkultur, TRB), the earliest Neolithic culture known from north-western Germany. These peoples occupied the area during the middle Neolithic (EN II–MN V according to the Northern European Plain chronology) between 3400 and 2800 cal. B.C. and were subsequently displaced by representatives of the Single Grave Culture (SGC;

ca. 2800–2200 cal. B.C.) (Brindley 1986; Müller et al. 2010). Little is known about the Neolithic peoples who settled in Hümmling and the way they used and influenced their environment. Limited information about settlement pattern, houses and related features is provided by investigations on a few domestic sites (Nösler et al. 2011). Macrobotanical data from domestic sites that might be expected to contribute to our knowledge of subsistence strategies are hence scarce. Most of the available information from the wider region relates to the Elbe-Weser area where charred cereal remains, mainly *Hordeum vulgare*, *Triticum dicoccum* and *T. monococcum*, have been recorded in the TRB settlement Flögeln (ca. 3050 cal. B.C., details in Behre and Kučan 1994).

The present perception of the Neolithic in north-western Germany differs from that in neighbouring regions such as the Netherlands and Schleswig–Holstein in that these regions have evidence for Neolithic cultures that predate the middle Neolithic (Raemaekers 1999; Out 2009, 2012; Out and Verhoeven 2013; Hartz et al. 2007; Müller et al. 2010). This is not easily explained given that present-day political boundaries can have had no bearing on these prehistoric cultural developments (Raemaekers 2013). Preservation may be important insofar as the sandy soils of north-western Germany do not favour preservation or indeed detection of Neolithic sites (Nösler et al. 2011). The study of vegetation change as detected by pollen analysis, on the other hand, can be a powerful tool in that pollen data give clear insights into human impact and especially farming activity (Behre and Kučan 1994; Kalis and Meurers-Balke 1998; Bakker 2003). Palynological investigations to date in the Emsland, however, have rather poor sample resolution and chronological control is often inadequate or indeed unsatisfactory (Koch 1934; Jonas 1935, 1941, 1943; Kramm 1981) and so the available data are insufficient to enable a critical and reliable reconstruction of early prehistoric farming impact. Investigations at the Dümmer Lake, ca. 60 km to the south-east, show early human impact in connection with archaeological finds at the settlement site Hüde I and a wooden trackway dated to ca. 4800 cal. B.C. (Schütrumpf 1988; Bauerochse 2003; see Kampffmeyer 1991 for further consideration of the function and chronology of the site). Detailed palynological investigations in the Elbe-Weser area (Dörfler 1989; Behre and Kučan 1994; Heider 1995) have provided evidence for Neolithic settlement periods that parallel trends observed in other parts of northern Europe (Troels-Smith 1954; Iversen 1941; Rasmussen 2005; Wieckowska et al. 2012) though here also some aspects of the chronology might be further refined. These investigations show the crucial importance of short distances between coring location and Neolithic settlement sites for the reflection of human activity in pollen spectra (Behre and Kučan 1986).

In this study, two well-dated peat pollen profiles from Hümmling are presented with a focus on reconstructing Neolithic impact. Holschkenfehn, that is expected to reflect mainly local vegetation development and farming activity, was selected because of its close proximity to several megalithic tombs and two possible settlement sites (Fig. 1c). The pollen profile from Bockholter Dose, on the other hand, is expected to provide information on vegetation development and Neolithic impact at a regional level.

Study sites

Hümmling, the study area, is in Emsland, Lower Saxony, between the river Ems and its tributaries Hase and Ohe (Fig. 1). The landscape is largely defined by an east–west orientated morainic (*Geest*) ridge formed during the Saale, i.e. the penultimate glaciation (Hauschild and Lüttig 1993). The landscape is also influenced by later geological

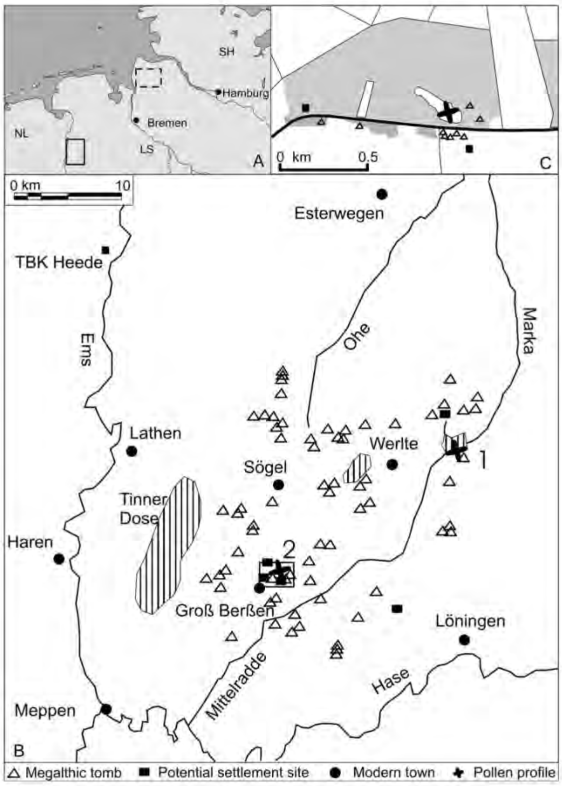

Fig. 1 Maps relating to the study area and the wider region: **a** overview of north-western Germany showing location of the study area and Flögeln (indicated by *rectangles* with *non-dashed* and *dashed* boundaries, respectively). NL, Netherlands; LS, Lower Saxony; SH, Schleswig–Holstein: **b** map of Hümmling showing main features including relevant archaeological sites. Hatching indicates present-day bog distribution. *1* Bockholter Dose, 2 Holschkenfehn; **c** Detailed map of sampling site Holschkenfehn. *Grey shading* indicates afforestation. Mapping of megalithic tombs and settlement sites based on current knowledge based on ongoing research

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Settlement and Coastal Research in the Southern North Sea Region (SCN)

The Funnel Beaker period settlement Lavenstedt 178, district of Rotenburg (Wümme)

Die trichterbecherzeitliche Siedlung Lavenstedt 178, Ldkr. Rotenburg (Wümme)

Moritz Mennenga

With 3 Figures

Abstract: This article presents the first results of archaeological investigations of the Funnel Beaker period settlement Lavenstedt 178, district of Rotenburg (Wümme). Apart from an occupation layer containing a large amount of finds, a well and the ground-plan of a house belonging to this period were recorded in the course of the excavations. For Northwest Germany this provides the first opportunity to obtain information not only about building structures but also about activities and infrastructural installations.

Key words: Lower Saxony, Lavenstedt, Neolithic, Funnel Beaker Culture, Settlement, House construction, Well.

Inhalt: Im folgenden Beitrag werden die ersten Ergebnisse der archäologischen Untersuchungen der trichterbecherzeitlichen Siedlung von Lavenstedt 178, Ldkr. Rotenburg (Wümme), vorgestellt. Bei den Ausgrabungen konnten neben einer Kulturschicht mit einer großen Menge an Fundmaterial auch ein Brunnen und ein Gebäudegrundriss dieser Zeitstellung dokumentiert werden. Damit ist hier zum ersten Mal für Nordwestdeutschland die Möglichkeit gegeben, neben Gebäudestrukturen auch Informationen über Aktivitäten und infrastrukturelle Einrichtungen zu gewinnen.

Schlüsselwörter: Niedersachsen, Lavenstedt, Neolithikum, Trichterbecherkultur, Siedlung, Hausbau, Brunnen.

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1 Introduction

Like numerous landscapes of western Central Europe, the cultural landscape between the rivers Elbe and Weser (Elbe-Weser Triangle) is still characterised by the monumental structures of the Funnel Beaker Culture (TBK), even though their construction dates back more than 5000 years. Only a fraction of the erstwhile number of graves remains visible above ground; these instances are impressive representations of Neolithic monumental structures. Not least for this reason, the study of these structures has been a mainstay of Central European prehistoric archaeology from the 19th century onwards; however, it is only within the scope of the German Research Foundation Priority Programme 1400 'Early Monumentality and Social Differentiation' (Deutsche Forschungsgemeinschaft, Schwerpunktprogramm 1400 „Frühe Monumentalität und soziale Differenzierung") that, for the first time, an integrated study examines all aspects surrounding the Funnel Beaker Culture.

It is intended not only to investigate the monumental architecture of the Funnel Beaker Culture, but to paint a comprehensive picture of Neolithic life and culture. This task is pursued through a cooperation of 22 university institutes, archaeological state services and research institutions. The study of the lives and environments of the builders of the megalithic tombs will not merely be confined to site specific consideration of settlements, enclosures, graves and ritual structures of this period; there will be an equal focus on communication-, population- and social structures as well as climatic change and landscape development. This demonstrates the extensive range of the Priority Programme and the opportunity it offers for the study of the period around the 4th millennium BC (further information on the Priority Programme under www.schwerpunkt-monumente.de/en/).

The Lower Saxony Institute for Historical Coastal Research (Niedersächsisches Institut für historische Küstenforschung [NIhK]) is host to two of the programme's research projects. Katrin Struckmeyer is studying pottery from sites all over Northern Europe in order to demonstrate 'Traditions, technologies and communication structures of the potter's craft' (Nösler et al. 2012; see Katrin Struckmeyer, this volume).

The second project concentrates on the investigation of 'Settlement and landuse in Northwest Germany'. Like the entire Priority Programme, this project has been planned as an interdisciplinary project from the outset, combining the disciplines of archaeology and palynology. As a model for Northwest Germany, the projects aim to demonstrate the structural interdependencies between site assemblages from graves and settlements in several sub-regions such as Flögeln, Hümmling, Lavenstedt, Wanna, Wildeshauser Geest and to examine the effects of changes in economic activity on the landscapes.

From an archaeological perspective, settlement history is prioritised. To this day, our knowledge of Funnel Beaker Culture settlement and house construction still remains scant in many regions. At present, most ground-plans of houses dating to the Early and Middle Neolithic periods are known from Southern Scandinavia. Some 100 ground-plans of houses have been excavated there; however, they do not solely belong to the Funnel Beaker Culture (Artursson et al. 2003; Müller 2013, 262). On the basis of these findings it is, nonetheless, possible to draw conclusions about the settlements' structural organisation and to compare the various house types (cf. Artursson et al. 2003).

In contrast to this, such studies have not yet progressed beyond initial stages in Northwest Germany, which is part of the settlement area of the Funnel Beaker West Group. This is predominantly owed to the circumstance that ground-plans of houses have only been found at a small number of sites. In many cases, settlements have only been located through surface scatters of diagnostic stone tools or pottery sherds, while upon excavation structural features, in most instances, are no longer extant or recognisable.

From the area of the Funnel Beaker West Group sensu Bakker (1979, 11), only eight sites have so far yielded ground-plans of habitation structures indicative of Funnel Beaker Culture occupation (Nösler et al. 2011; Jöns et al. 2013; most recently Müller 2013; Raemaekers 2013, 121). However, these sites have been published in rather diverse form and to varying levels of completeness, which complicates comparison of structural history or analysis of settlement structure. The problem is compounded by the fact that the finds assemblages from some sites remain unpublished to this day. In many instances, preservation conditions even preclude certainty in assigning the usually large numbers of finds to the frequently small number of features.

Sites with houses of the TBK West Group have been found at Bouwlust, Prov. Noord-Holland (NL) (Raemaekers 2013, 121); Engter, district of Osnabrück (Rost & Wilbers-Rost 1992); Flögeln, district of Cuxhaven (Zimmermann 2000); Heek, district of Borken (Finke 1990), Hunte, district of Diepholz (Kossian 2005); Pennigbüttel, district of Osterholz-Scharmbeck (Assendorp 2000); Visbek, district of Vechta (Mennenga et al. 2013); and finally Lavenstedt, district of Rotenburg (Wümme), which will be considered further below.

A similar picture emerges from the neighbouring settlement regions of the TBK North- and Altmark Groups, respectively, where only isolated house remains have been recorded so far. Sites include Rullstorf, district of Lüneburg (Gebers 2004); Wittenwarter, district of Uelzen (Voss 1965); Oldenburg-Dannau (Hoika 1981, 55) and Hobbersdorf (Hingst 1990, 38), both district of Ostholstein; Hemmingstedt, district of Dithmarschen (Krause-Kyora 2007, 16); Büdelsdorf, district of Rendsburg-Eckernförde (Hage in prep. after Müller 2013, 262) and Rastorf, district of Ostholstein (Steffens 2009, 29).

Buildings with wall foundation trenches, known from the sites at Flögeln, Pennigbüttel and Visbek, can be considered a typical feature of the TBK West Group. So far they appear to be most common in the region of Northwest Germany, although this cannot be substantiated statistically due to the small overall number of excavated ground-plans. These two-aisled houses have a rectangular or trapezoid ground-plan, occasionally with partition walls dividing the interior into separate rooms. The wall posts were sunk into the foundation trenches. However, there are also other types of construction, as for instance in the above mentioned cases of the ground-plans from Wittenwarter, Rullstorf and Engter which feature a classic post built structure (Kramer et al. 2012, 321).

The current state of knowledge about the West Group is largely owed to the poor preservation conditions for Neolithic features. The soils in the areas of the sandy moraines (*Geest*) have been transformed by long-lasting soil formation processes, such as the development of podsols or brown earths; consequently, features dating to the Funnel Beaker period can now only rarely be identified, or they have already been transformed completely. The currently known buildings with wall foundation trenches were mainly discovered below natural or anthropogenic colluvial layers which afforded sufficient protection from soil formation processes. Visbek was protected against such influences by a substantial Plaggen soil (Mennenga et al. 2013), Pennigbüttel by deposits of sand (Assendorp 2000) and Flögeln by sedimentation through soil creep along a slope (Zimmermann 1980, 480-481). However, no Neolithic occupation layers have yet been discovered at any of these sites.

To redress these research lacunae, archaeological work in the above mentioned sub-regions focussed on the search for sites with both structural remains and occupation layers, which would allow inferences about the internal structure and, thereby, life in these settlements. Within the same parameters the project's palynological side concentrated on the study of the pollen archives of the sites' environs in order to facilitate direct comparison between the analyses of landscape and settlement.

2 Lavenstedt 178

One of these sub-regions, which has been the focus of archaeological research for several years, is the sub-region of Lavenstedt in the district of Rotenburg (Wümme), located between Hamburg and Bremen. In this sub-region there are megalithic tombs, some no longer extant (Nösler et al. 2011, 34), as well as flat graves and barrows of Neolithic date (Deichmüller 1969; Tempel 1984). Among the best-known sites from the sub-region is the Lavenstedt flat grave, located about 1 km to the west of the excavated settlement (Deichmüller 1969). However, there is also evidence for settlements of the Funnel Beaker Culture, although

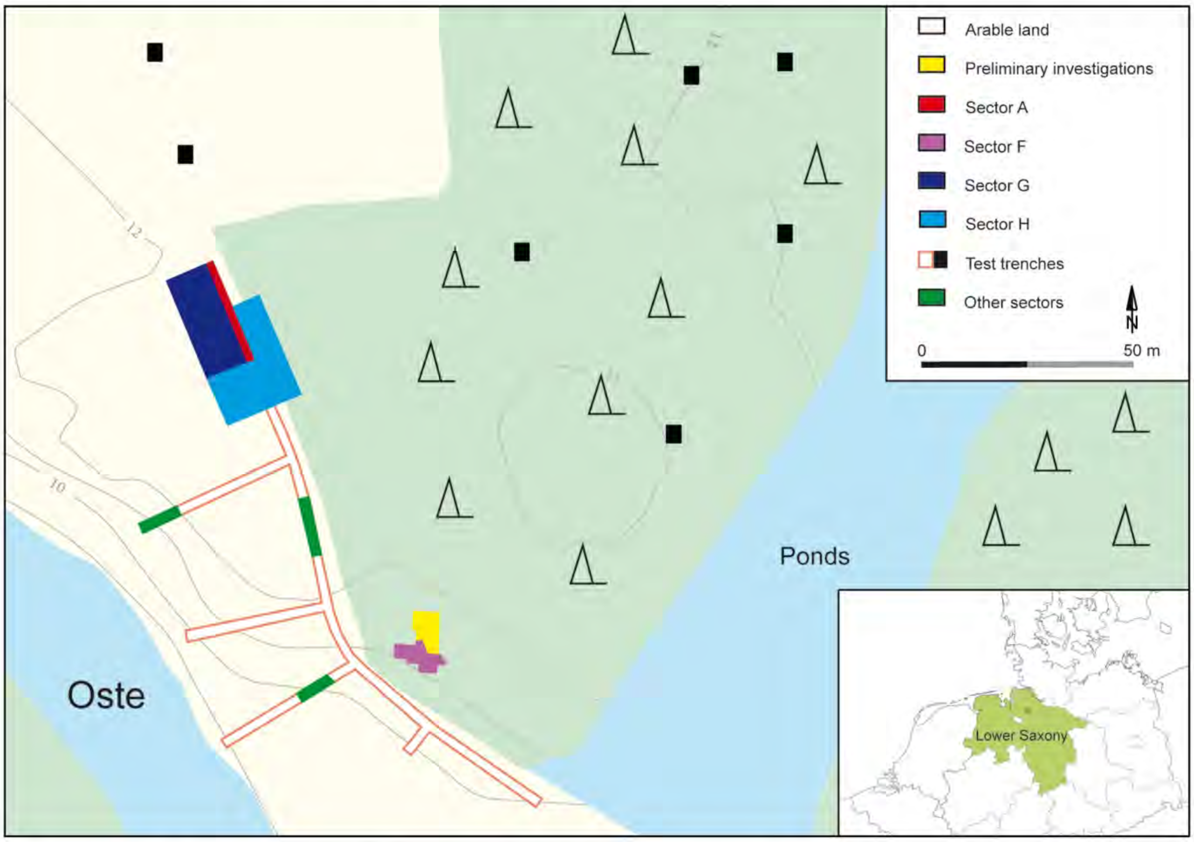
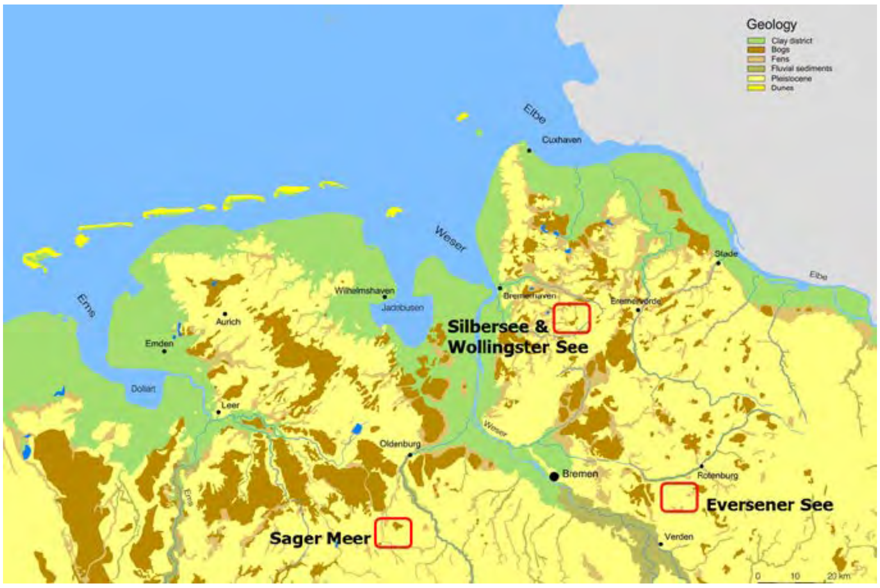


Fig. 1. Lavenstedt 178, district of Rotenburg (Wümme). Location of excavation areas and sondages (Graphics: M. Mennenga).

3

The effects of prehistoric land-use on lake systems and their catchment areas in north-western Germany

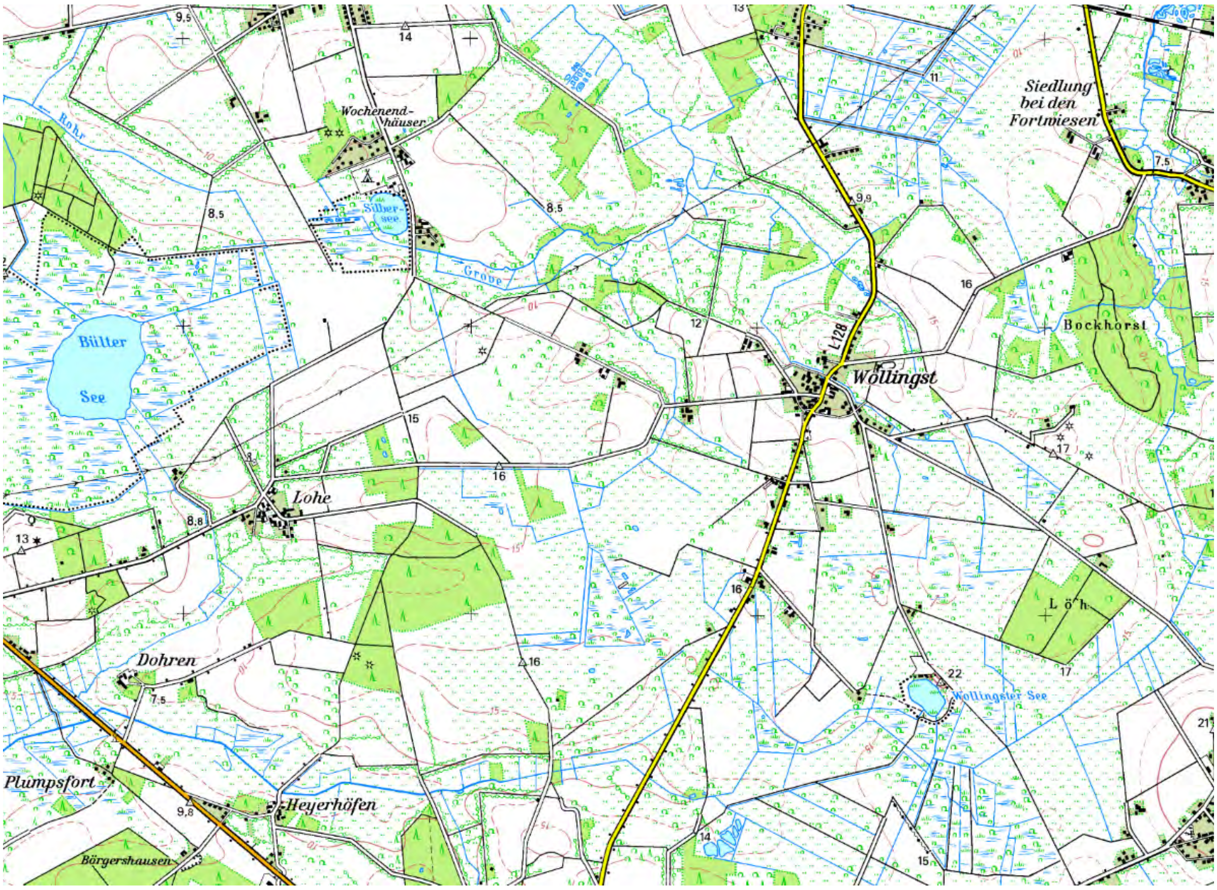
Here we apply a multi-proxy approach on four Northwest German lakes. The origin of these morphologically similar lakes are most likely related to subrosion processes. They are situated in a rather uniform macro-landscape but differ in their ecological setting and their specific settlement history. We use sedimentological and geochemical parameters (e. g. element concentrations and stable isotopes) as well as biological proxies (pollen, macro fossils and diatoms) to investigate environmental changes in the lake systems and their catchment areas. We specially focus on anthropogenically induced changes of the water quality, e. g. eutrophication and acidification as well as natural regeneration during phases of weaker impact of land use. Archaeological surveys in the vicinity of the lakes provide a detailed record on the prehistory of the landscapes investigated. Sedimentation in the lake basins started during the Late Glacial and early Postglacial and thus also allows documenting the pre-anthropogenic status of the lake systems.



The lake sediments reflect prehistoric land-use in north-western Germany back to Neolithic times in a rather diverse pattern. The geochemical evidence of human impact is only discernible in one lake, where records of terrigenic elements K and Ti exhibit distinct peaks as result of increased soil erosion caused by logging activities. We explain this exclusive record with the specific topography of that lake. The most prominent palynological feature is the proof of Medieval hemp retting in two lakes (Cannabis-type >30% TTP), whereas the widespread contemporaneous rye cultivation is reflected in all lakes only by relatively low values. Land-use had a long lasting effect on the lakes’ trophic states not until Medieval times. Until then the lakes seem to have been insensitive to catchment disturbances or reacted only with short term changes in their trophic states.

Our efforts to construct robust age-depth relationships based on AMS 14C-dates of terrestrial plant macrofossils reveal a specific dating issue of Northwest German lakes. Especially in younger sediments we observe 14C-dates which are on the one hand too old and on the other hand among themselves roughly contemporaneous. We explain this feature with extensive bog growth since Neolithic times which eventually reached the lake shores. Successive erosion of the bog margins caused the observed contamination of lacustrine sediments with older material.

Wollingster See



Topographic map of the area around Wollingster See und Silbersee

Mitt. AG Geobot. Schleswig-Holstein u. Hamburg **57**, 17-27, Kiel 1998

Die Entstehung und Entwicklung des Wollingster Sees und seiner Ablagerungen.

- J. Merkt & A. Kleinmann, Hannover -

Zusammenfassung

Der Wollingster See ist eine im Weichselglazial entstandene große Pingo-Narbe. Das folgt aus der Lage und dem Aufbau des an den See angelehnten Seebergs, aus der Morphologie des Beckens, aus dem vorhandenen Randwall und der Natur der älteren Beckenfüllung, die aus weichselzeitlichen Schluffen und Tonen aus aufgearbeitetem elsterzeitlichen Lauenburger Ton besteht, der durch den Eiskern des Pingos angehoben worden war. Die holozäne organische Mudde ist 9 m mächtig. Die häufigen Sandlagen während der letzten 8000 Jahre sind teilweise äolisch. In den spätglazialen Ablagerungen von 1 m Mächtigkeit sind vom Meiendorf bis zur Jüngeren Tundrenzeit alle Zeitzonen repräsentiert. Erstmals in einem nordwestdeutschen See sind die Bölling-zeitlichen Ablagerungen gewarvt. 250 ± 20 Jahreswarven wurden gezählt.

Abstract: Origin and development of lake Wollingst and its sediments

Lake Wollingst is a big pingo scar, formed during the Weichselian glaciation. This is evidenced by the position of the Seeberg adjacent to the lake, the morphology of the basin, the existence of a rampart and the nature of the older sediments: weichselian lacustrine silt and clay from reworked elsterian Lauenburger Ton, which had been lifted by the ice of the pingo core. The holocene organic mud is 9 m thick and monotonous, apart from frequent sandy streaks which are in part of eolian origin. The Lateglacial section encompasses in 1 m the complete suite of biozones from the Meiendorf to the Younger Dryas. The sapropelic mud of the Bölling period consists of 250 ± 20 varves which is unique in NW-Germany.

1 Lage, Geologie der Umgebung, Methoden

Der Wollingster See (300 x 180 m, ca. 14,5 m tief) liegt in Wasserscheide-Position bei ca. 15,3 m NN neben dem Seeberg, der sich 7 m über den See erhebt. Während der See in eine Ebene eingetieft ist, die aus Geschiebelehm besteht, ist der Seeberg aus horizontal geschichtetem Schmelzwassersand aufgebaut, der den Geschiebelehm überlagert. Das Nebeneinander von See und Seeberg ist zu ungewöhnlich und zu eng, um als Zufallsprodukt erklärt zu werden. Jede Erklärung der Genese hat darauf Rücksicht zu nehmen.

In der Umgebung des Wollingster Sees bis in Ufernähe sind durch LADE (1974, 1979) eine größere Anzahl tieferer Sondierbohrungen und mehrere auf einem Profilkreuz angeordnete maschinelle Bohrungen (bis ca. 30 m) niedergebracht. Insofern ist der Aufschlußstand besser als gewöhnlich. Unmittelbar am SW-Rand des Sees steht ferner eine 279 m tiefe hydrogeologische Aufschlußbohrung. Dort folgen über 200 m miozänen tonigen Schluffen, denen zum Hangenden Feinstsand beigemengt ist, 20 m (80-60 m unter Gelände = u.G.) pleistozäne feinsandige Feinstsande, gelegentlich mit mittelsandigen Lagen, 5 m (60-55 m u.G.) feinsandiger bis grobsandiger Mittelsand, 14 m (55 - 41 m u.G.) feinsandiger Mittelsand mit etwas Grobsand. Diese Schmelzwassersande werden von 16 m (25-41 m u.G.) grauem, tonigem Schluff, dem elsterzeitlichen Lauenburger Ton, überlagert, der zum Hangenden feinsandige Lagen enthält. 20 m (25-5 m u.G.)

Mitt. AG Geobot. Schleswig-Holstein u. Hamburg **57**, 44-52, Kiel 1998

Palynologische Untersuchung eines Sedimentprofiles aus dem Wollingster See

- Helmut Müller & Angelika Kleinmann, Hannover -

Kurzfassung

Im Hangenden der weichsel-pleniglazialen Sedimente konnten bei der palynologischen Untersuchung eines Sedimentprofils aus dem Wollingster See die Ablagerungen der spätglazialen Warmzeiten Meiendorf, Bölling und Alleröd sowie des frühholozänen Friesland-Thermomer nachgewiesen werden. Im Holozän lief in der Seeumgebung die auf armen Altmoränenboden NW-Deutschlands typische Waldsukzession ab. Nach Birken und Kiefern folgte im Boreal die Ausbreitung der Hasel, der Eichen und Ulmen, im Atlantikum der Erlen, Linden und Eschen. Buchen und Hainbuchen erreichten das Untersuchungsgebiet im Subboreal, breiteten sich wegen der armen Böden aber erst nach der Eisenzeit stärker aus. Den Charakter eines Urwaldsees verlor der Wollingster See im Laufe der mittelalterlichen Rodung. Der See war seit seiner Entstehung im ausgehenden Pleniglazial ein oligotrophes Gewässer. Dieser Zustand wurde erst nach der mittelalterlichen Rodung, vor allem im Zusammenhang mit Hanf- und Flachsrotten, erheblich verändert. Die Sedimente der Neuzeit liegen im Profil völlig gestört vor. Sie weisen einen hohen Gehalt an umgelagertem Material, an Blaualgen und an Resten des hier Eutrophie anzeigenden Elefantenkrebschens *Bosmina longirostris* auf.

Abstract: Palynological Study of a Sediment Core from Lake Wollingst

A palynological study of a 15 m sediment core from the centre of Lake Wollingst (water depth 14.5 m) is presented. The pollen record shows 3 lateglacial thermomers, called Meiendorf, Bölling, Allerod and the early holocene Friesland-Thermomer. The succession of forest vegetation taking place on the lake surroundings during the Holocene was typical for older moraine soils which are poor in nutrients: forest vegetation started with birch and pine, followed by hazel, oak and elm in the Boreal and by alder, lime and ash-tree in the Atlantic. Beech and hornbeam reached the area during Subboreal. However, due to the poor soils they spread out only after the Iron Age. With the deforestation during the medieval time the lake lost its character of a primeval forest lake. Lake Wollingst was oligotrophic since its origin at the end of the Pleniglacial. After medieval forest-clearing the lake has changed its quality of water particularly in connection with hemp- and flax-rotting. The modern sediments in this profile are completely disturbed. They contain reworked material, a lot of blue-green algae and remains of *Bosmina longirostris* indicating eutrophic conditions.

1 Einführung

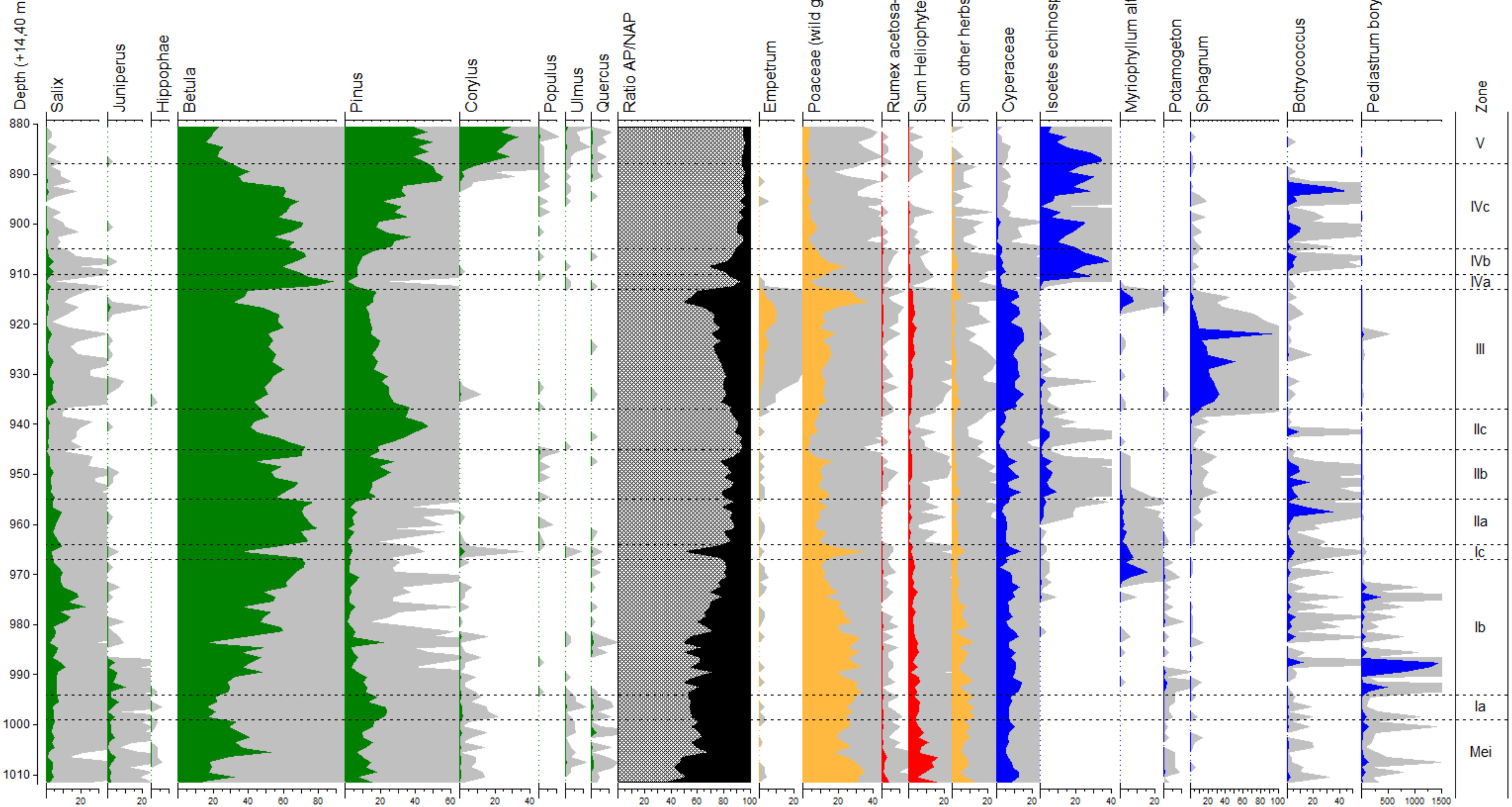
Seit den 30-er Jahren ist die Frage nach der Entstehung des Wollingster Sees mit der weit und breit einzigen Anhöhe direkt am NE-Ufer, dem Seeberg, immer wieder Gegenstand von Untersuchungen gewesen, die keine abschließende Antwort erbrachten.

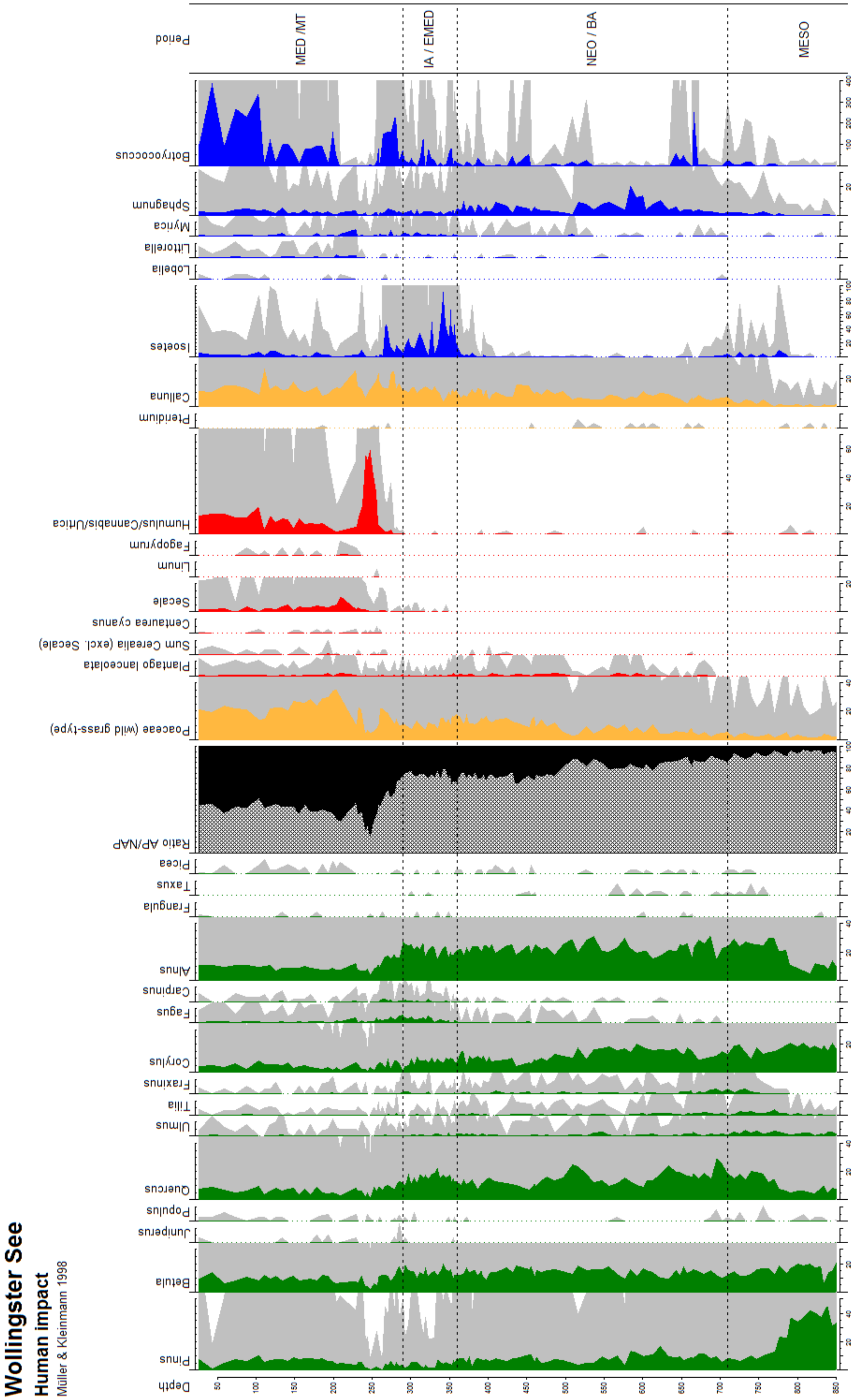
Auch eine erste 1976 von U. LADE und J. MERKT niedergebrachte Bohrung in dem See konnte die Genese und Entwicklung des Sees nicht endgültig klären; dabei untersuchte K.-E. BEHRE 8 über diese Bohrung verteilte Proben auf ihren Pollengehalt und konnte 3 Proben dem jüngeren Subboreal, dem älteren Atlantikum und dem älteren Boreal zuordnen; die restlichen 5 älteren Proben ließen sich wegen schlechter Pollenerhaltung nicht sicher datieren (LADE 1979). Eine

Wollingster See

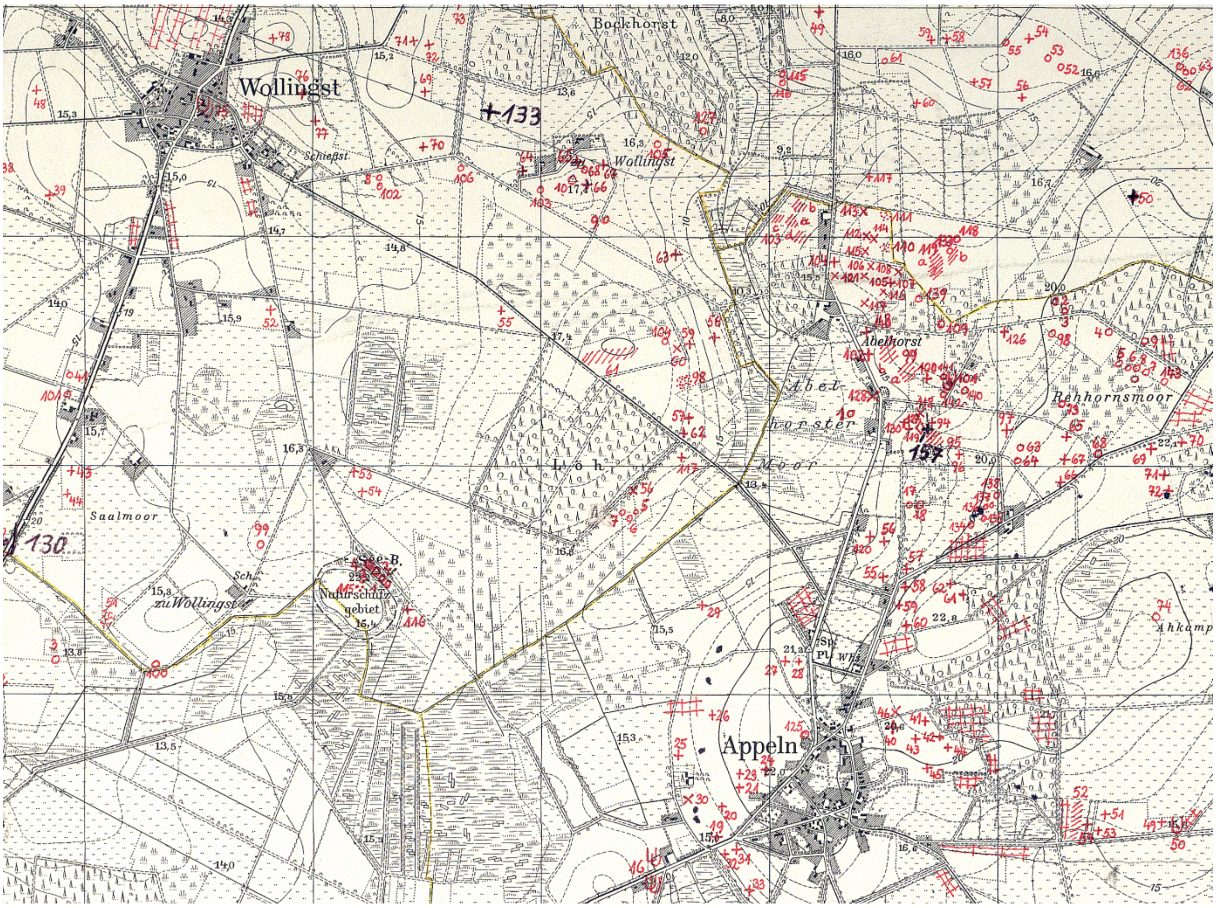
Late Glacial

Müller & Kleinmann 1998



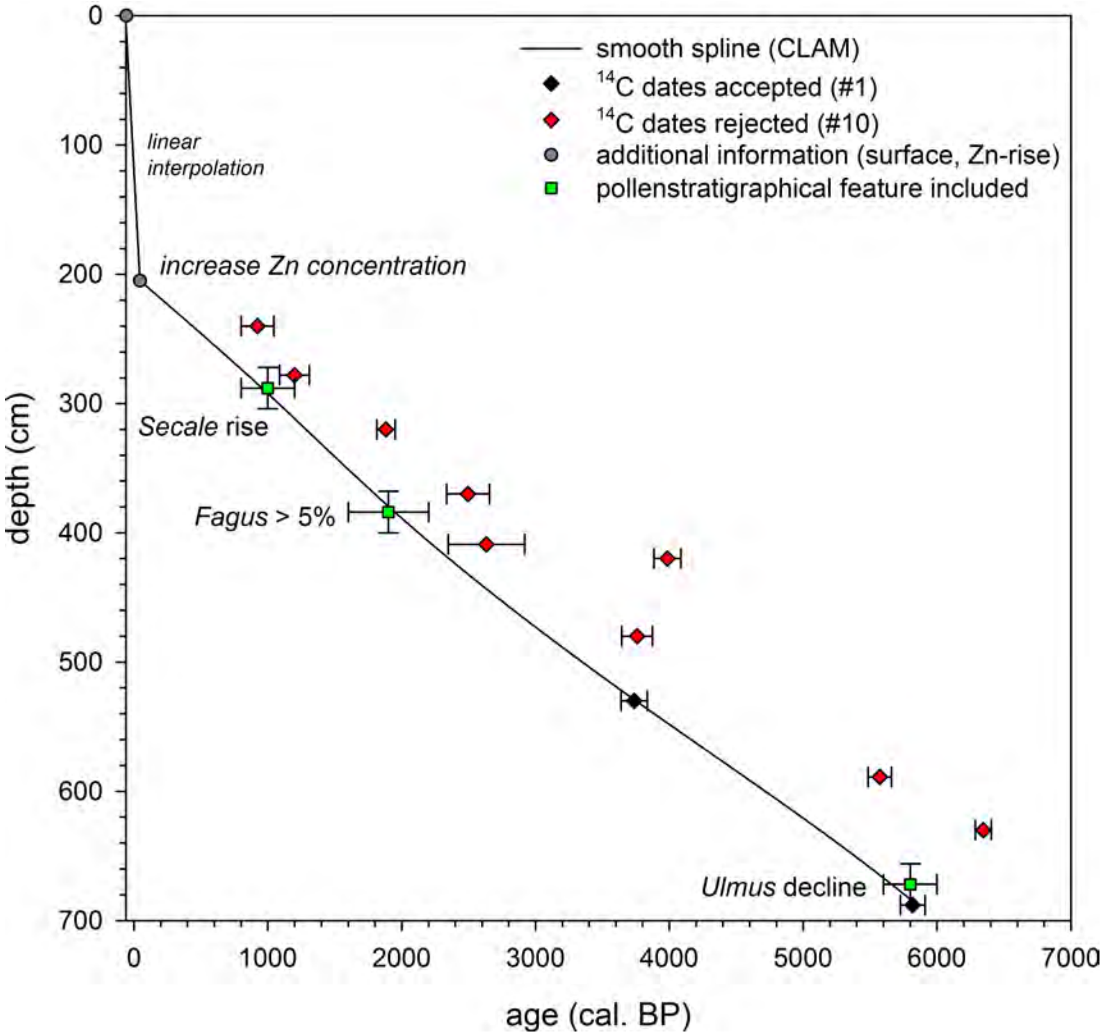


Wollingster See
Human impact
Müller & Kleinmann 1998
Depth
Pinus
Betula
Juniperus
Populus
Quercus
Ulmus
Tilia
Fraxinus
Corylus
Fagus
Carpinus
Alnus
Frangula
Taxus
Picea
Ratio AP/NAP
Poaceae (wild grass-type)
Plantago lanceolata
Sum Cerealia (excl. Secale)
Centaurea cyanus
Secale
Linum
Fagopyrum
Humulus/Cannabis/Urtica
Pteridium
Calluna
Isoetes
Lobelia
Littorella
Myrica
Sphagnum
Botryococcus
Period
MED /MT
IA / EMED
NEO / BA
MESO



Archaeological records around Wollingster See

Lobelia dortmanna



Depth cm	composite depth	Sample code	Age 14C	Err.	cal age BP from	cal age BP to	calibrated age BP midpoint	cal age BP error
687-688	688	Poz-57173	5060	35	5910	5725	5818	93
529-530	530	Poz-60005	3470	35	3835	3640	3738	98

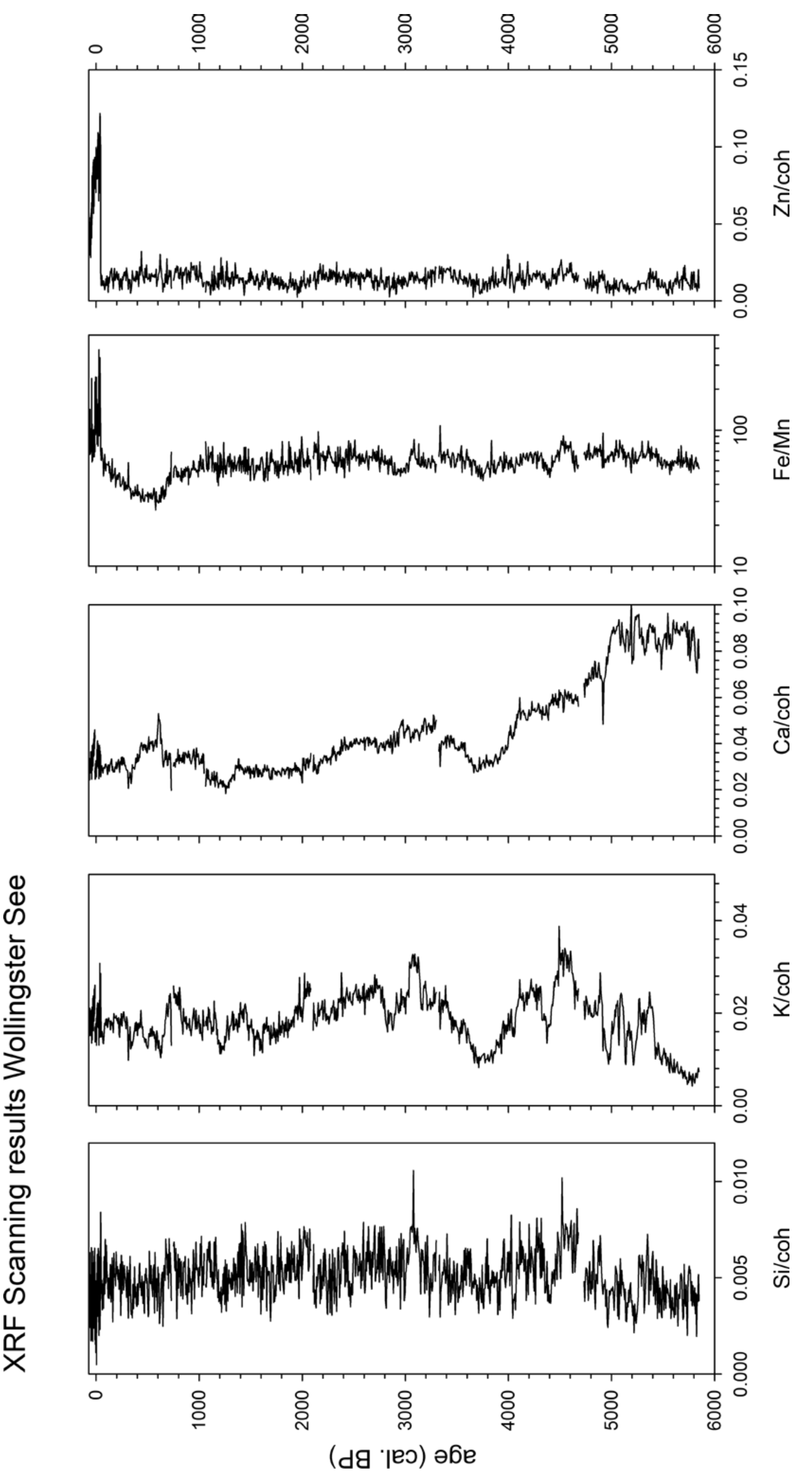
Depth cm	composite depth	pollen anal. feature			cal age BP from	cal age BP to	calibrated age BP midpoint	cal age BP error
656-688	672	Elm decline			6000	5600	5800	200
368-400	384	Fagus >5%			2200	1600	1900	300
304-272	288	Secale rise			1200	800	1000	200

Depth cm	composite depth	geochemical feature			cal age BP from	cal age BP to	calibrated age BP midpoint	cal age BP error
209-210	200	Zn rise			100	0	50	50

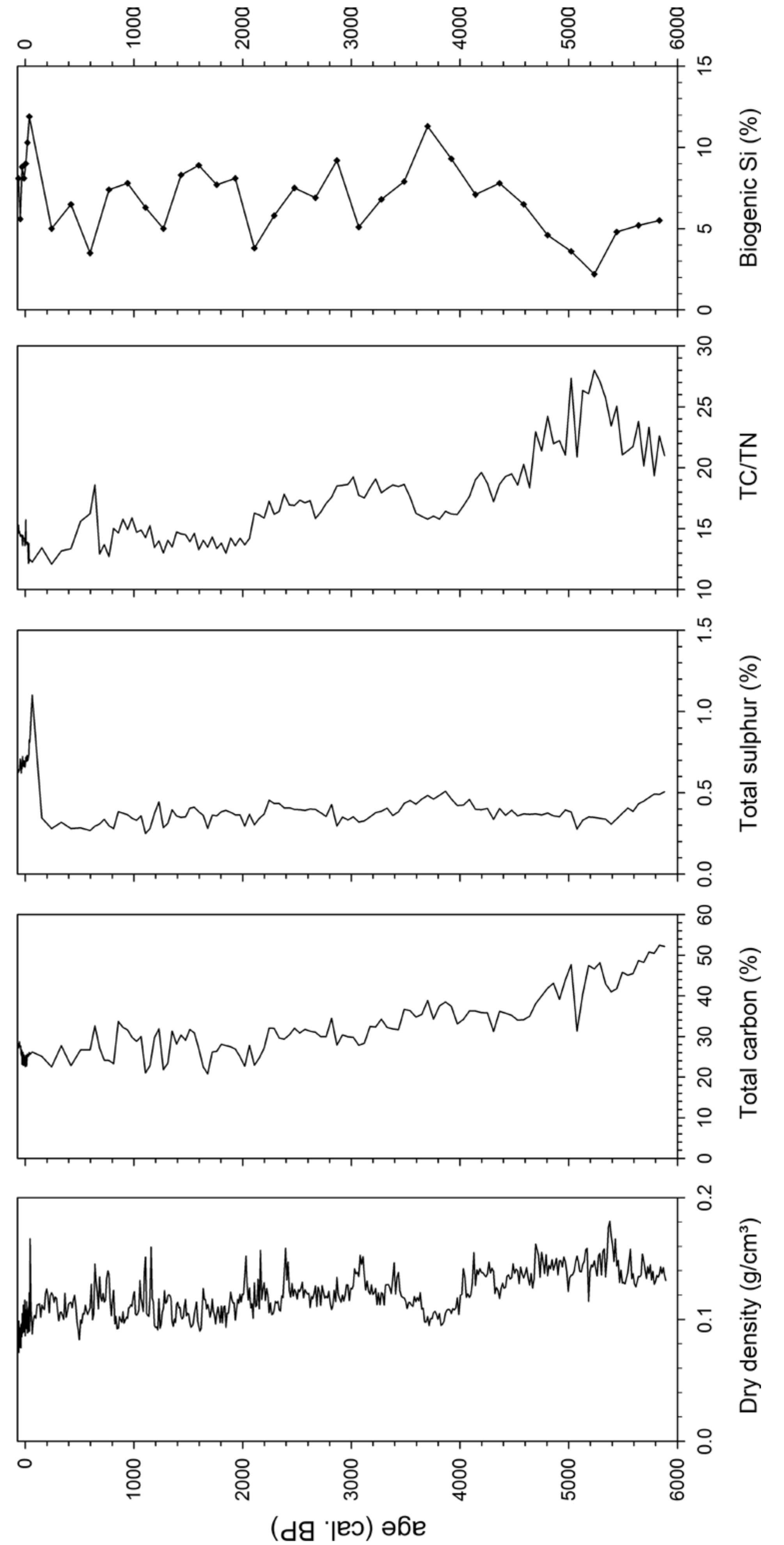
Outlier

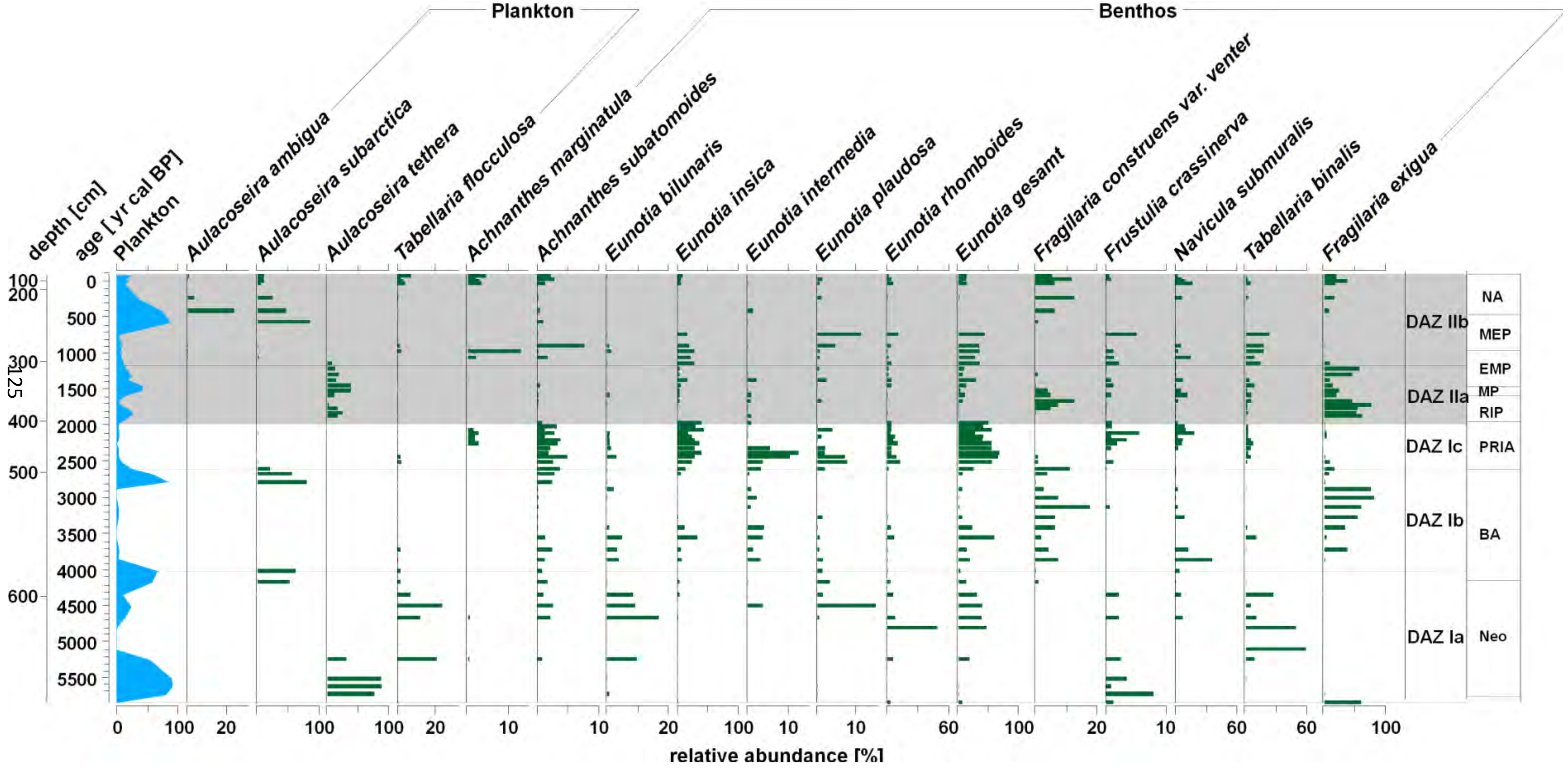
Depth cm	composite depth	Sample code	Age 14C	Err.	cal age BP from	cal age BP to	calibrated age BP midpoint	cal age BP error
239-240	240	Poz-60002	1020	30	1045	800	923	123
277-279	278	Poz-63386	1310	50	1311	1087	1199	112
319-320	320	Poz-60003	1930	30	1950	1815	1883	68
369-370	370	Poz-58265	2375	30	2655	2335	2495	160
408-410	409	Poz-63387	2560	120	2918	2347	2633	286
419-420	420	Poz-60004	3655	35	4085	3885	3985	100
479-480	480	Poz-58266	3500	40	3875	3645	3760	115
588-589	589	Poz-57311	4870	35	5660	5485	5573	88
629-630	630	Poz-60006	5540	40	6405	6285	6345	60

Age-depth model Wollingster See


XRF Scanning results Wollingster See
age (cal. BP)
Si/coh
K/coh
Ca/coh
Fe/Mn
Zn/coh

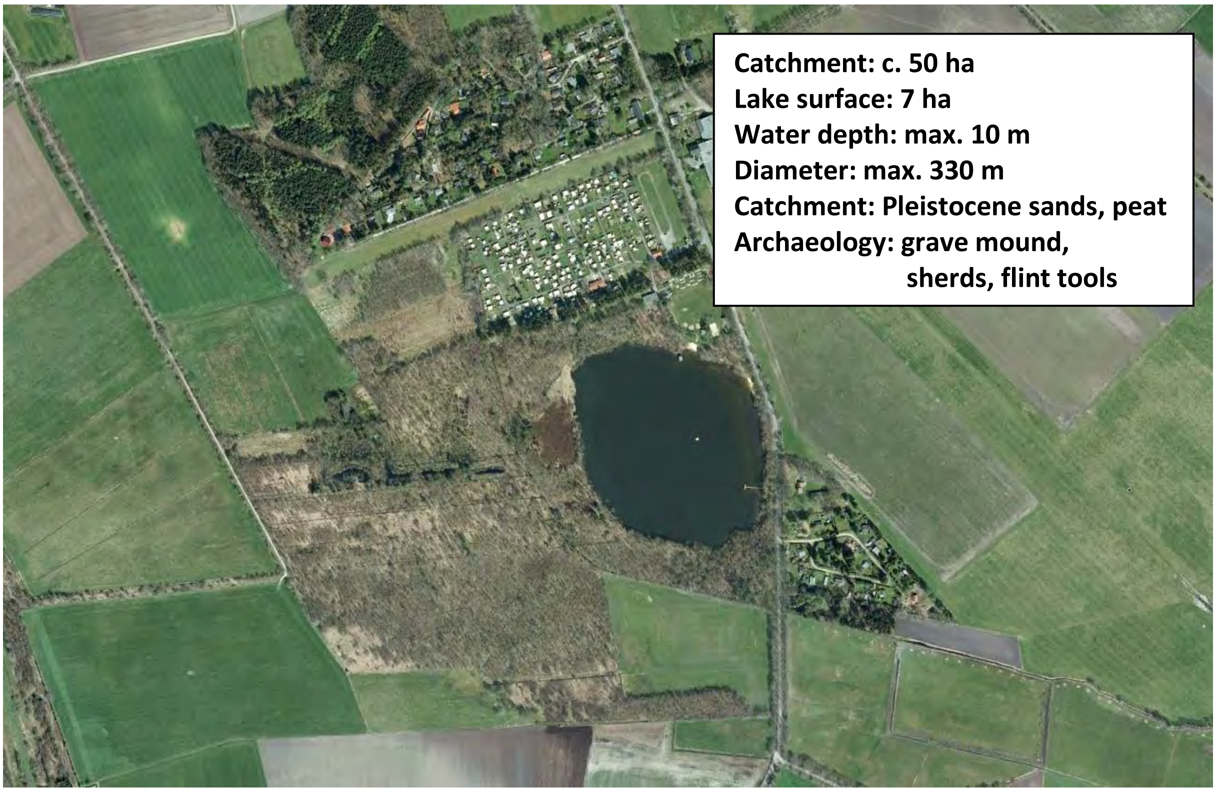
Geochemical data Wollingster See

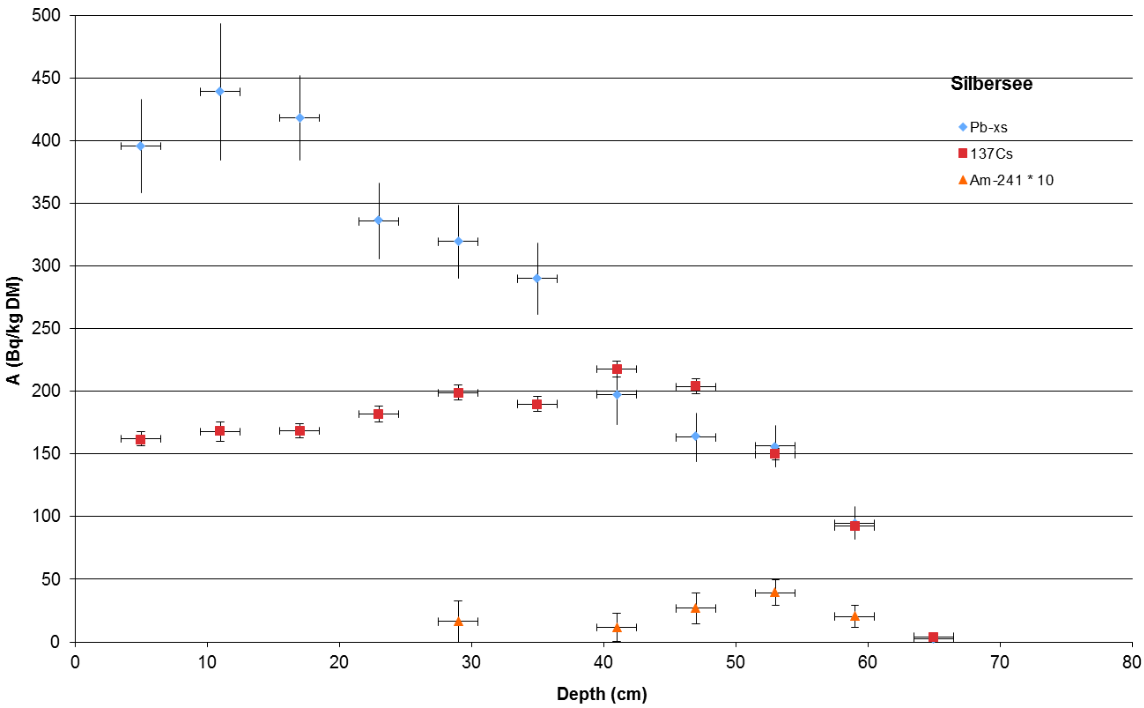




Diatom diagram Wollingster See

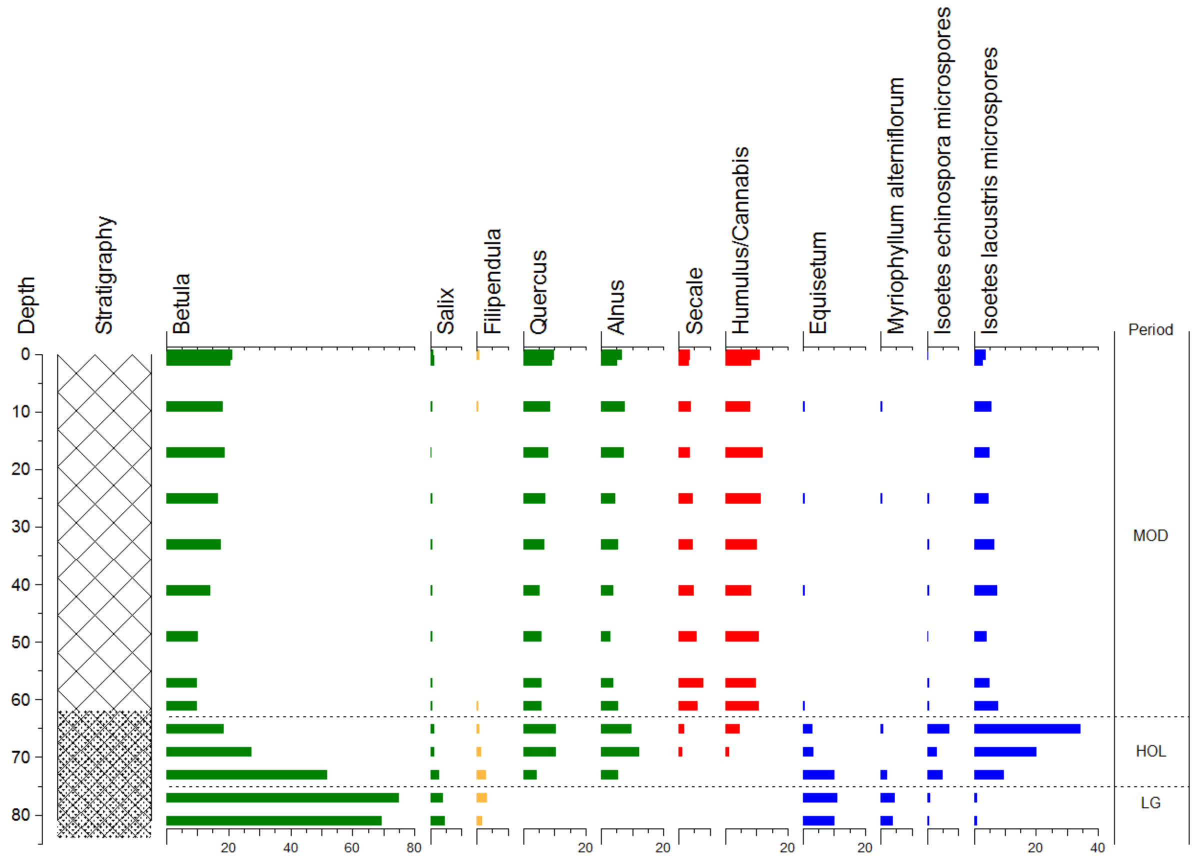
Silbersee



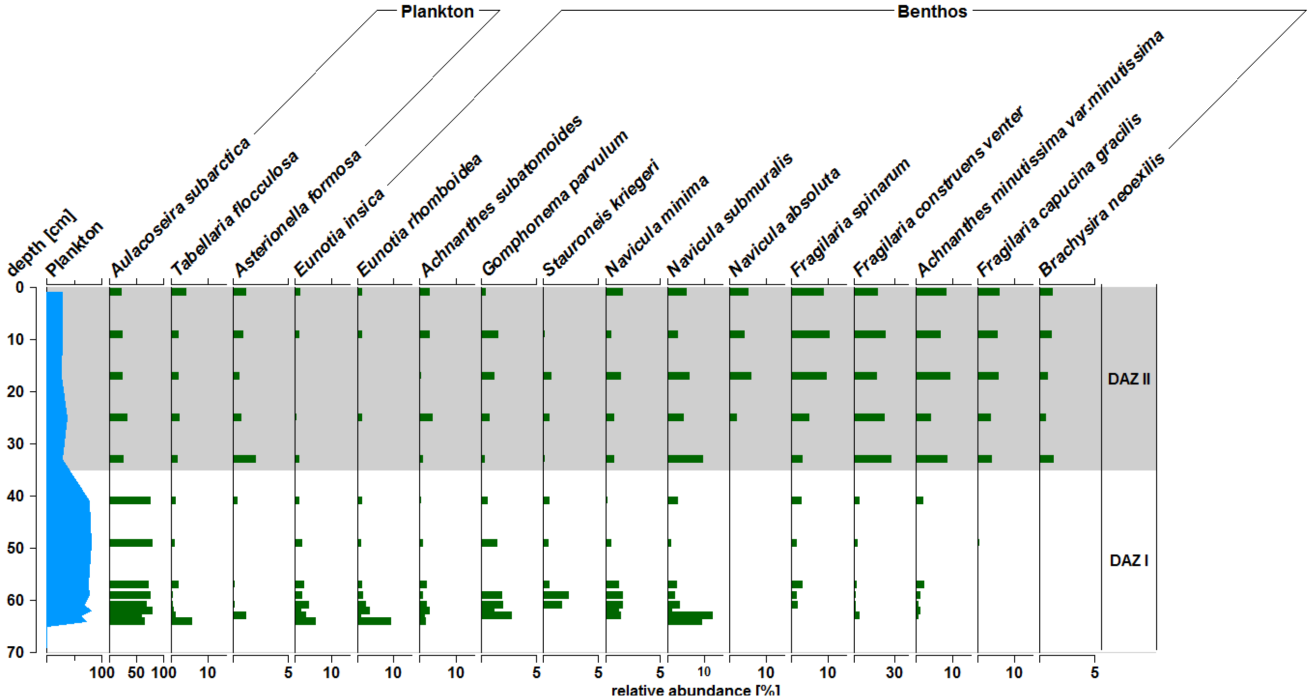


D. Pittauerova, Uni Bremen

Chronology by means of gamma spectroscopy

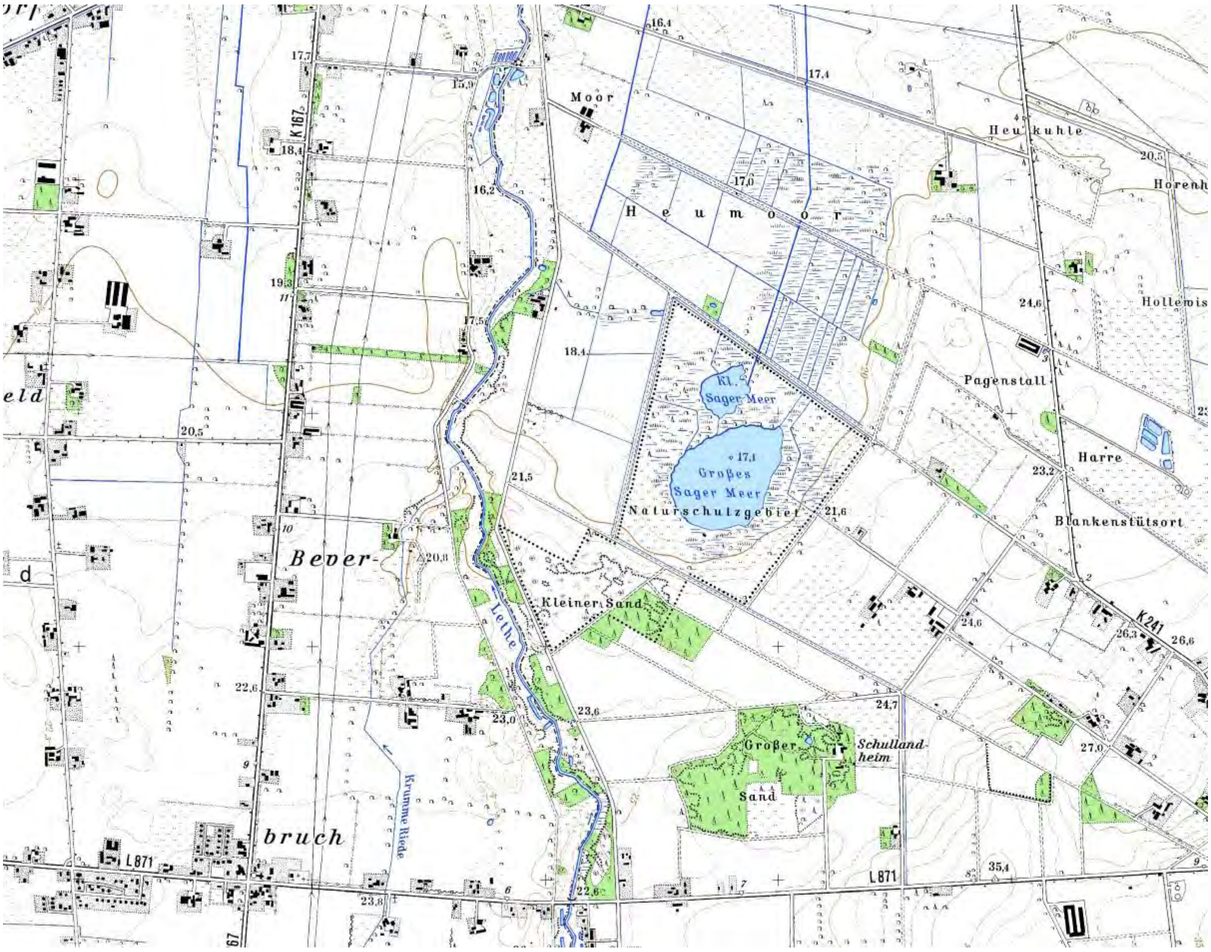


Pollen diagram Silbersee

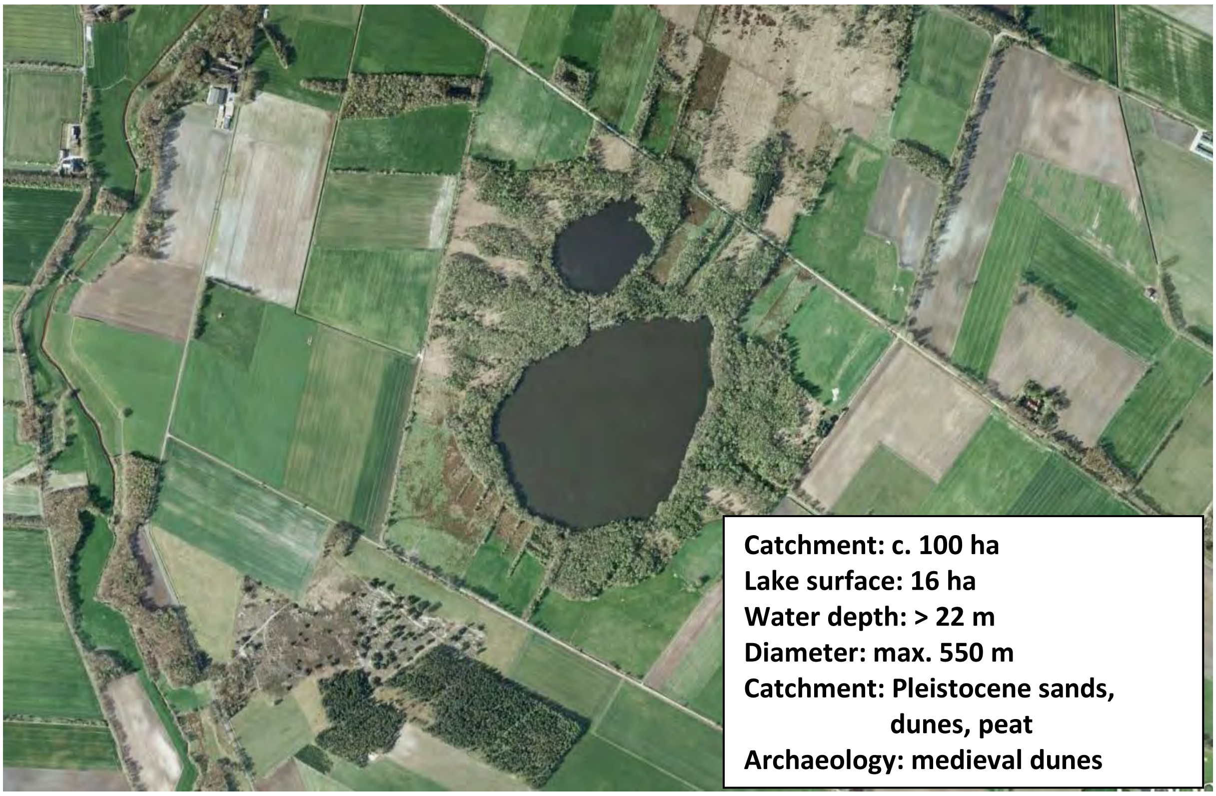


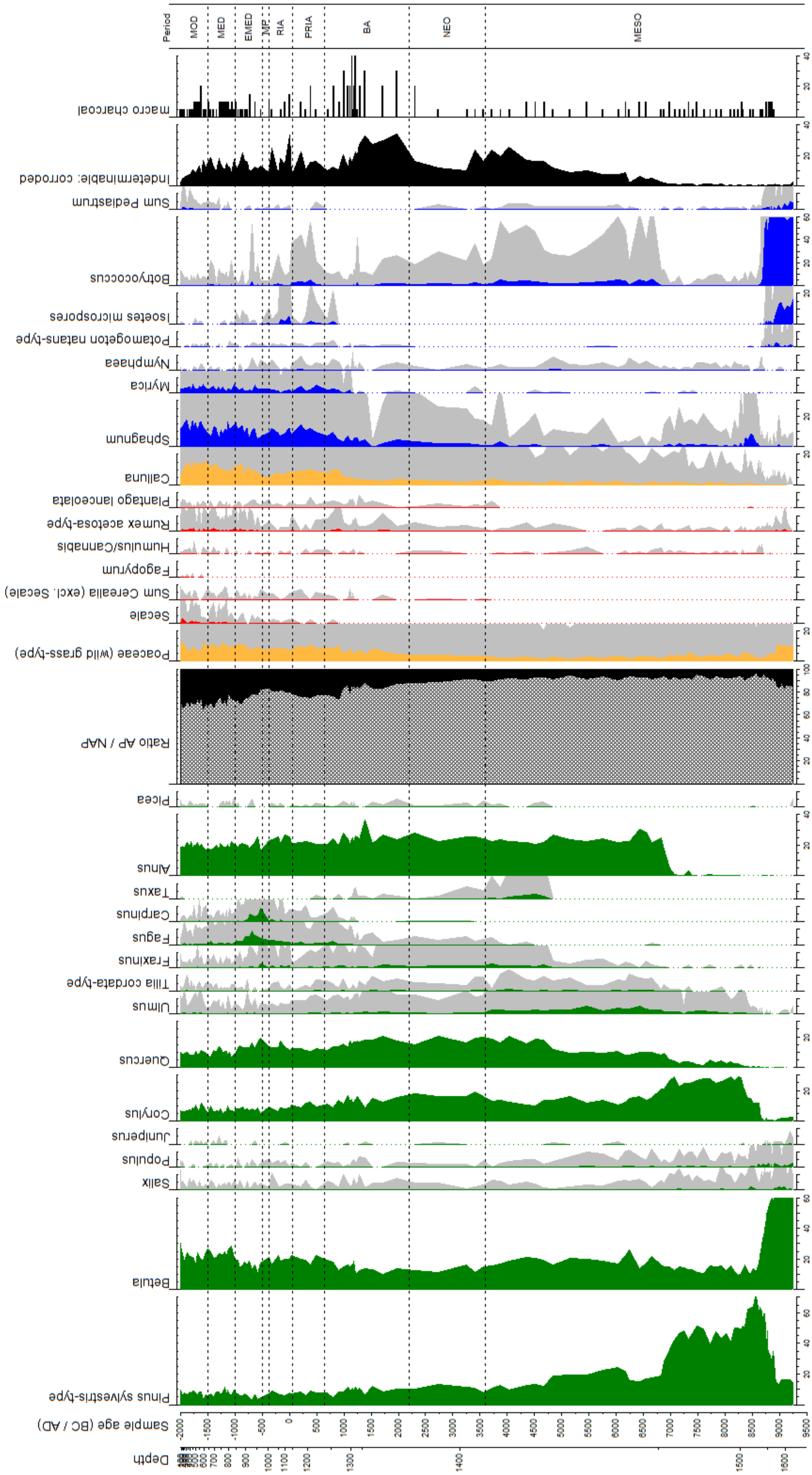
Diatom diagram Silbersee

Sager Meer

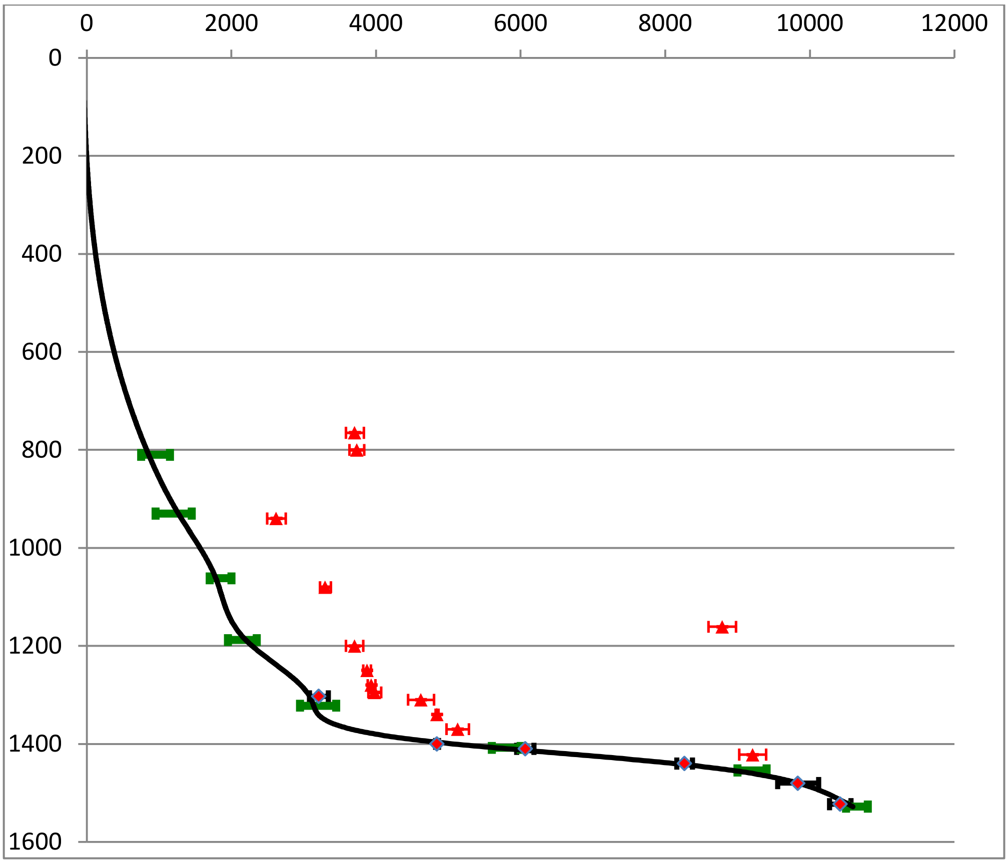


Topographic map of The Sager Meer area

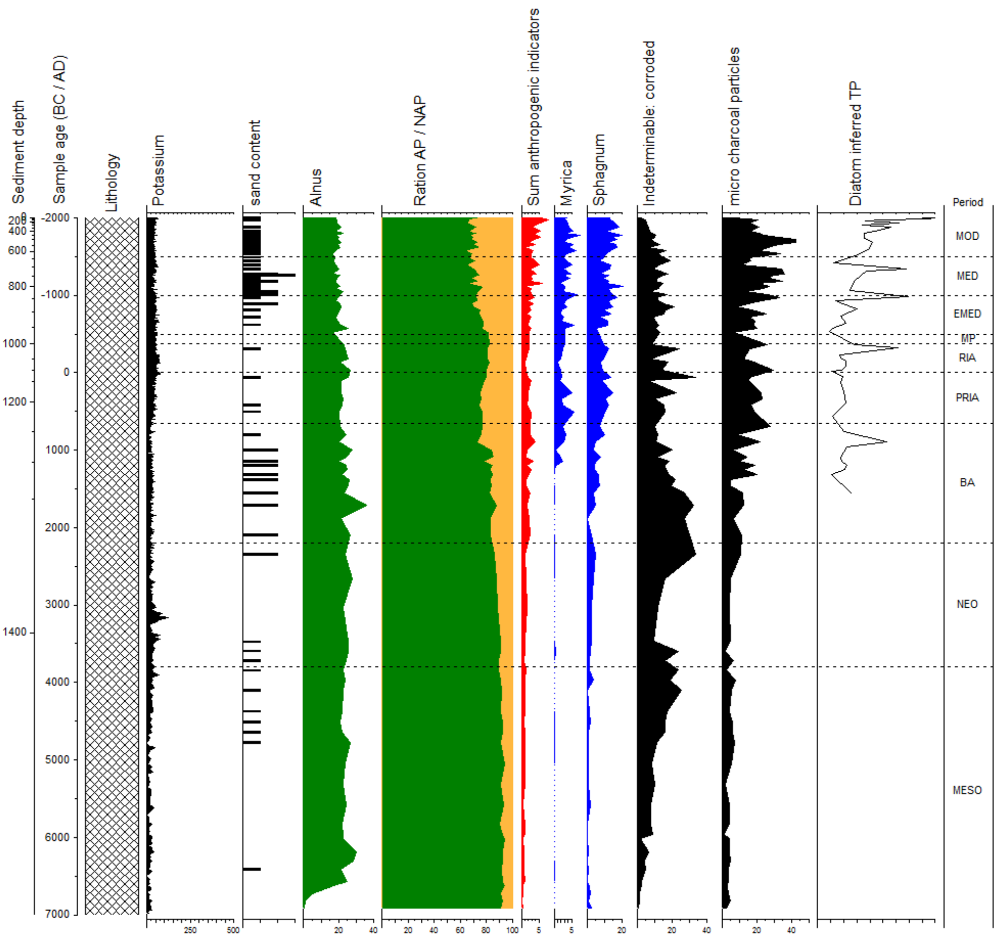




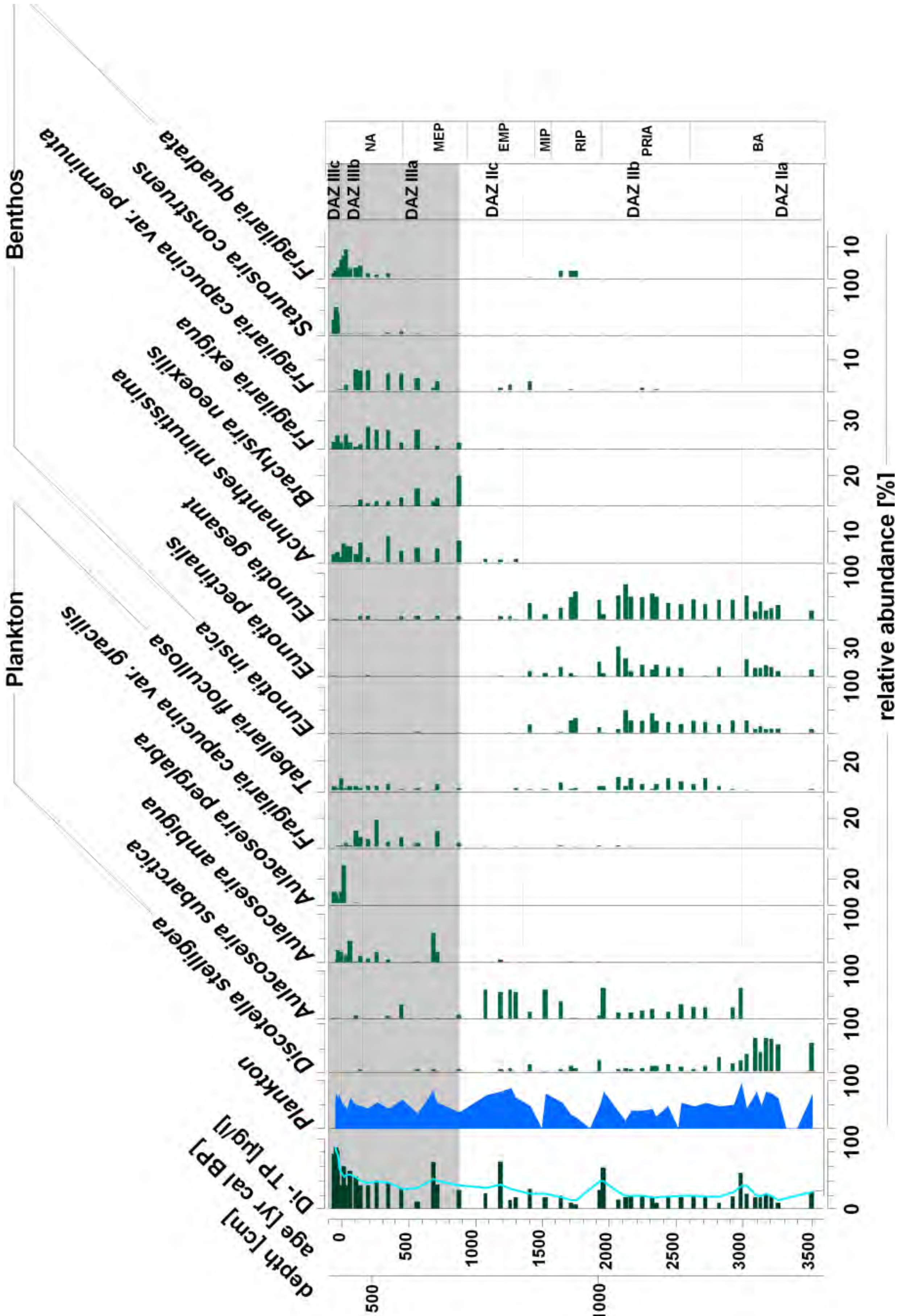
Pollen diagram Sager Meer



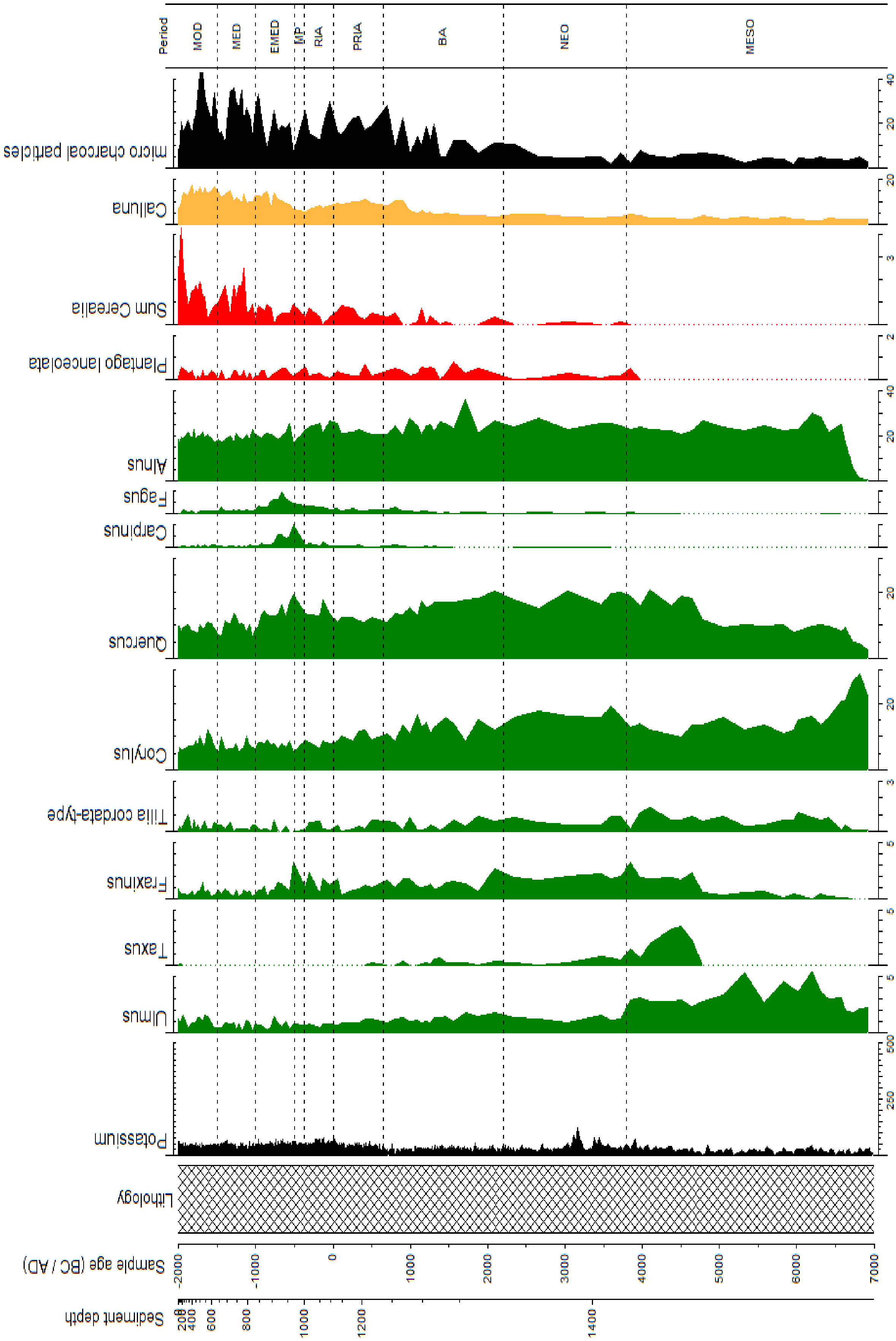
Age depth model Sager Meer



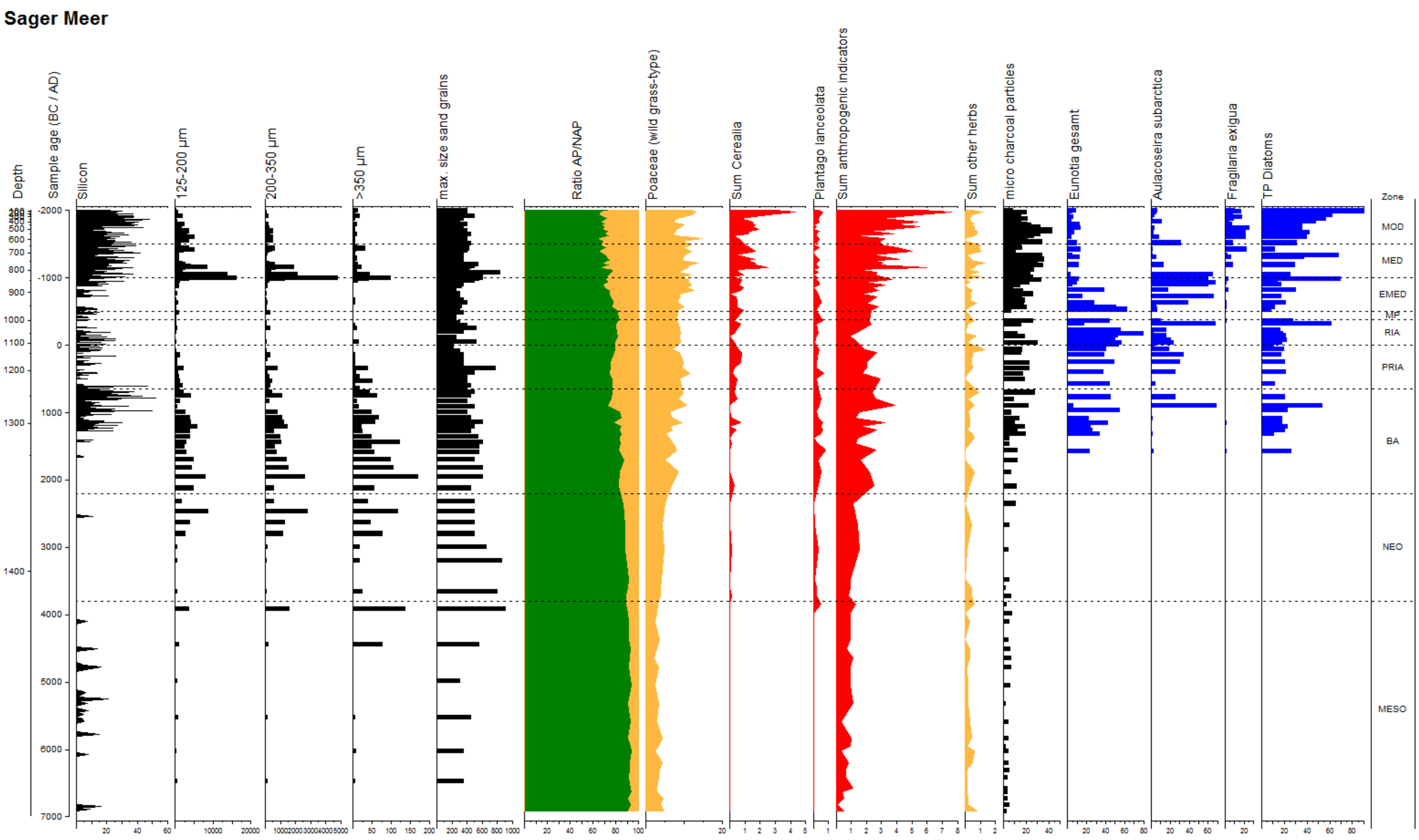
Pollen diagram indicating bog erosion



Diatom diagram Sager Meer



Pollen diagram Sager Meer indicating human impact



Mineral grain analysis Sager Meer

Development of diatom assemblages in northwest German lakes

Eversener See

Out of 101 samples the diatom assemblage could be divided into two big zones (0- 1330 cal BP, 1330 – 5500 cal BP), so the DAZ I splits into three smaller sections. In the early stages of DAZ I (5500 – 3500 cal BP) the plankton content seems to be in trend higher and drops to the end of DAZ I. Although also during this period short term events cause higher plankton contents. In example 3220 cal BP the plankton content rises up to 86 % inducing years with higher precipitation or shorter ice cover in winter causing longer mixing periods in spring. An increase of planktonic species could also be observed in DAZ I between 1330 cal BP – 650 cal BP. The dominating planktonic species throughout DAZ I are *Tabellaria flocculosa* and *Fragilaria tenera*. The first is known as a species of wide range in trophy and electrolyte preference, whereas *Fragilaria tenera* prefers oligotrohic waters with an acidic to circum-neutral pH- value. A magnificent shift of the plankton content takes place at about 1330 cal BP, accompanied by a significant change in the species community. This marks the beginning of the middle ages. The ratio of benthic species drops to redound to the advantage of the planktonic diatoms. The former species are replaced by different *Aulacoseira* species and *Discotella stelligera*, which have in common a wide ecological range. The mass growth of *Aulacoseira granulata* in 1276 cal BP and *Asteriella formosa* in 809 cal BP induce short term increase of the trophic situation. The pH seems to be rising in DAZ I indicated by a lowering of the ratio of *Eunotia* species. In general there seems to be a combination of pH and trophy controlling factors especially in the beginning of the middle ages.

Lake Sager Meer

Diatoms have been found in 52 samples. 232 taxa in 30 genera could be identified and diver significantly in 3 diatom assemblage zones. DAZ I includes only three samples and isn`t displayed here (DAZ II 3600 – 880 cal yr BP, DAZ III 880- 0 cal BP). A significant shift takes place at about 880 cal BP with the beginning of the high medieval period (MEP). A complete change in the diatom community can be observed. But right from the beginning in DAZ II significant changes are existent. The oligotrophic planktonic species *Discotella stelligera* is replaced by the more mesotraphent planktonic *Aulacoseira subarctica*. Latter is almost vanishing in DAZ III and supplanted by the meso to eutrophic *Aulacoseira ambigua*. Simultaneously different *Fragilaria* species occur which indicate a rising trophy. From ca. 1300 cal BP the decrease of the *Eunotia* ratio seems to give evidence for a rising pH as well. Of all the three lakes (excluding Silbersee) the changes in Lake Sager Meer are most drastic.

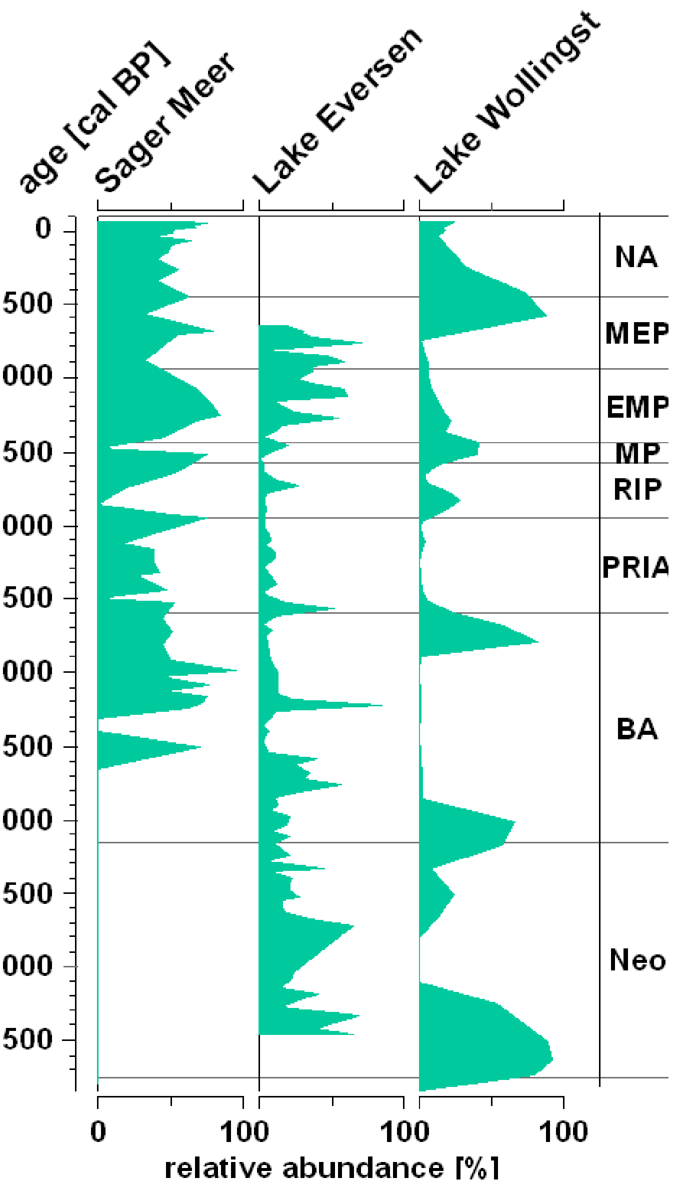
Silbersee

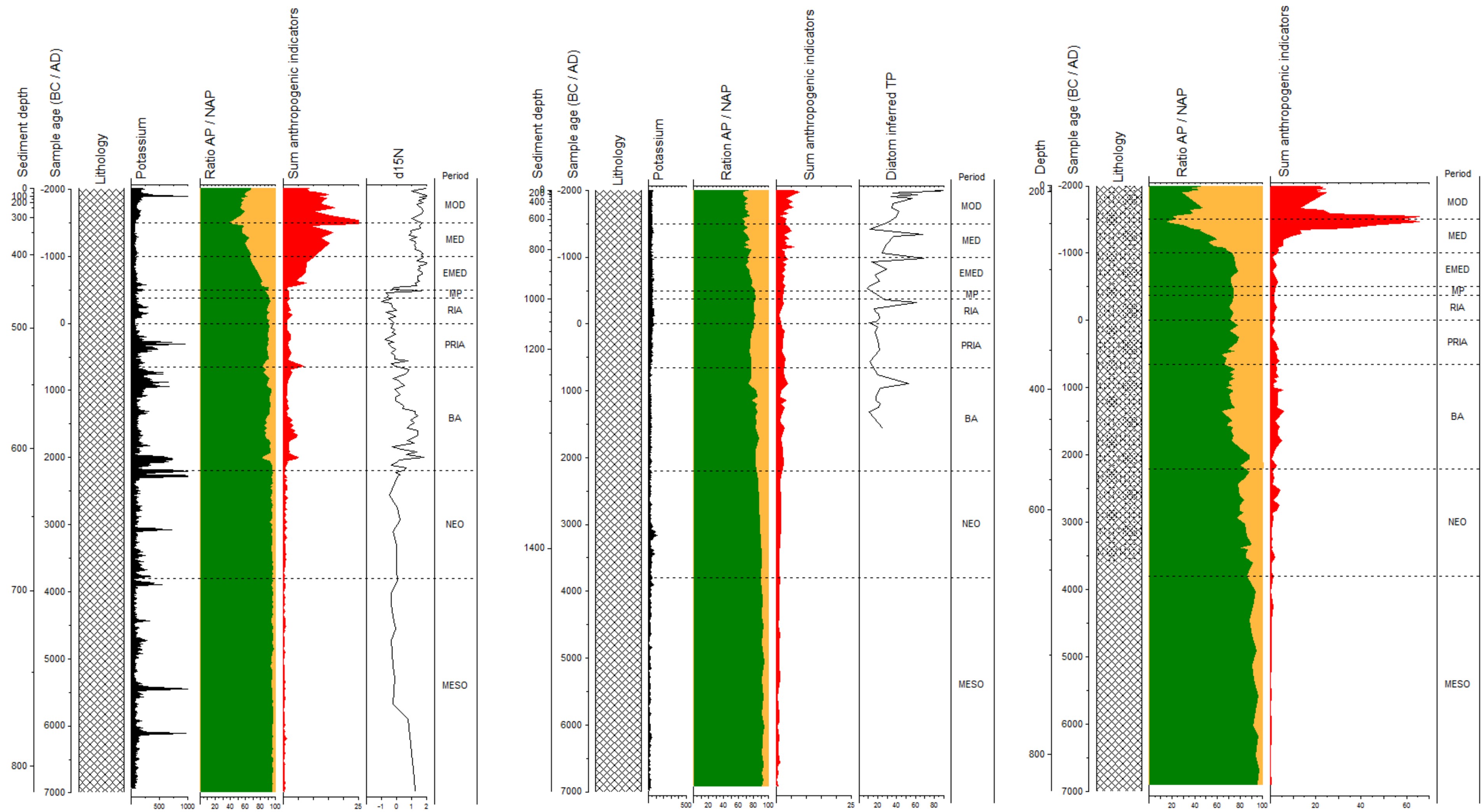
The short core of Lake Silber displays in 13 samples two zones of diatom assemblage (35-70 cm, 0-35 cm) displaying the last 60 years. A clear shift took place from mesotrophic to clearly eutrophic conditions. On the other hand the dominance of plankton was suppressed with the occurrence of more benthic species. So it might have been a combination of rising trophy and less precipitation which caused this change.

Lake Wollingst

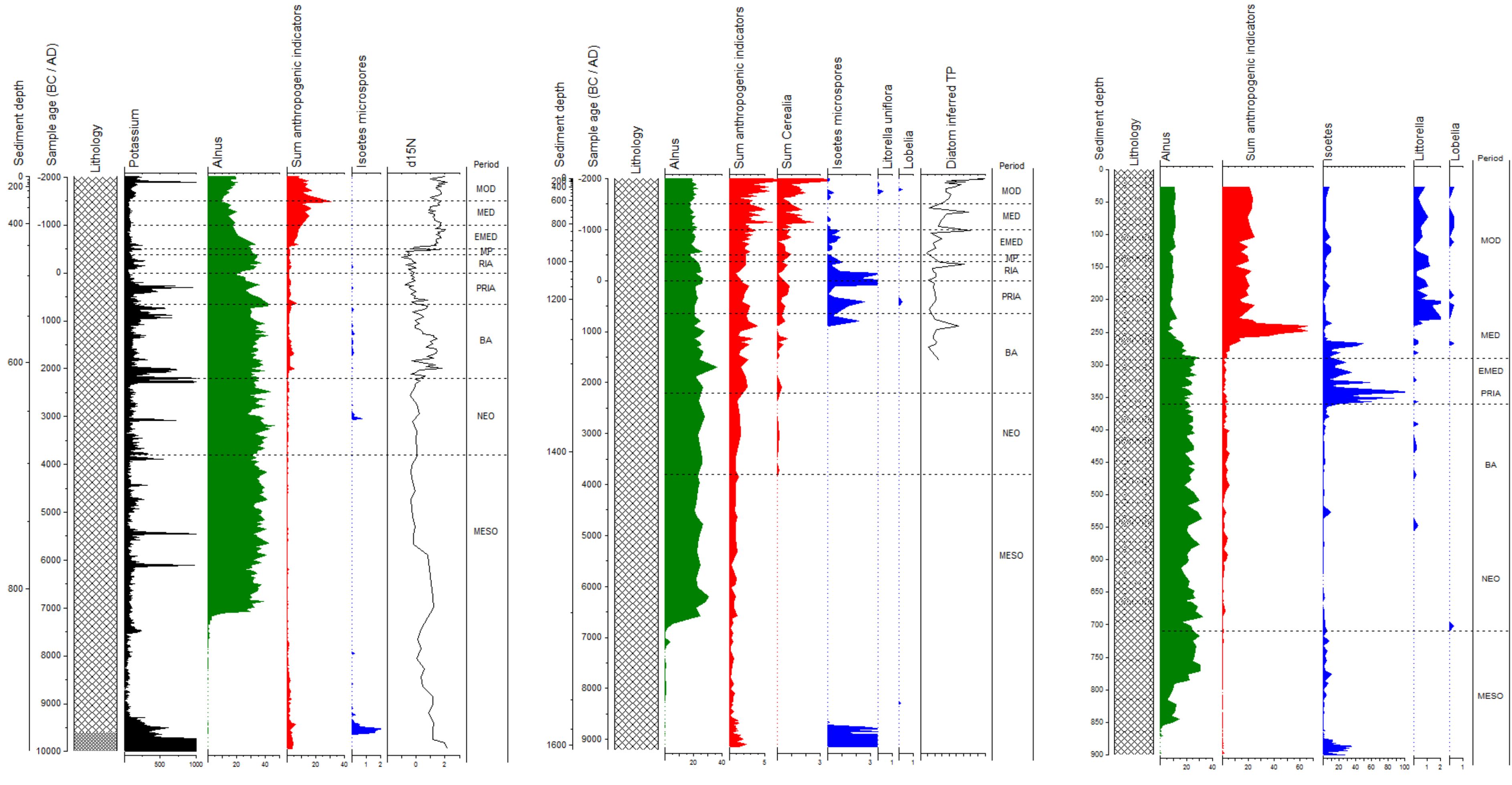
The diatom community out of 57 samples of Lake Wollingst can be divided into two assemblage zones (DAZ I 5800- 1980 cal BP, DAZ II 1980 – 0 cal BP). The community shifts appear more cyclic than in the other lakes. Except the eutrophic *Aulacoseira ambigua* all species of higher abundance occur throughout both zones. The first appearance of *Aulacoseira ambigua* takes place at 417 cal BP with the beginning of the new ages. That indicates a slightly rising trophy, although *Aulacoseira subarctica* is still present in a very high abundance. A very low pH indicating species is *Tabellaria binalis*. It could be found throughout the entire investigated core section, whereas the highest abundance is in DAZ Ia. It seems to be replaced by *Eunotia* and *Fragilaria exigua* and regains a higher abundance in DAZ IIb. So there seems to be a process of slightly rising and falling pH values. The lowering is simultaneously with a lower plankton ratio. So obviously pH regulating processes depend on the precipitation or the ice cover during winter and hence the duration of the mixing periods in spring.

Over regional events could cause similar developments in lakes situated in one region. So a comparison of the plankton development should give evidence for such events. At about 5400 cal BP Lake Eversen and Lake Wollingst both are characterized by a high plankton ratio. Lake Sager Meer and Lake Eversen match at about 3200 cal BP, as well throughout the entire Medieval Period, which is known for wetter climate conditions. With the end of the migration period Lake Wollingst is characterized by a dropping plankton ratio, which increases again in the end of the MEP. There are no fitting parts in all three lakes but by trend Lake Sager Meer and Lake Eversen seem to be similar.





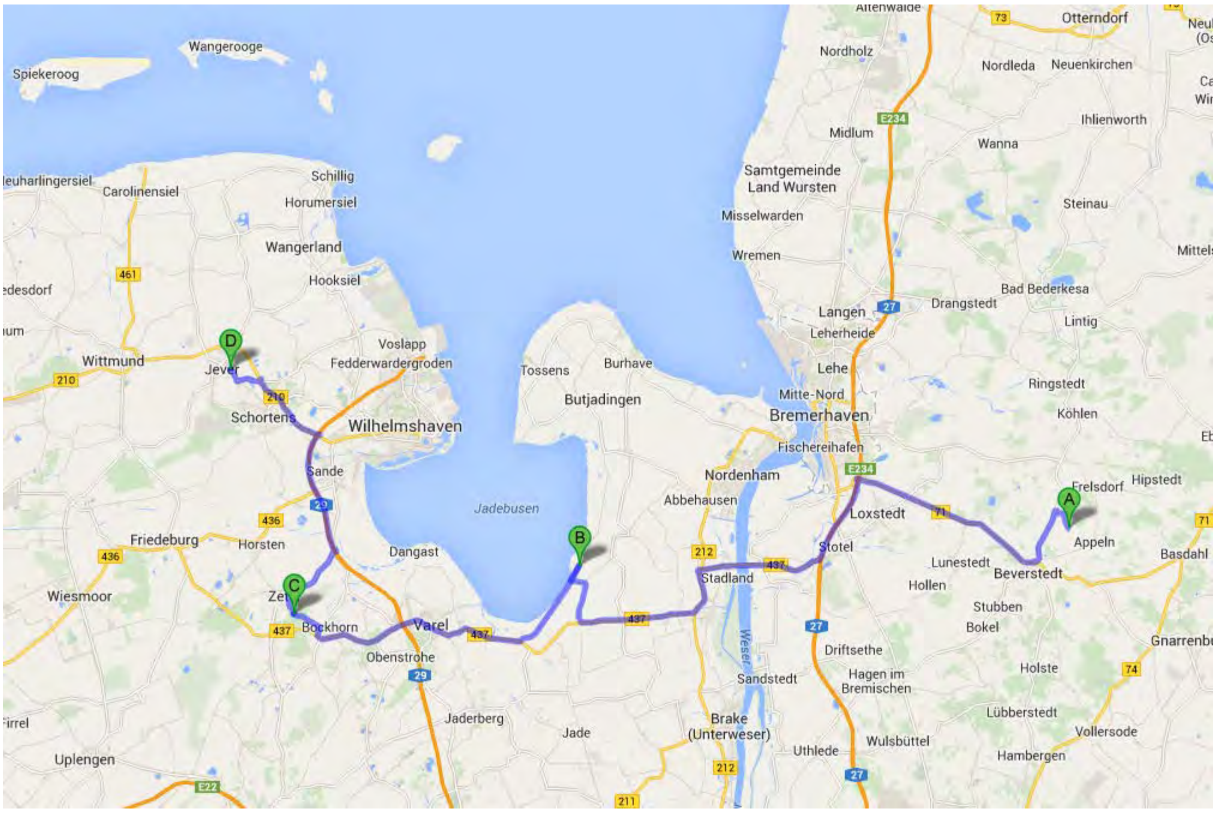
Human impact in sediments of northwest German lakes

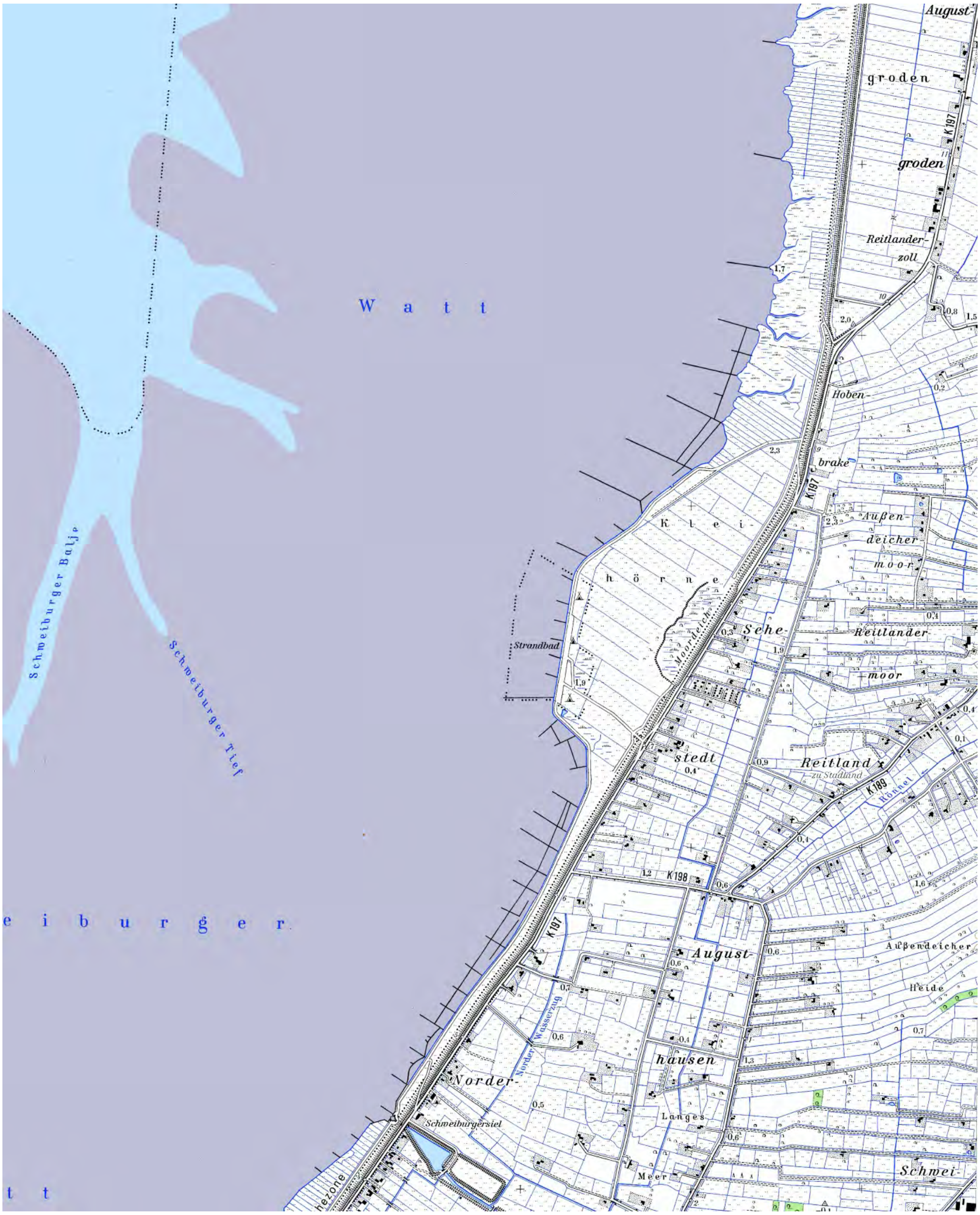


History of Isoetes in northwest German lakes

Thursday, 11.09.2014
Jade Bay and Frisian Geest

The Sehestedter Moor – a unique mobile geological monument at the Jade Bay (K. E. Behre)
The Neuenburger Urwald – an outstanding historic woodland in Lower Saxony (K. E. Behre)
Guided tour at the Frisian brewery, Jever
Accomodation at Friesenhotel, Jever





Topographic map of the southeastern Jade Bay

The Sehestedter Moor –
a unique mobile geological monument at the Jade Bay

The Sehestedter Moor, a raised bog outside the dike, represents the remnants of an extensive raised bog which originally covered large areas on both sides of the present dike. Its formation started, when the predecessor of the present Jade-Bay, the Ur-Jade Bay, silted up. Between 1500 and 1000 B.C. there was a regression phase in the North Sea and the whole area turned from marine to freshwater conditions resulting in swamps and the formation of fen peat. The hydroseral succession led further to brushwood peat and during the next decline of the sea level shortly before the Birth of Christ, it changed to a raised bog, dominated by Sphagnum. This development to a bog, which grows independently of the ground water, was caused by the lowering of the ground water, as consequence of the sea level decline. Behind the elevated levee along the coastline a huge backswamp area existed until the Middle Ages, when the Jade Bay was formed.

Aerial photography of the Sehestedt Außendeichsmoor from 2003

The formation of the Jade Bay started in the early 13th century, when storm surges broke through the elevated levees and flooded the low-lying backswamps. Many storm floods continuously eroded the peat bogs and enlarged the bay step by step until it extended far beyond its present size and had even connections with the Weser river.

The development of the Jade area since the Birth of Christ

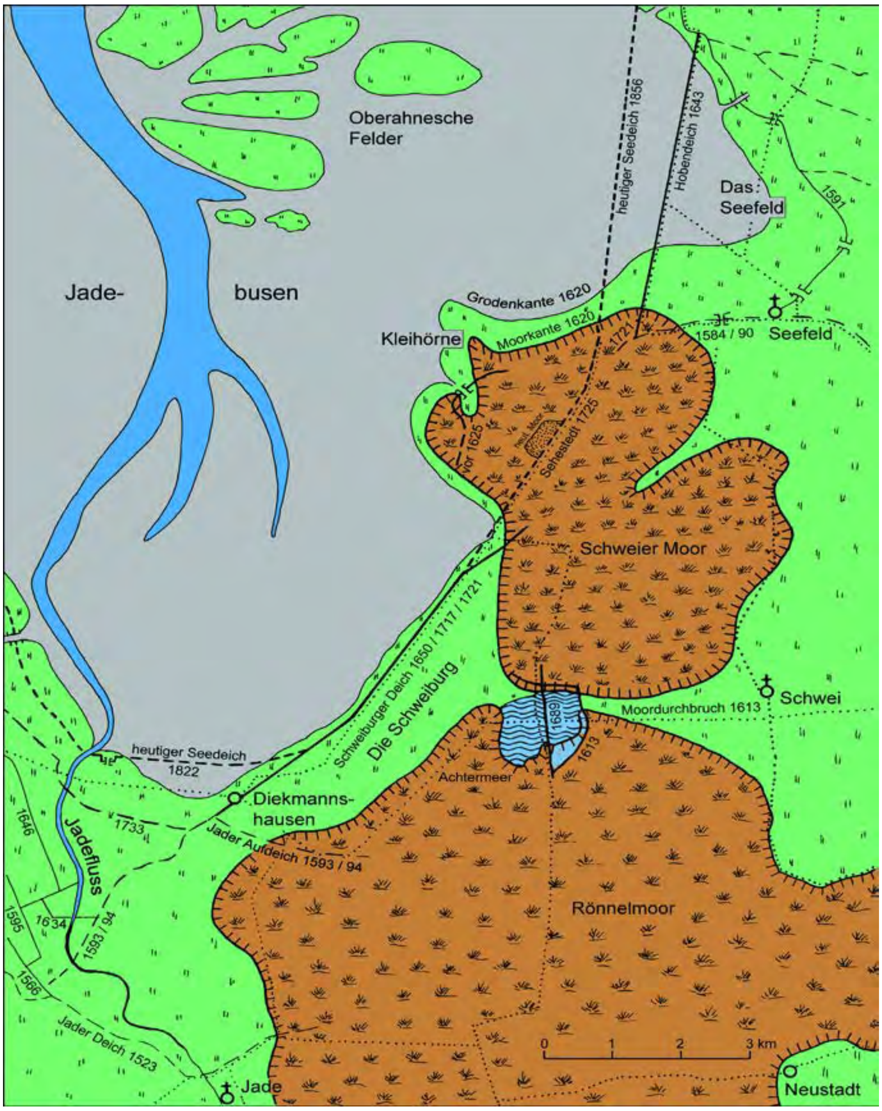
A very special way of resistance prevents the raised bog from being flooded and covered with sediments: during high storm tides it floats up on the seaward side. Because the body of the raised bog is completely filled with fresh water and the part along the cliff is dried out, it is lighter than sea water and rises. In this way it protects the hinterland.

Before diking this phenomenon of the floating of raised bogs was quite common and happened later outside the dikes. This is documented by the occurrence of clay layers within the bogs which are frequently recorded in corings from the Clay District of Germany, the Netherlands and elsewhere, and which are called *Klappklei* (turn up clay).

Nowadays the Sehestedter Moor is the only place at least in Europe, where this specific phenomenon can still be studied and thus provides the explanation for the special geological phenomenon of the *Klappklei*.

For many centuries the southeastern part of the Jade Bay was not protected by dikes as all the other regions along the coast but by the floating up of the raised bog.

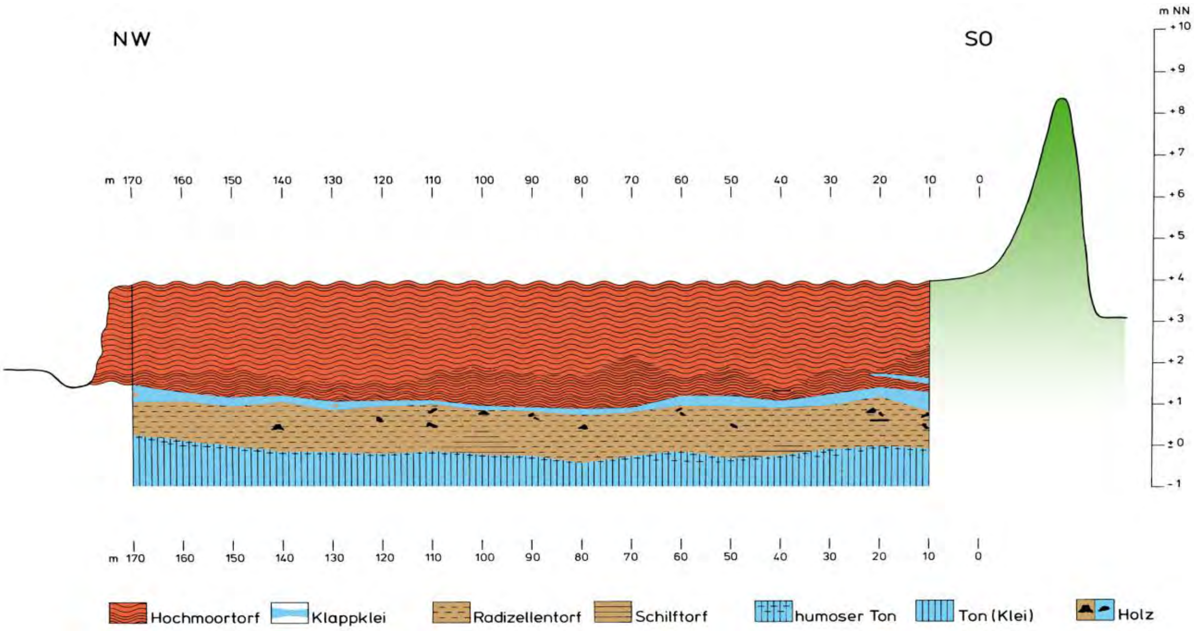
Only in 1725 a dike across the bog was built and for this an exact survey was carried out. So we know that in 1722 the extension of the Sehestedt bog which was left outside the dike amounted to 165 ha. At that time there still lived several farmers on the bog where they raised sheep and had small fields. During storm floods their houses were lifted together with the bog and these farmers were more safe than their relatives behind the dikes that sometimes broke. The last inhabited farmhouse outside the dike was destroyed only in 1908, not by the sea but by lightning.

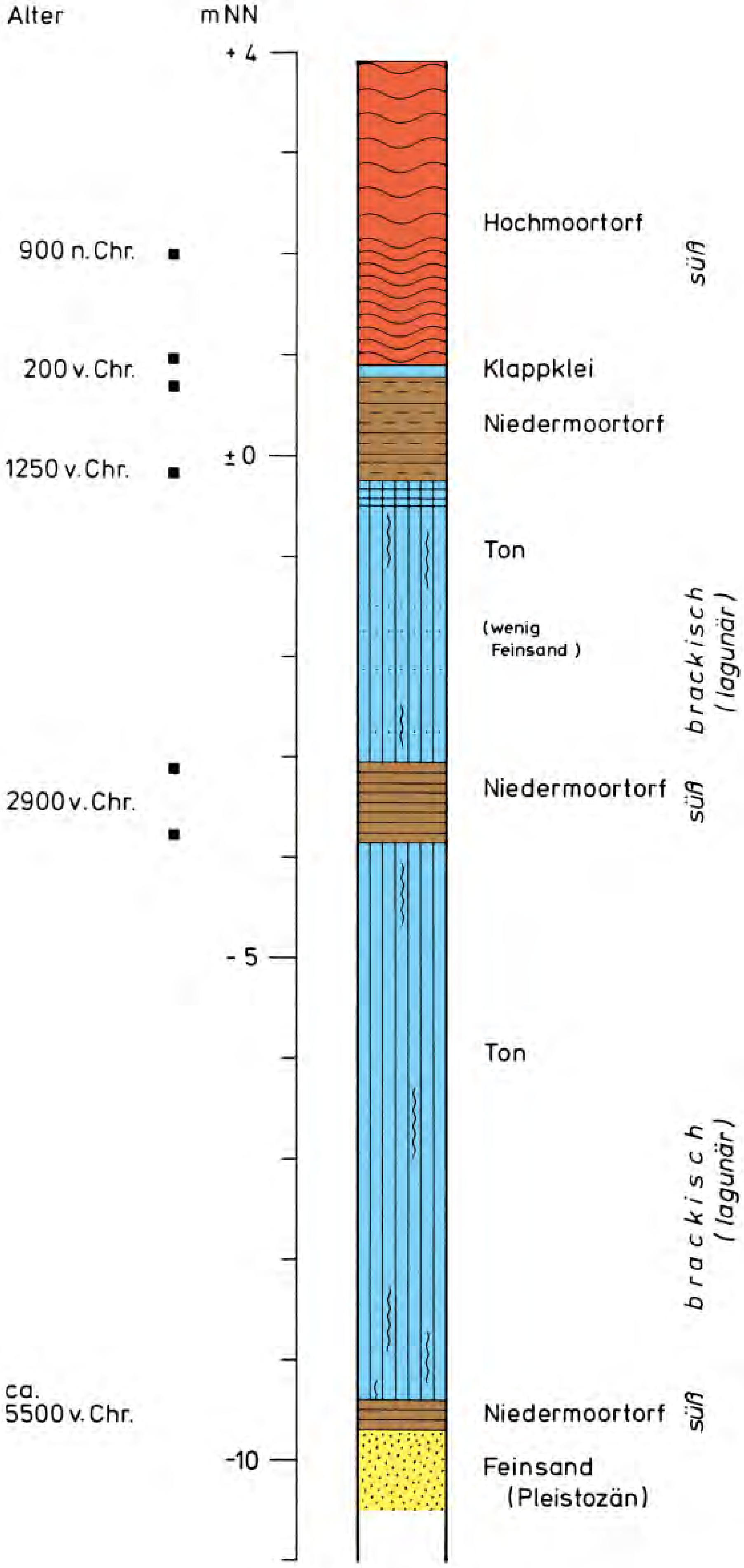


Map of the south-eastern Jade Bay ca. AD 1620

Aerial photography of the raised bog out-side the dike and the cultivated part inside

The erosion of the *Außendeichsmoor* (=bog outside the dike) continued further and further and its size was reduced to 107 ha in 1820, 21 ha in 1932 and only 9.6 ha nowadays. Although this bog is an important refuge for plants and animals, it had been decided not to protect it in order to preserve this unique mechanism of a floating bog which lacks any counterpart. The floating of this bog takes place when the level of a storm flood reaches 1,70 m above mean high water. This is not the case in every winter; there have been many years without floating, in the most recent years, however, there were several severe floods and the bog floated up. In winter 2006/2007 this occurred even three times, causing most severe damage. Nov 1st 2006 during a huge gale the bog was lifted and the complete southern part was torn off and drifted around 5 m southwards and also up onto the dike. At its edges peat walls bulged, while along the separation line in the bog a channel came into existence which now runs at right angle across the whole bog to the dike.

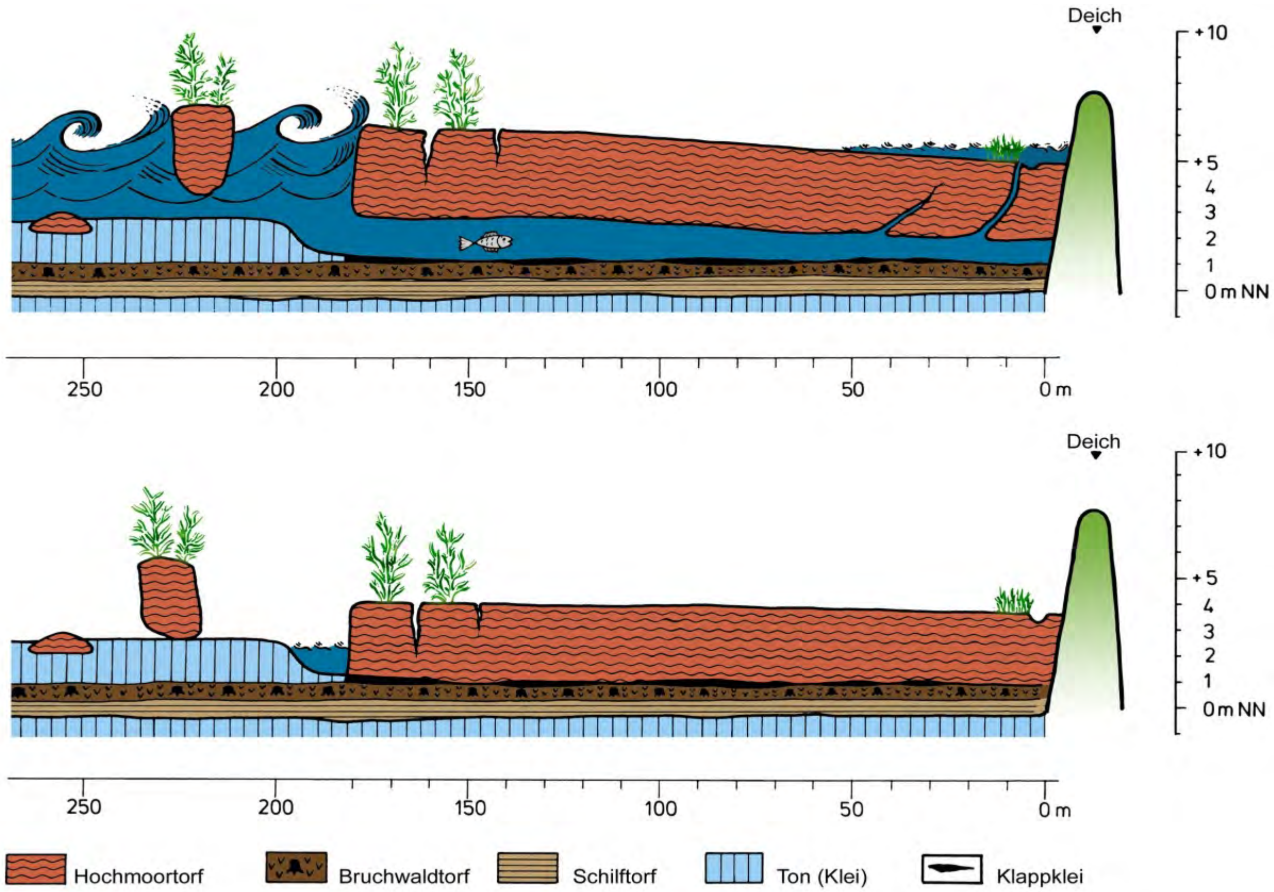



Alter
mNN
+ 4
900 n. Chr.
200 v. Chr.
± 0
1250 v. Chr.
2900 v. Chr.
- 5
ca.
5500 v. Chr.
-10
Hochmoortorf
süß
Klappklei
Niedermoortorf
Ton
(wenig
Feinsand)
brackisch
(lagunär)
Niedermoortorf
süß
Ton
brackisch
(lagunär)
Niedermoortorf
süß
Feinsand
(Pleistozän)

When the bog floats up during storm surges, waves, driven by the gale, bounce against the bog and strong erosion takes place. Peat chunks up to more than 10 m in length are torn off and drift to the north and south. This is the way in which fresh and steep forms of the cliff are created and maintained. During years without uplift the cliff slopes and becomes overgrown by plants. When it floats up, the bog tears off exactly at the boundary between the fen and the carr peat below and the *Sphagnum* peat of the raised bog above. Then a hollow develops into which the water intrudes. Within minutes this churned up water calmes down completely and loses its transport ability.

Now for many hours the dispersed clay and sand particles are deposited inside the bog and form the *Klappklei*. With each floating up this *Klappklei* increases in thickness and reaches in places up to more than 30 cm. This clay layer is sharply delimited at the top and the bottom as can be seen in many co-rings in this bog and elsewhere along the coast. It is younger than the peat above, which is demonstrated by pollen analyses of the clay compared with those from the peat.

When the sea retreats after the storm, the bog drops into its former position. Now many torn off peat chunks are scattered in front of the cliff; they will be eroded in the course of the next years.



Opening-up of the Sehestedt bog and the formation of Klappklei

above: floating at severe storm floods
below: normal position

Storm flood at the cliff of the bog

Peat cliff in the southern part of the bog

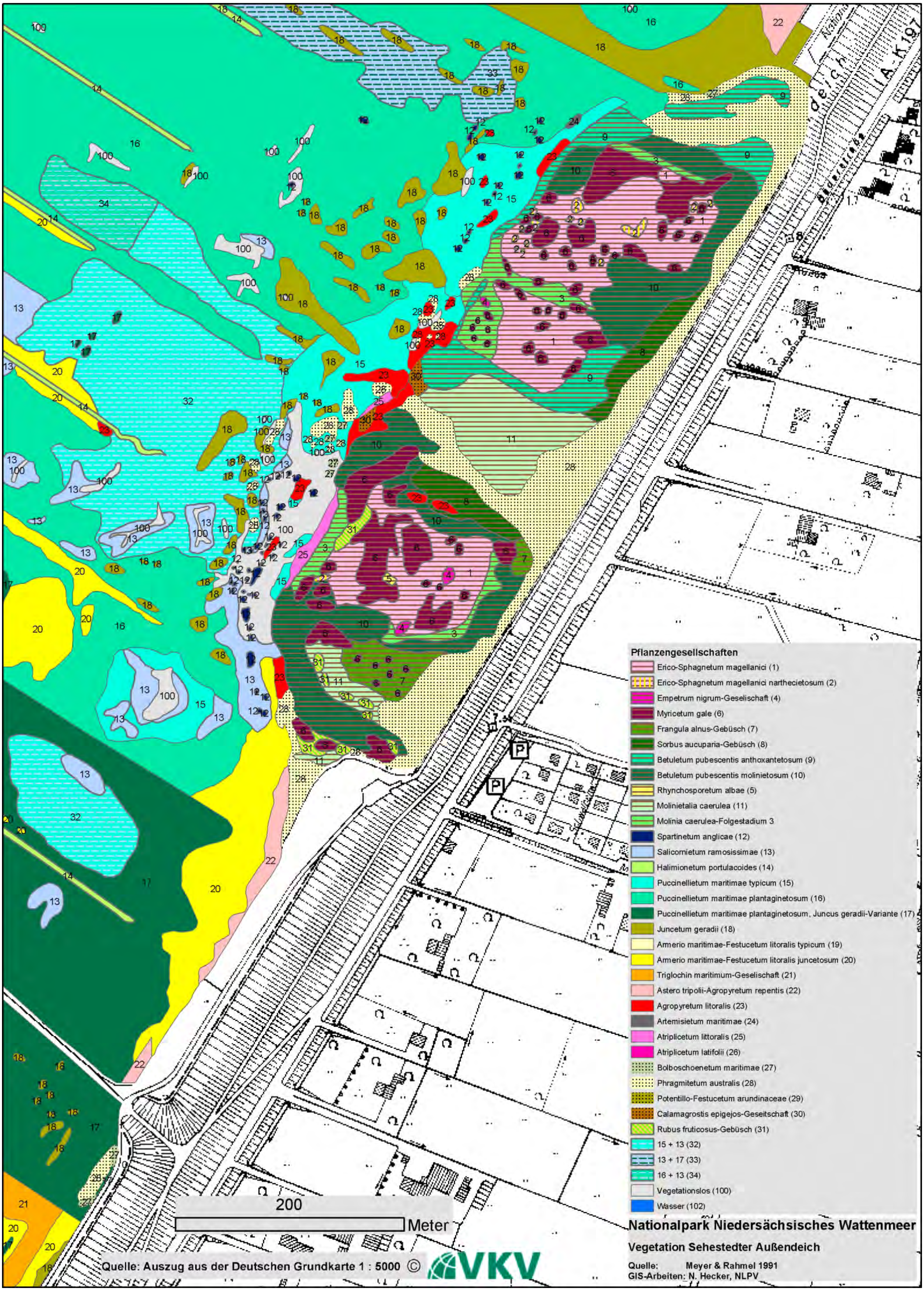
Freshly eroded peat chunks

Bog surface in spring with *Myrica gale*

By now the Sehestedt bog has become very small, but in its area it still protects the coast and the dike behind it is one meter lower than north and south of it. It is estimated that it helps to protect the dike until about 2040 and that smaller parts of the Sehestedt bog may withstand until the end of this century.

Nowadays everywhere along the coast the dikes are increased to meet the expected rise of the sea level. Such dikes have to be constructed much broader because of the soft clay underground. In this special case it would mean that about half of the bog would have to be given up. To avoid this, an iron sheet-pile wall was driven into the dike to provide additional safety.

Apart from its eminent geological value the Sehestedter Moor is also very important for plants and animals. Although it dries out continuously and is influenced by salt spume during storm floods it is still ombrotrophic in large parts and several typical plants of the raised bog have survived. That includes more than ten *Sphagnum* species, two species of *Drosera* as well as *Rhynchospora alba*. It is also a refuge for several rare birds and many small animals.


Pflanzengesellschaften
Erico-Sphagnetum magellanici (1)
Erico-Sphagnetum magellanici narthecietosum (2)
Empetrum nigrum-Geselischaft (4)
Myricetum gale (6)
Frangula alnus-Gebüsch (7)
Sorbus aucuparia-Gebüsch (8)
Betuletum pubescentis anthoxantetosum (9)
Betuletum pubescentis molinietosum (10)
Rhynchosporetum albae (5)
Molinietalia caerulea (11)
Molinia caerulea-Folgestadium 3
Spartinetum anglicae (12)
Salicornietum ramosissimae (13)
Halimionetum portulacoides (14)
Puccinellietum maritimae typicum (15)
Puccinellietum maritimae plantaginetosum (16)
Puccinellietum maritimae plantaginetosum, Juncus geradii-Variante (17)
Juncetum geradii (18)
Armerio maritimae-Festucetum litoralis typicum (19)
Armerio maritimae-Festucetum litoralis juncetosum (20)
Triglochin maritimum-Geselischaft (21)
Astero tripolii-Agropyretum repentis (22)
Agropyretum litoralis (23)
Artemisietum maritimae (24)
Atriplicetum littoralis (25)
Atriplicetum latifolii (26)
Bolboschoenetum maritimae (27)
Phragmitetum australis (28)
Potentillo-Festucetum arundinaceae (29)
Calamagrostis epigejos-Geseitschaft (30)
Rubus fruticosus-Gebüsch (31)
15 + 13 (32)
13 + 17 (33)
16 + 13 (34)
Vegetationslos (100)
Wasser (102)
200
Meter
Quelle: Auszug aus der Deutschen Grundkarte 1 : 5000 ©
VKV
Nationalpark Niedersächsisches Wattenmeer
Vegetation Sehestedter Außendeich
Quelle: Meyer & Rahmel 1991
GIS-Arbeiten: N. Hecker, NLPV

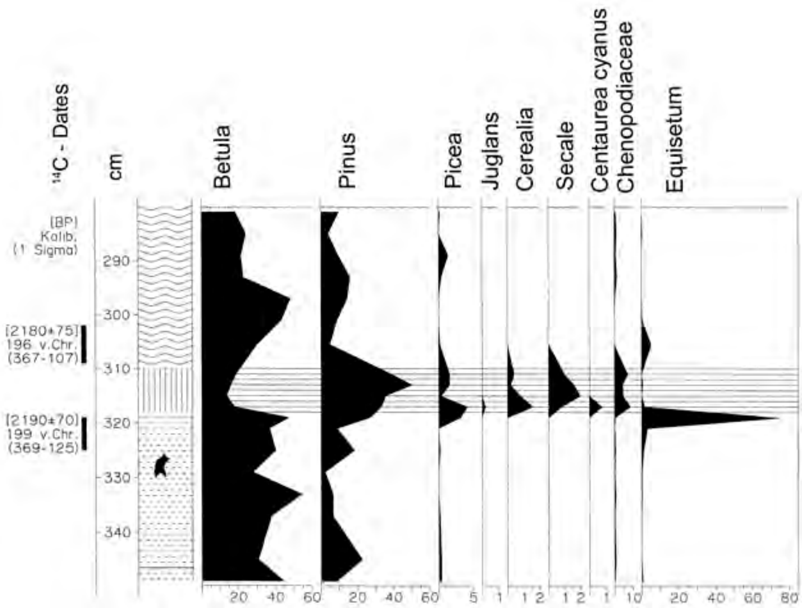
For the vegetation history the Sehestedter Moor is a very important archive as it is the last remnant of the former huge bog and the only place in a wide region where a pollen diagram could be elaborated. The pollen diagram is presented here in a short form only. Apart from the youngest part, when the raised bog became smaller and was even cultivated in some parts, the pollen diagram shows the local bog vegetation, which produces only little pollen, and the pollen input from the wide area around from where mainly the tree pollen came.

In the lowest part of the diagram the vicinity of brackish or marine environments can be seen, expressed in the declining curve of Chenopodiaceae. The tree pollen of the *Klappklei* layer (see also the detail diagram) is characterized by high percentages of *Pinus*, which is common in marine sediments as well as some *Picea*, not native in NW Germany and occurring here as redeposited and far distance transport. Important is the record of *Juglans*, *Secale* (up to 2%!) and *Centaurea cyanus* long before these species reached this region. They confirm that the material of this layer is younger than the peat above, where these species disappear again. There are two 14C-dates from below and above the clay layer: 2190±70 respective 2180±75 years BP.

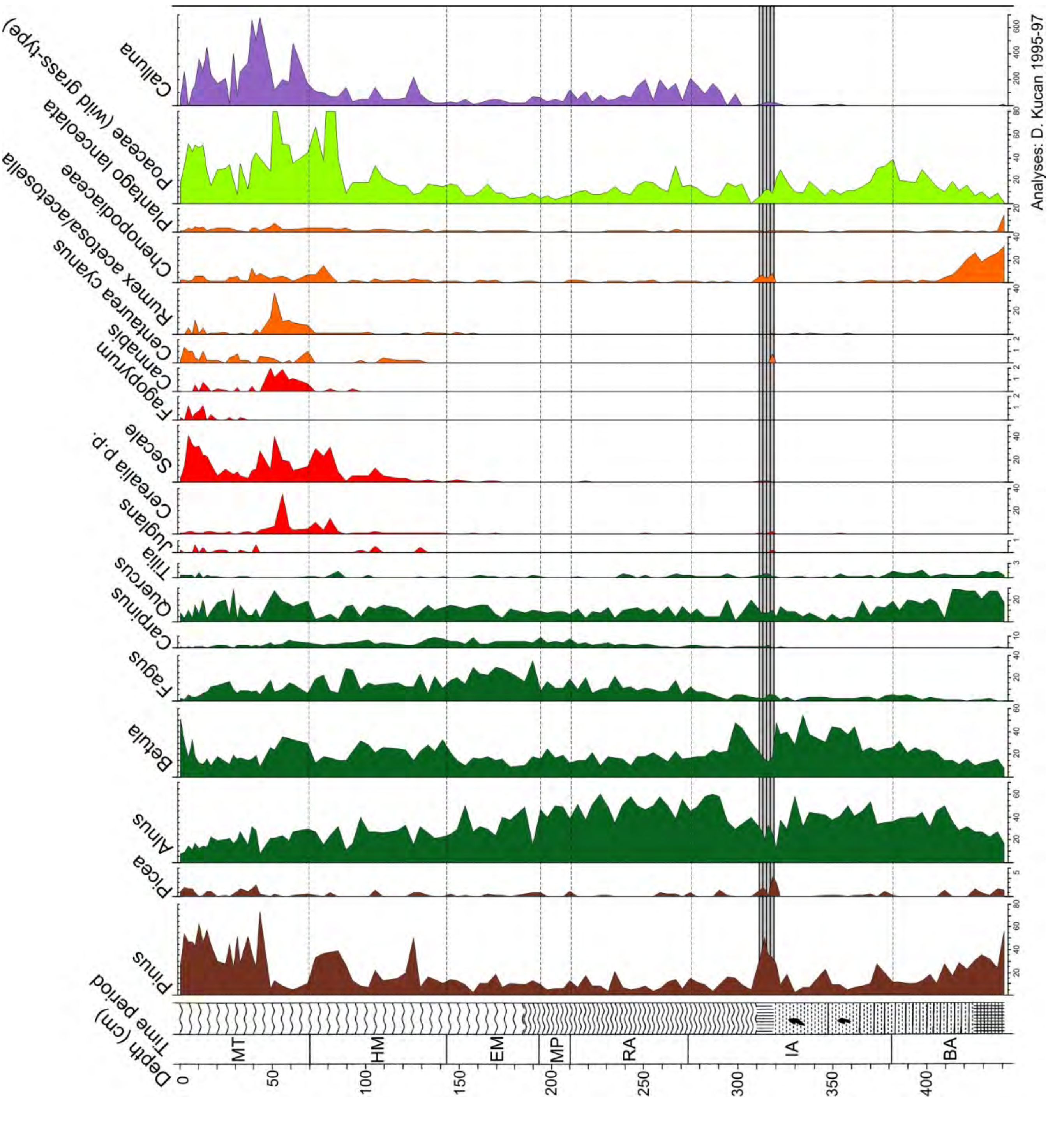
The upper part of the pollen diagram shows the history of agriculture upon the bog and around. The start of the *Secale* curve points to the rye cultivation on the Pleistocene ground 10 km away, but since the Late Medieval period, when *Secale* reaches remarkable 31 %, rye was grown on the peatbog itself, together with *Avena strigosa* (hidden in Cerealia p.p.), which is supported by written sources. Later also *Fagopyrum esculentum* was cultivated here, which at that time was a common fruit on the poor soils of the raised bogs in NW Germany and the Netherlands. *Cannabis* on the other hand has never been grown on the bog, but in the Clay District around, where Medieval macro-remains were found. The considerable increase of Poaceae indicate the cultivation of small parts of the bog for grazing, for which as for the fields, manuring was necessary. Together with Chenopodiaceae the grasses also show that the salt marshes came closer to the coring point in the course of the destruction of the bog.

The Sehestedter Moor has been a nature reserve since 1938 and is strictly protected. 1986 it became part of the national park Niedersächsisches Wattenmeer, together with all salt marshes around the Jade Bay. Only in 2007 a wooden trackway was constructed along the southern margin of the bog in order to open it at least slightly for the public.

Stratigraphy with *Klappklei*



Pollen diagram: Detail from the *Klappklei*



Pollen diagram Sehestedt bog

Probleme der Küstenforschung im südlichen Nordseegebiet | 26 | 35-64 | Oldenburg 1999

Neue Untersuchungen am Außendeichsmoor bei Sehestedt am Jadebusen

Von KARL-ERNST BEHRE und DUŠANKA KUČAN

Mit 4 Tabellen und 21 Abbildungen

Inhalt: Das Sehestedter Außendeichsmoor wurde mit Hilfe von 40 Bohrungen systematisch untersucht. Dabei konnte festgestellt werden, daß die zwischen dem liegenden Niedermoortorf und dem darauf folgenden Hochmoortorf eingelagerte Tonschicht in dem gesamten Moor vorhanden ist. Sie wird beim Aufschwimmen des Hochmoorteils bei hohen Sturmfluten dort abgesetzt. Pollenanalysen bestätigten, daß dieser Klappklei jünger ist als der darüberliegende Torf. Ein neues detailliertes Pollendiagramm umfaßt den Bereich der letzten 3000 Jahre und hat mit 9 Radiokarbondaten ein absolutes Zeitgerüst. Es reflektiert die Vegetations- und Siedlungsgeschichte des Weser-Jade-Raumes. Roggen, Hafer und Buchweizen sind seit dem Mittelalter auf dem Moor angebaut worden. Ab etwa 1500 wurde in der benachbarten Marsch auch Hanf kultiviert. - Mehr als 300 Bohrungen lieferten Material zum Aufbau des Holozäns am Ostrand des Jadebusens, das hier vielfach durch sehr weichen Ton gekennzeichnet ist. Dieser ist Ursache für häufige starke Grundbrüche beim Deichbau, deren Folgen an mehreren Beispielen beschrieben werden.

Schlüsselwörter: Nordwestdeutschland, Holozän, Moore, Pollenanalyse, Vegetationgeschichte, Deichbau.

Abstract: The Sehestedter Außendeichsmoor represents the remnants of an extensive raised bog that originally covered large areas on both sides of the present dike. The remnant on the seaward side, the Sehestedter Außendeichsmoor, shows the unique phenomenon of floating, i. e. being uplifted, during severe storm surges. The bog has now been systematically investigated by means of 40 corings. The results of these corings show that a clay layer is everywhere present between the basal fen peat and the overlying *Sphagnum* peat. The clay is deposited as the bog is uplifted during storms. The clay is thus younger than the peat above it, a fact demonstrated by pollen analyses. - A newly constructed pollen diagram, which includes nine radiocarbon dates, spans the last 3000 years. The data provide a detailed history of vegetation and settlement in the Weser-Jade region. Rye, oats and buckwheat were grown on the bog from the Middle Ages onwards, and starting at ca. A. D. 1500 hemp was cultivated in the adjoining Clay district. - More than 300 corings along the eastern margin of the Jade bay, i. e. in the wider study area, provided evidence of sedimentation patterns within the wider region during the Holocene. The sediments consist mainly of very soft clay that provides a poor foundation for the overlying dikes. Examples of dike damage due to compaction and displacement of the underlying clays are provided.

Key words: NW Germany, Holocene, Bog, Pollen analysis, Vegetation history, Sea level, Diking.

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Die Auswirkungen der Wintersturmfluten 2006/2007 auf das Sehestedter Außendeichsmoor (SO-Jadebusen)

Karl-Ernst Behre

Abstract: The bog of Sehestedt, situated outside the dike at the south-eastern shore of the Jade Bay, represents the remnants of an extensive raised bog that originally covered the whole Jade Bay and the surroundings. The flooding of this bog was prevented by its floating on the seaward side during high storm surges. By erosion from the sea its size has been reduced to only 9.6 ha by now. During the winter 2006/2007 severe damages occurred due to several strong storm surges. The whole bog was lifted and the complete southern part was torn off and drifted around 5 m southwards and at the same time 1–2 m up onto the dike. At its edges peat walls bulged, while along the separation line a channel came into existence, which now runs at right angle across the whole bog to the dike. Damages occurred along the peat cliff, too, where strong erosion took place. Here, the reed belt that had grown up in recent years slowed down the attacks of the waves.

Einleitung

Das Sehestedter Außendeichsmoor im Südosten des Jadebusens ist wohl das interessanteste geologische Objekt in Nordwestdeutschland. Es ist der letzte Rest des riesigen Moores, das einmal den heutigen Jadebusen ausgefüllt hat und dessen Fortsetzung binnendeichs das inzwischen vollständig kultivierte Schweier Moor bildet, das sich weiter unter den Namen Rönnelmoor und Ipweger Moor nach Süden bis an die Hunte erstreckt.
Entstanden ist das Moor um 1500 v. Chr., als der damalige Ur-Jadebusen als Folge einer Meeresspiegelabsenkung aussüßte und verlandete (Behre 2005). Zunächst bildeten sich ausgedehnte Niedermoore, die um 200 v. Chr. großflächig in ein Hochmoorwachstum umschlugen. Diese Moore wurden während der Dünkirchen Ib-Transgression seeseitig überschlickt; dabei bildete sich dort ein Uferwall, der die Torfe im eigentlichen Jadebusenbereich von der See abschirmte. Diese Sietlandmoore wuchsen zudem in Form von Hochmooren schneller als der Meeresspiegel anstieg, sodass sie sich auch dadurch vor Überflutung schützten.
Ab dem 13. Jhdt. brach der Jadebusen ein und die Sturmfluten räumten nach und nach die dortigen Torfe aus, die dem Wasser nicht viel Widerstand boten. Bereits im 13. Jhdt. war die See an Varel vorbei bis in die Friesische Balje vorgestoßen (Behre 1999). Dabei zeigte sich an der seeseitigen Kante der Hochmoore ein eigentümliches Phänomen: die Moore schwammen auf und verhinderten die Überflutung, obwohl sie am Rande ständig weiter erodiert wurden.
Bei diesem Aufschwimmen riss der Torf in der Regel an der Grenze Niedermoor-/Hochmoortorf unten ab, in den dabei entstehenden Spalt drang Seewasser ein und hinterließ dort tonige Sedimente, die sich heute vielerorts in Bohrungen – nicht nur am Jadebusen – finden. Dieses Phänomen des Aufschwimmens lässt sich heute in Europa nur noch an dem Sehestedter Außendeichsmoor studieren und macht dieses deshalb zu einem überaus wichtigen mobilen geologischen Bodendenkmal.

Die bisherige Entwicklung des Außendeichsmoores

Aufbau und Geschichte des Sehestedter Moores wurden kürzlich in einer Monographie vorgelegt und darin die gegenwärtigen Verhältnisse dokumentiert (Behre 2005, vgl. auch Behre & Kučan 1999). Die ältesten Berechnungen zu seiner Größe gehen bis 1620 zurück. Damals war das gesamte Gebiet des südöstlichen Jadebusens zwischen dem Hobendeich im Norden und dem Jader Aufdeich im Süden noch unbedeicht, da hier im Gegensatz zu den übrigen Küstengebieten das Moor durch sein randliches Aufschwimmen das Hinterland vor Überflutungen schützte.

The Neuenburger Urwald –
an outstanding historic woodland in Lower Saxony

During Medieval and early Modern Times almost the entire Pleistocene region in NW Germany was covered with heaths; only in very small areas woodland existed then. One of these places was the Neuenburger Urwald west of Varel, which nowadays is of course no primeval forest as the name suggests, but woodland that has been utilized and transformed by man for many centuries.

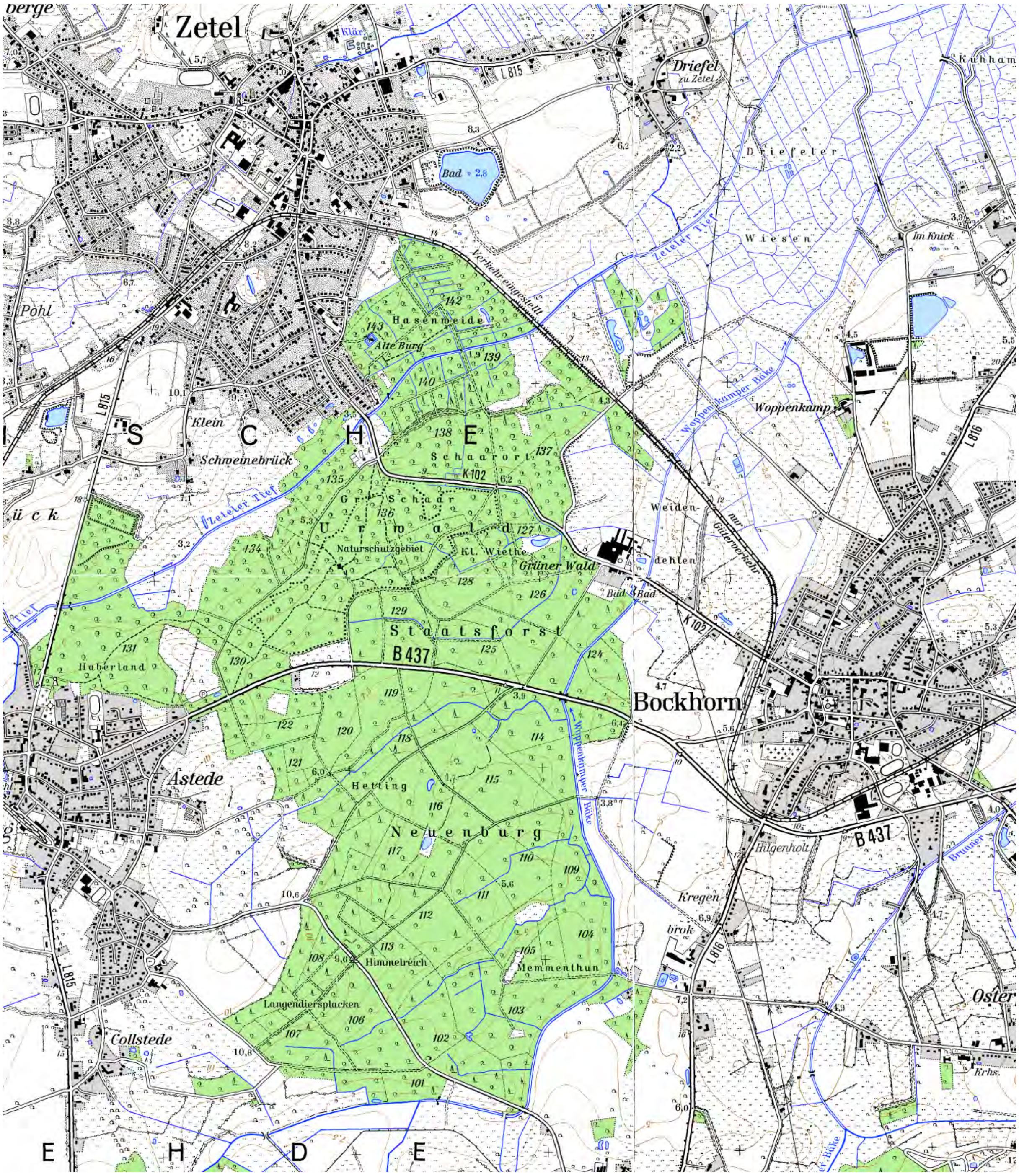
In addition to this old wood large parts of the former heathland around have been afforested within the last 150 years, mainly with conifers, which are introduced.

Last impression of the former grazed forest

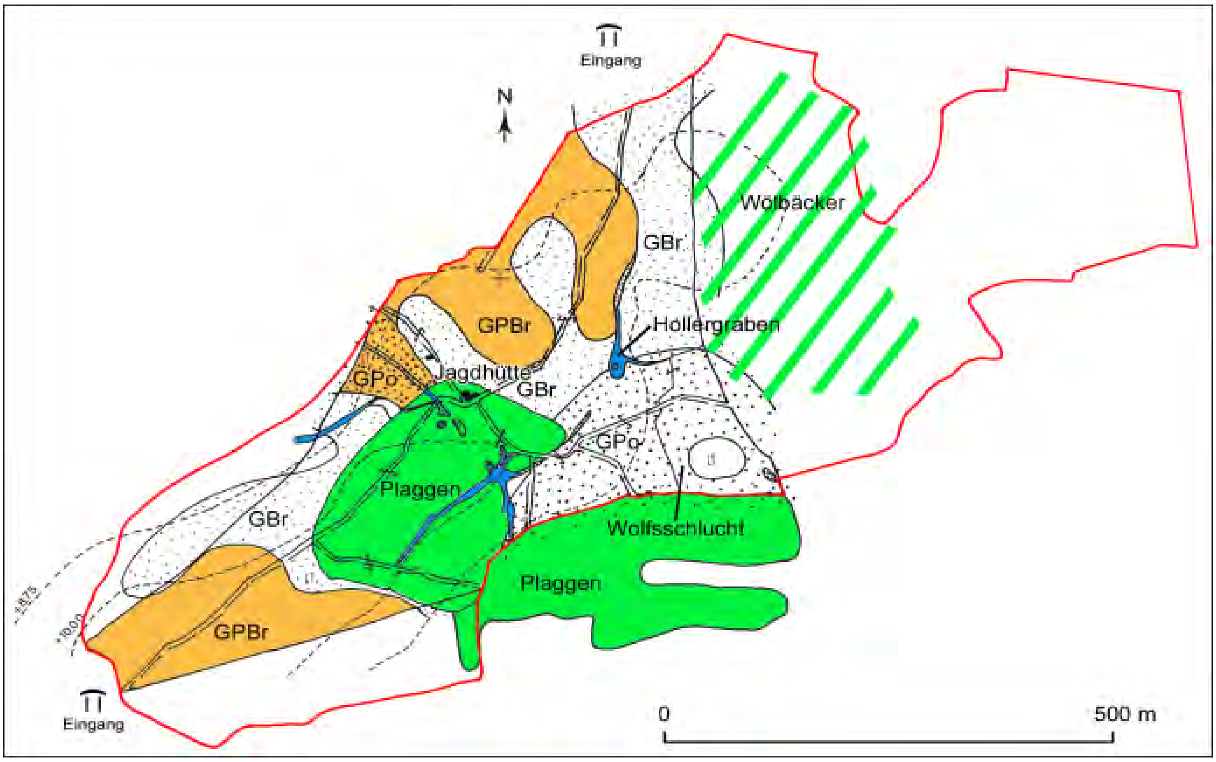
The Neuenburger Urwald is situated on relatively good soils: Lauenburg clay of Late Elsterian origin is covered by a thin layer of Saalian (Drenthe) till. There are no pollen diagrams from the forest area, but the recent “natural” development shows the climax vegetation or at least the potential natural vegetation of nowadays. It comprises mainly three forest communities: oak-hornbeam-forest (Stellario-Carpinetum), beech-oak-forest (Fago-Quercetum) and wood millet-beech-forest (Milio-Fagetum).

This forest has been used in many ways since the Middle Ages and there are many written and other sources about this. After the repopulation in the Early Middle Ages there existed several settlements in this area and their fields, manured with plaggen, could be traced in the wood.

As a consequence of the Black Death in the 14th century, these fields as well as some settlements were abandoned and the count of Oldenburg took possession of the area which became wooded more or less naturally. However, the farmers around maintained the rights of forest grazing.



Topographic map of the Neuenburg forests



Soil map of the *Neuenburger Urwald*. White: sandy soils; yellow: loamy soils, green: old fields.

During the early Modern period the shortage of timber increased considerably, mainly due to ship building and the demands of the treeless Clay District to the north. Therefore Anton Günther, the famous count of Oldenburg, initiated in the 17th century a large scale afforestation of this area with almost exclusively common oak (*Quercus robur*) because of its high prices. So this was by no means natural woodland but a timber forest, grazed by cattle.

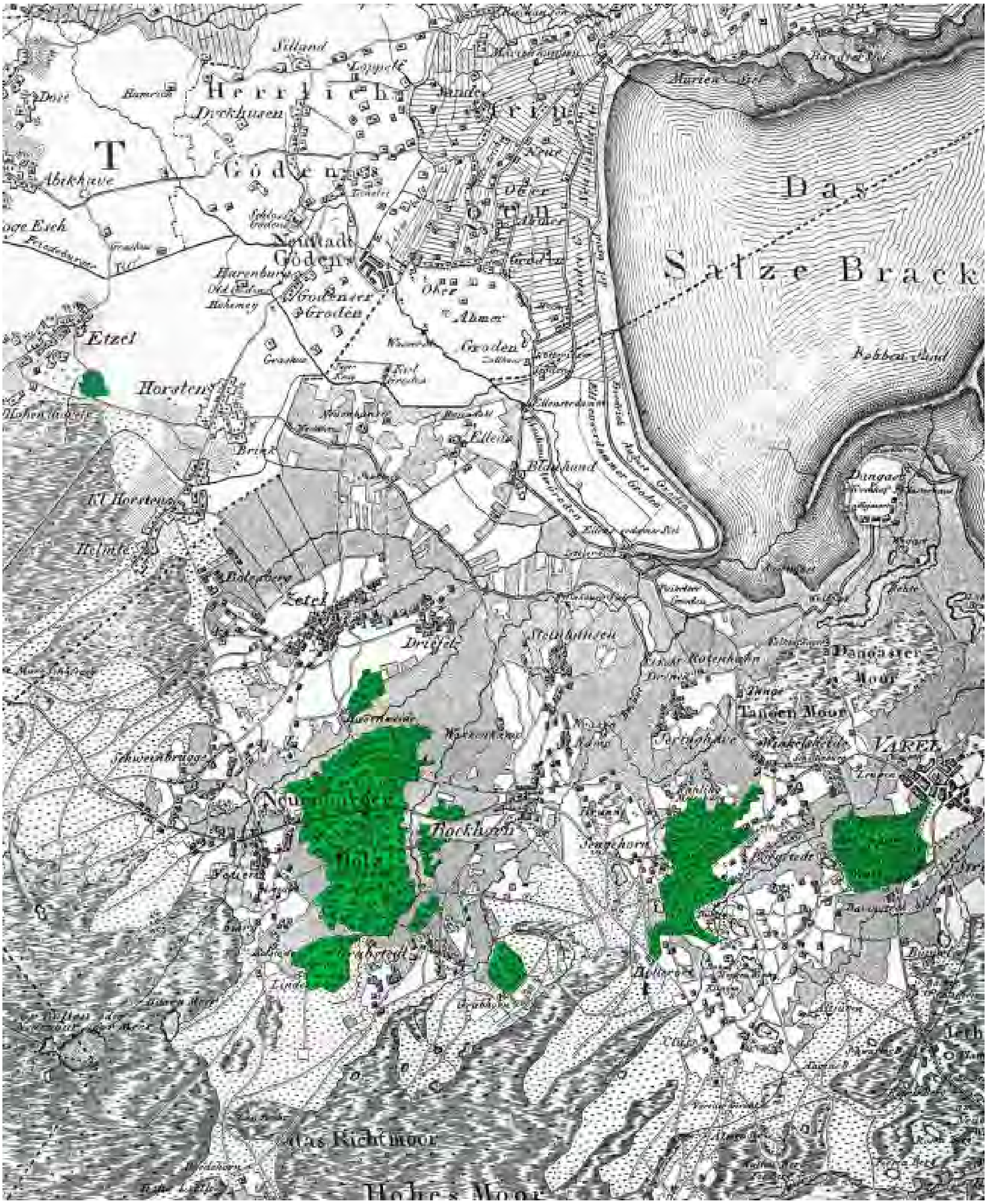
During the Danish period of Oldenburg (1667-1773) the forest was severely exploited and several farmers from the neighbourhood acquired small private plots in the forest as pastures, the boundaries of which can still be seen as slight banks and ditches in the Urwald.

Boundary of an old private plot

Detail of the first map of the Neuenburger Urwald from 1782

After this period a complete reconstruction of the forest took place. In this connection a precise forest map was produced 1782, probably one of the oldest of this kind in northern Germany. Now new plantations were made in the large clear cut areas, however, not only with oak but now also with beech and hornbeam. Often two or more seedlings were planted together in one hole in order to have at least one tree that grows up. However, in many cases two or even more developed, forming twins or even bunch trees, which are still now frequent in the Urwald.

From this time the Urwald has been used not only for timber but for many other purposes. Many written sources tell us that the humic soil surface was removed to manure the fields, the litter was used for the cattle and pollarding as well as lopping were practised, too. But the most important factor that transformed the wood into a semi-open area was forest grazing. The farmers around the forests owned grazing privileges and a very sophisticated system was practised to answer the various demands of exploitation. According to a chronicle of 1792, 284 horses, 861 heads of cattle, 660 pigs and 1292 geese were driven into this forest. Before this also goats had been allowed. Numerous oaks were protected as mast trees, but everything else – sprouting trees and shrubs as well as herbs were eaten by the domestic animals, which caused high pressure upon this ecosystem.



Map by Lecoq, showing the few forests at 1805

Thus a park-like open forest, dominated by oaks, with a green floor mainly of grasses developed, which is documented in several paintings from the 19th century. From 1850 the government tried to ban forest grazing but with little success, so the wood pasture continued up to the 1920ies.

On the other hand, already in the middle of the 19th century the public interest in the beauties of this old forest started and as a consequence the central part, the Urwald area, was protected in the way that any utilization apart from grazing was forbidden. Now also recreation became a topic for the society and the middle classes discovered a passion to promenade, for which this old forest with its bizarre oaks and beautiful tree ensembles became a favourite target.

Oak, capped in order to get a wider crown for more mast

A strict nature protection regulation prohibiting forest activities, which has been intensified by law since 1938, lead to the strong spread of beech. This was enforced by the old drainage system, which favours *Fagus* in its competition against *Quercus*. The beeches occupied the open areas and soon overgrew the oaks so that many of these died. Nowadays the succession towards the potential natural forest has more or less finished in most parts of the protected area; some of the dead oak trunks are still standing upright, others have fallen down. In the underwood there took place a considerable expansion of *Ilex aquifolium*, favoured not only by the oceanic climate of the coastal region, but also by the advantage of having been present in the forest from the beginning, but being rather resistant to grazing. There exist impressive trees of *Ilex* with a height up to 15 m and a trunk diameter up to 29 cm.

Nowadays this old forest is one of the very few historic woodlands in Germany, where the different ways of former forest utilization such as pollarding and coppicing can be studied. Pollarding for instance often led to peculiar trees with a stump carrying several stems and forming typical candelabra. Some of the deformed trees, broken down, give the impression of dangerous ghosts, especially at night. Perhaps the most important treasure of the Urwald is the large amount of dead wood that offers special biotopes for some plants and many animals, in particular fungi, birds and insects.

Around the protected area the forest is still today endangered by the activity of the brick industry which for centuries has been using the weathered uppermost 2 m of the Lauenburg clay for bricks of excellent quality.

Forest grazing around 1870 (J. Preller)

Shredded hornbeam (*Carpinus betulus*)

Pollarded hornbeam (*Carpinus betulus*)

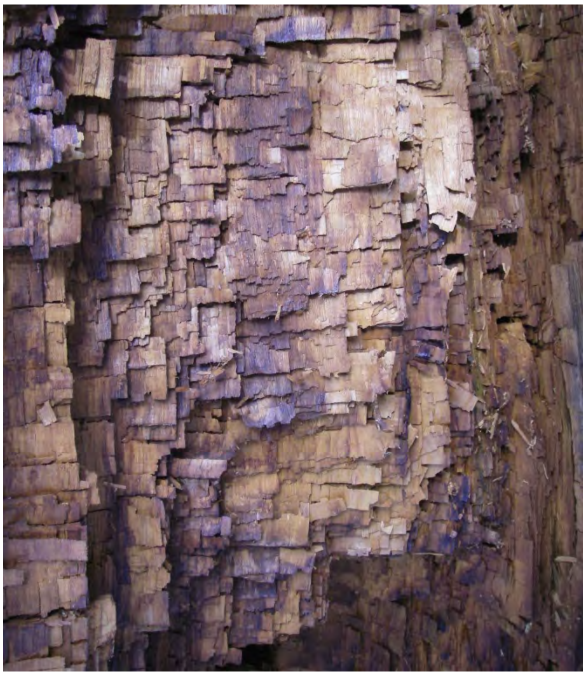
Bunch hornbeam (*Carpinus betulus*)

Oak and beech – twins, planted together
(*Quercus robur*, *Fagus sylvatica*)

Oak dead wood

Tinder fungus (*Fomes fomentarius*) on beech

Tinder fungus (*Fomes fomentarius*) in detail

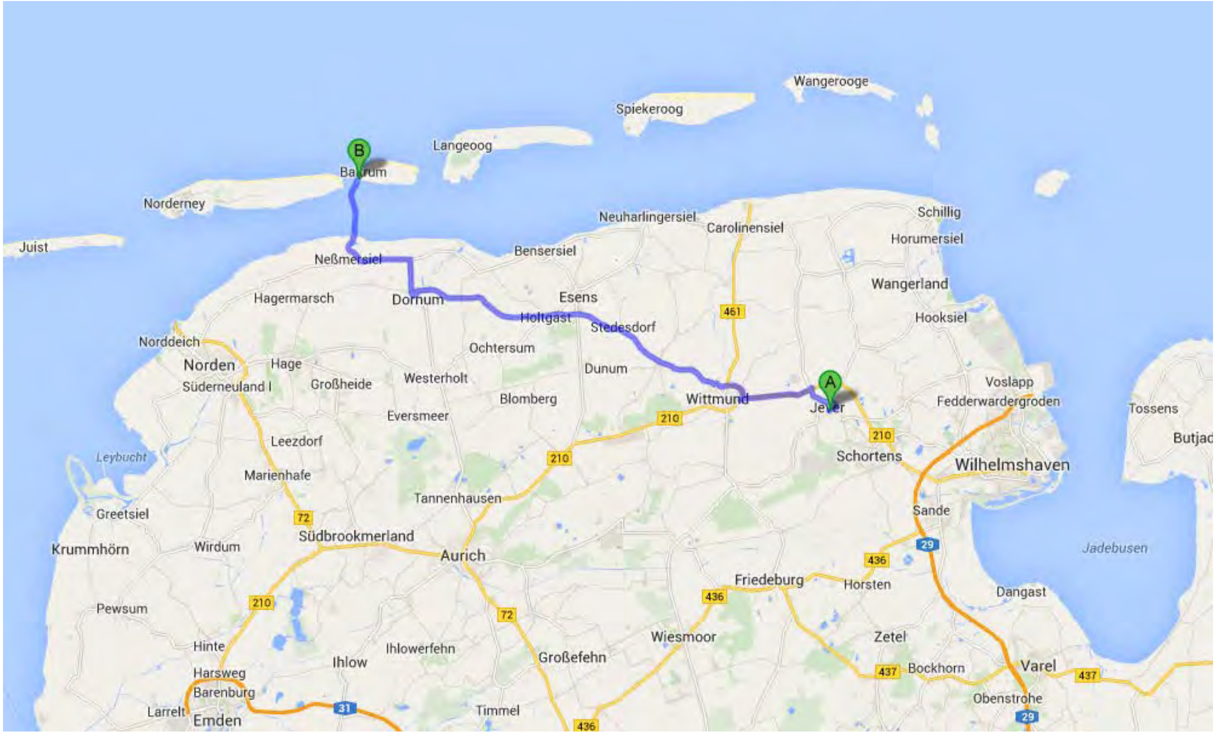


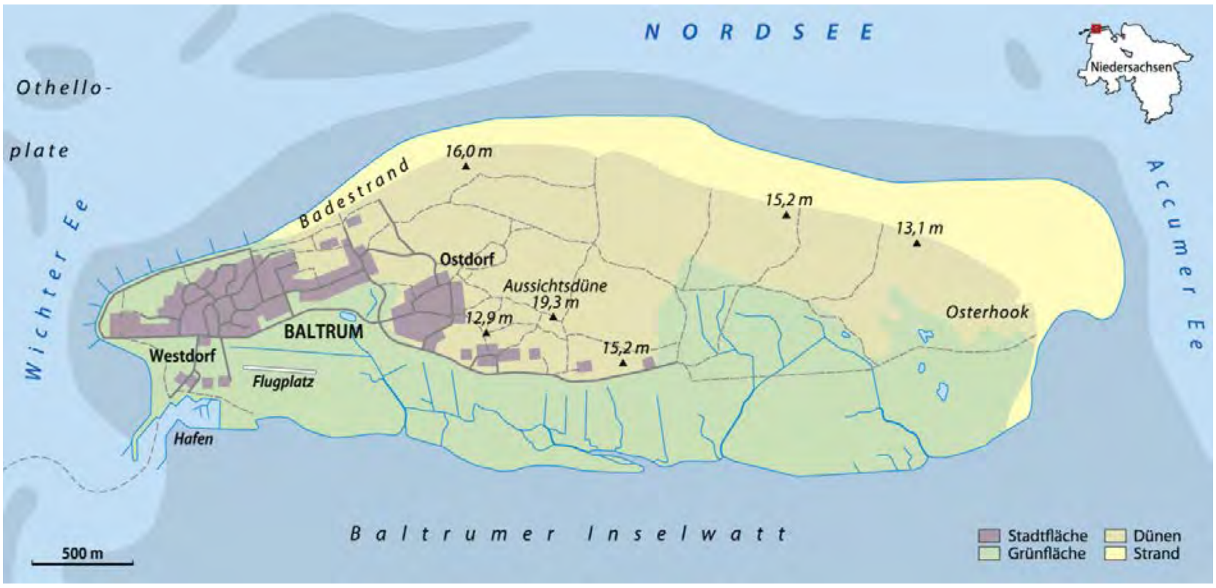
Heartwood affected by blight

Sapwood (oak)

Friday, 12.09.2014
Baltrum Island

Settlement and Cultural History of the Wadden Sea (J. Goldhammer & M. Karle)
Tidal flat development and genesis of the East Frisian Islands (F. Bungenstock)
Submerged prehistoric landscapes of the North Sea (S. Wolters)
Accomodation at Friesenhotel, Jever




N O R D S E E
Niedersachsen
Othello-
plate
Wichter Ee
Accumer Ee
Badestrand
16,0 m
15,2 m
13,1 m
Ostdorf
Aussichtsdüne
19,3 m
12,9 m
15,2 m
BALTRUM
Westdorf
Flugplatz
Hafen
Osterhook
Baltrumer Inselwatt
500 m
Stadtfläche
Grünfläche
Dünen
Strand

Some facts on Baltrum

Baltrum is a barrier island off the coast of East Frisia, in Germany, and is a municipality in the district of Aurich, Lower Saxony. It is located in the middle of the island chain known as the East Frisian Islands and is the smallest permanently inhabited island in the chain according to the area and number of inhabitants. The gut Wichter Ee in the west separates Baltrum from Norderney and the gut Accumer Ee in the east separates it from Langeoog. There are two villages on the island – Ostdorf and Westdorf – although they have essentially merged into one. The ferry for Baltrum departs from the small port near the village of Neßmersiel. The island has its own ferry terminal and a small airstrip.

The island is about 5 km long and 1.5 km wide. It covers an area of 6.5 square kilometres and has a population of 554 people (31.12.2012), rising to about 3,500 during the summer months due to tourism. The highest point on the island is a coastal dune with a viewing platform on top and rises 19.3 metres a.s.l.

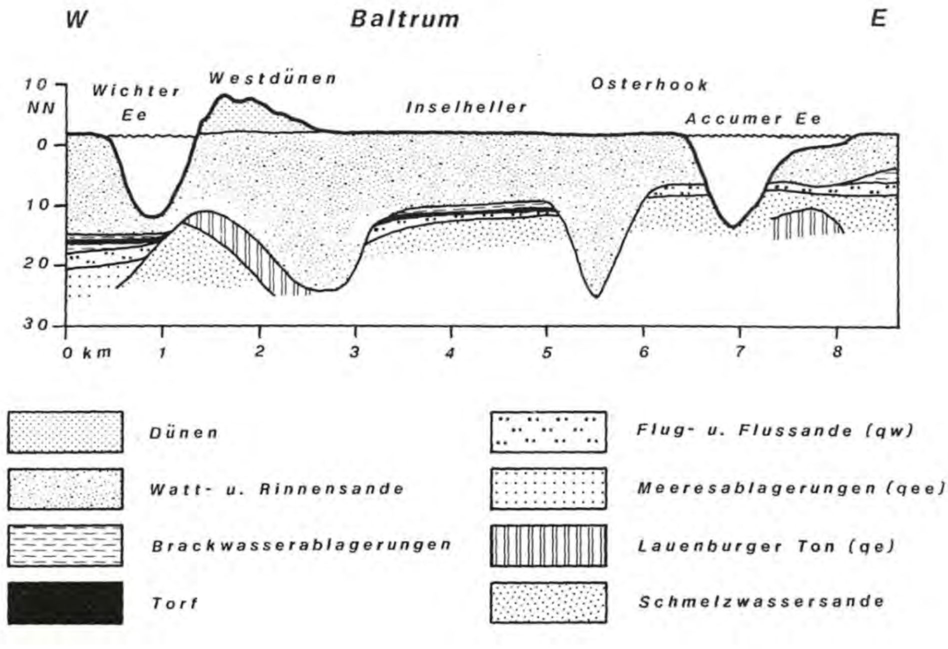
The origin of the name Baltrum is under dispute. In 1398, the island was mentioned for the first time in a document of enfeoffment as “Balteringe” meaning either "pasture" or "[the place of] the sons or followers of Balter" in Old Frisian. Another assumption is that the name is derived from the Germanic god Balder/Baldur. Other spellings were Baltrum or Baltern. However, since 1825 the name of the island is spelled Baltrum.

The geographers Strabo and Pliny the Elder provide an indication that the island existed since the first century BC and AD. During the era of the East Frisian chieftains, from 1350 to 1464, the East Frisian islands belonged to the powerful family tom Brok. In 1398 Widzel tom Brok assigned Balteringe (besides the other islands) to Duke Albert I of Bavaria and received them back as fief.

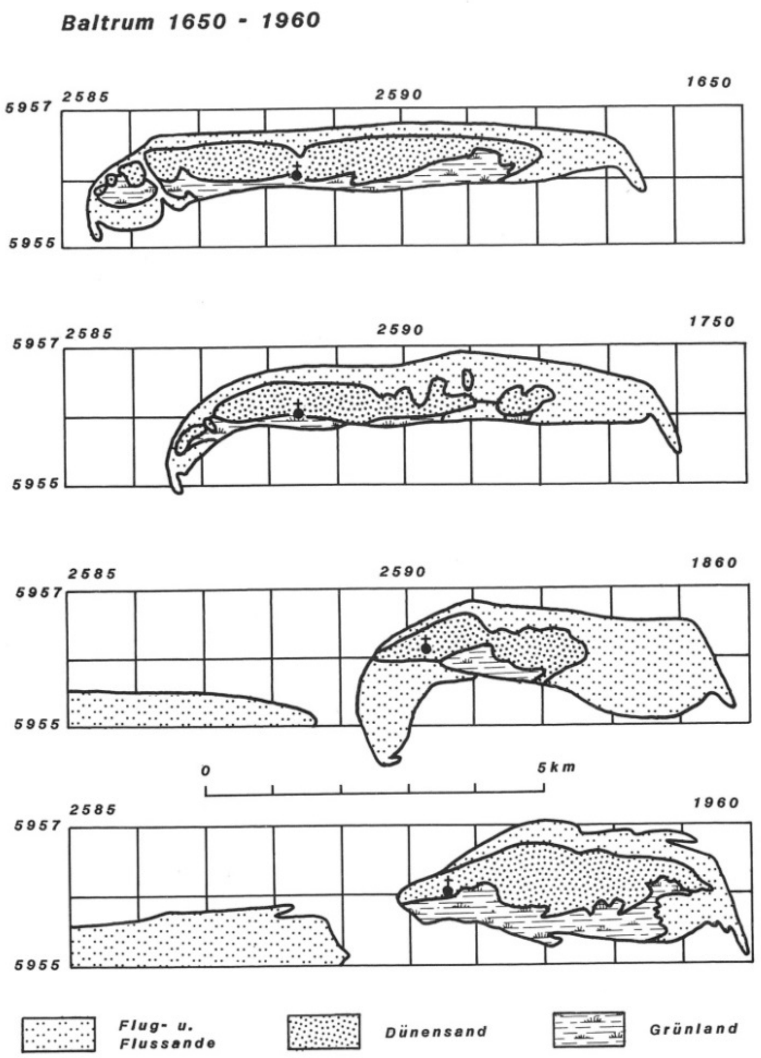
In the 17th century Baltrum had an elongated shape similar to the present shape of the barrier islands Norderney and Juist. Unlike any other East Frisian island Baltrum suffered a severe land loss at its western coast over the centuries and in return gained only little land at the east. Between 1650 and 1960 the island moved about 4.5 km at its west side to east, whereas the east coast moved only 1.5 km further to the east. This dynamic is caused by the tidal current in the gut between Baltrum and Norderney.

A committee in 1650 reports that the 14 inhabitants on the island of that time were in jeopardy by the sea. In 1737 there was one village with a church but it had to be abandoned in 1800 due to silting up of shifting sand dunes. The new village, named Westdorf, was founded c. 800 m to the west of the present day west coast on a nowadays sand plate between Baltrum and Norderney. A second village– Ostdorf – was founded 1820 in the east. Following a storm surge in 1825 which disrupted the island into several parts and made it virtually uninhabitable, Westdorf was abandoned and had to be rebuilt at the place of the present site. From 1873 onwards the island was protected against the power of the sea with groynes, wooden palisades and revetments. Furthermore levees are protecting the built-up area against floodings.

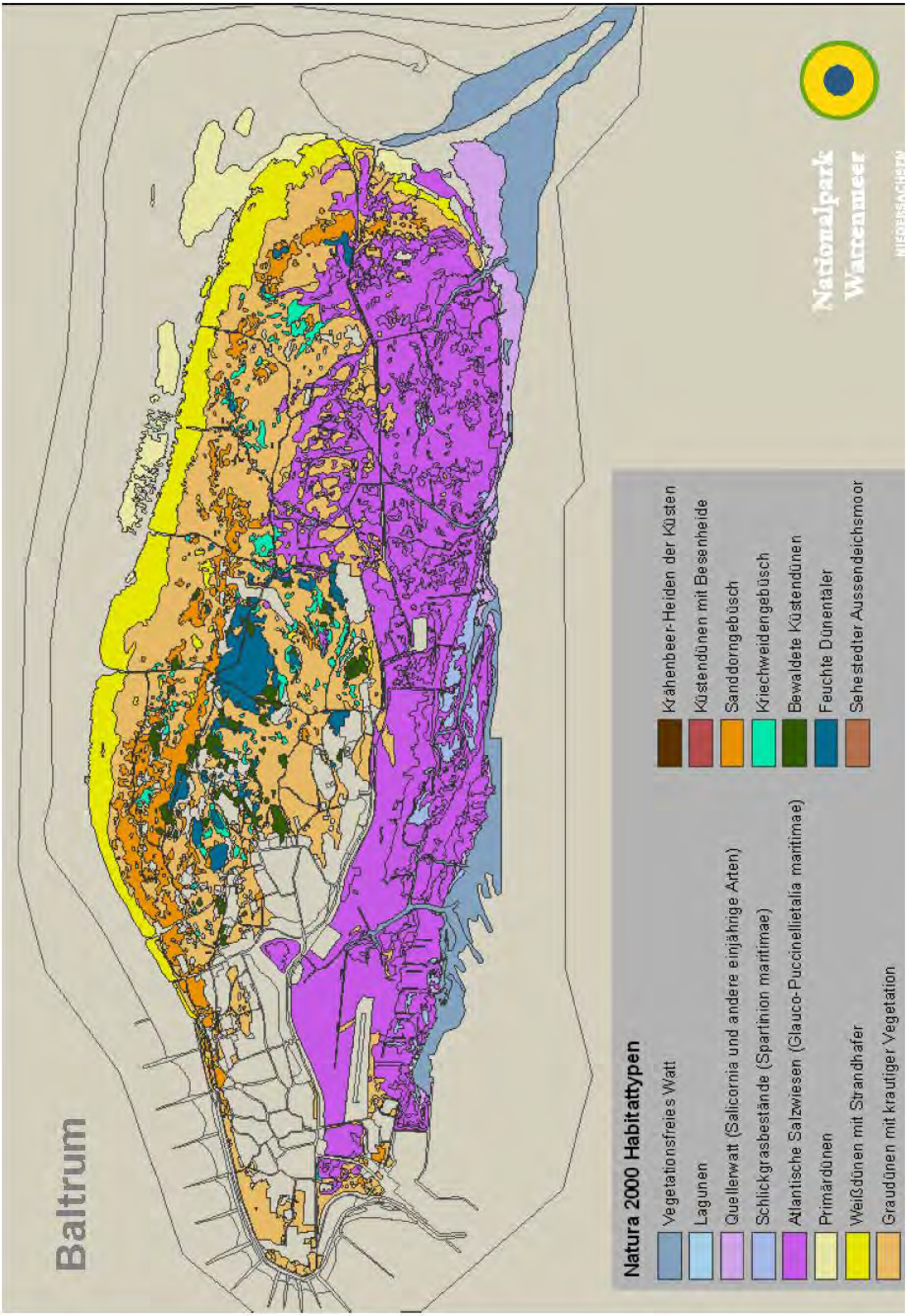
Although Baltrum became a seaside resort in 1898, tourism grew very slowly. Since 1966 Baltrum has been a seaside health resort approved by the state of Germany. Two hotels were opened in the end of the 19th century, Hotel Küper in 1892 and Hotel zur Post in 1895. Before the World War II broke out 5,000 to 6,000 people visited Baltrum annually. In 1960 nearly 17,000 tourists showed up rising to c. 30,000 in the 1970s. Today Baltrum is visited by c. 50,000 guests per year.



Geological profile section of Baltrum, after Sindowski (1973)



Historical development of Baltrum between 1650 and 1960


Baltrum
Natura 2000 Habitattypen
Vegetationsfreies Watt
Lagunen
Quellerwatt (Salicornia und andere einjährige Arten)
Schlickgrasbestände (Spartinion maritimae)
Atlantische Salzwiesen (Glauco-Puccinellietalia maritimae)
Primärdünen
Weißdünen mit Strandhafer
Graudünen mit krautiger Vegetation
Krähenbeer-Heiden der Küsten
Küstendünen mit Besenheide
Sanddorngebüsch
Kriechweidengebüsch
Bewaldete Küstendünen
Feuchte Dünentäler
Sehestedter Aussendeichsmoor
Nationalpark
Wattenmeer

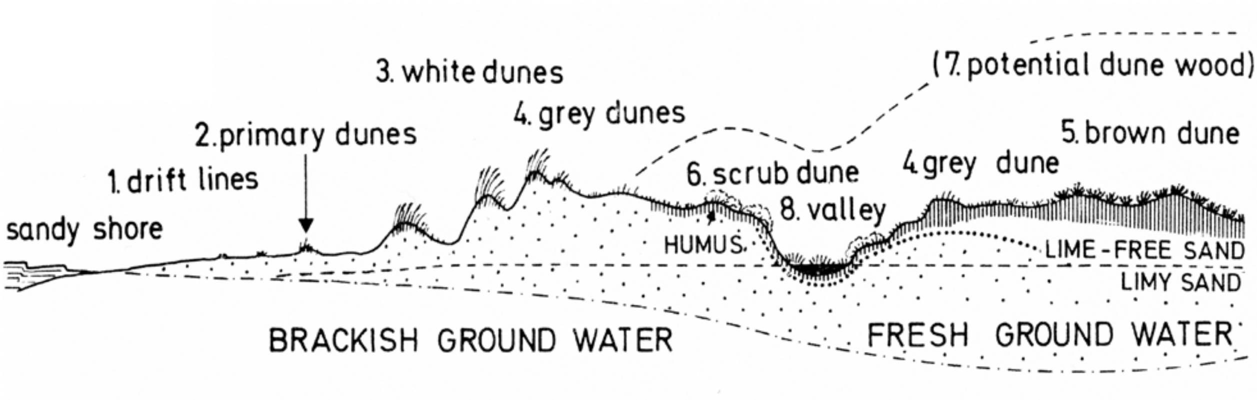
Flora and vegetation of the East Frisian Islands

The dunes at the northern exposed (seaward) side of the islands

Along the seaward coast of the barrier islands, the constant supply of sand lead to the formation of dunes which are a characteristic element on barrier islands. Sand grains, ground-up mussel shells and organic material washed ashore by wave action are transported by wind above the high water mark and deposited behind obstacles. Particularly important as dune builder is the grass *Ammophila arenaria*, a gras which traps sand between the stalks and is able to persist on the growing dune due to its rhizomes.

A series of plant communities takes part in the formation and further development of the coastal dunes (Ellenberg 1988). These are typically arranged in a series of successional zones. However, because of their importance for coastal defense, the natural geomorphological patterns have largely been modified and artificially fixed today, thereby losing their dynamics.

Along the drift lines, decomposing organic matter at the extreme high water mark facilitates the occurrence of annual nitrophytes (e.g. *Cakile maritima*, *Beta maritima*, *Atriplex litoralis*). Further inland, *Agropyron pungens*, *A. junceum* and *Ammophila arenaria* form 'primary dunes' which later developed to high 'white dunes' by continuous accumulation of sand. Typical plant species include *Eryngium maritimum*, *Lathyrus maritimus* and *Viola tricolor*. Eventually, sand accumulation ceases and more organic-rich 'grey dunes' develop with a plant cover consisting of short grasses and low herbaceous plants (e.g. *Jasione montana*, *Sedum acre*) as well as of mosses and lichens. This is accompanied by a rapid leaching of carbonates, leading to the formation of 'brown dunes' characterized by dwarf-shrub heathlands (e.g. *Empetrum nigrum*, *Calluna vulgaris*). Quite often, bushes can be found growing on the lee side of the dunes (e.g. *Hippophaë rhamnoides*, *Salix repens*). Neophytic species found in the dune vegetation include *Rosa rugosa*, *Senecio inequidens* and *Prunus serotina*.



Schematic zonation of dune vegetation along the North Sea Coast. In the absence of disturbance by man or domestic animals, trees or at least bushes would be found growing in the small depressions (valleys) and on the brown dunes (heath dunes) and probably also on the grey dunes. Leaching of carbonates takes place rapidly once the dunes stabilized. In larger dune complexes it is possible to find freshwater. This is rainwater which has drained through the sand is collected as a "cushion" above the more dense salt water (Ellenberg 1988).

Salt marshes and upper tidal flats at the southern sheltered (landward) side of the islands and at the mainland coast

The flora of a salt marsh is differentiated into levels according to the plants' individual tolerance to salinity and water table levels. The plant species must be able to survive high salt concentrations, periodical submersion, and a certain amount of water movement, while plants further inland in the marsh can sometimes experience dry, low-nutrient conditions.

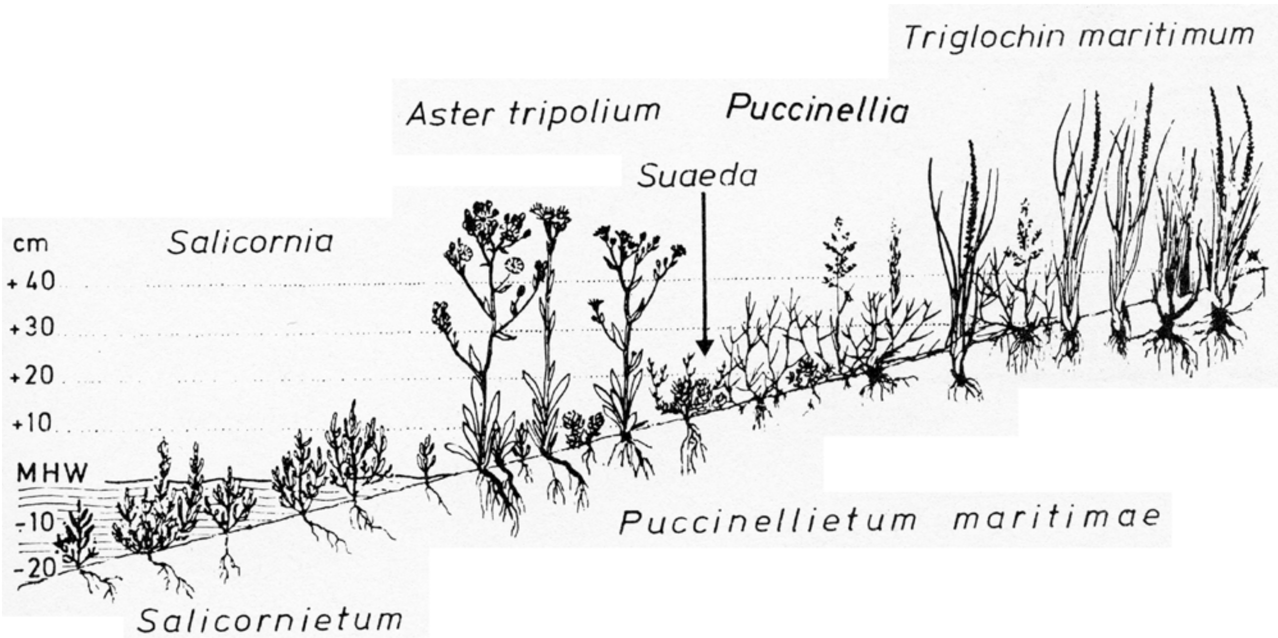
The most common salt marsh plants are glassworts (*Salicornia* spp.). They are the first plants to colonize a mudflat and begin its ecological succession into a salt marsh. Their shoots lift the main flow of the tide above the mud surface while their roots spread into the substrate and stabilize the sticky mud and carry oxygen into it so that other plants can establish themselves as well. Plants such as sea lavenders (*Limonium* spp.), plantains (*Plantago* spp.), and various sedges and rushes grow once the mud has been vegetated by the pioneer species.

Salicornia spp. as pioneer species.

Salt marshes form the upper parts of the intertidal zone, the interface between land and sea, and are strongly controlled by geomorphological, physical and biological processes, such as sedimentation in interaction with the vegetation, tidal regime and wind-wave pattern. They constitute a habitat for a wide range of organisms. On a European scale, among 1,068 plant species that are bound to coastal habitats, nearly 200 are restricted to salt marshes (van der Maarel and van der Maarel-Versluys, 1996).

Three main salt marsh zones with different vegetation can be distinguished: the pioneer zone where plant growth starts at about 40 cm below mean high tide (MHT); the low marsh, inundated during mean spring tides (100-400 floods/year), and the middle/high marsh with less than 100 floods per year. In addition, the sandy green beach and the brackish marsh can be differentiated by a special type of vegetation. Adjacent to the salt marshes fresh (anthropogenic) grassland occurs.

Salt marsh with *Limonium vulgare*. The species composition of salt marshes is determined by the frequency of flooding as well as by the intensity of grazing.



Schematic zonation of terrestrial plants at the German North Sea cost. The habitats depend on their position relative to the mean highwater mark (Ellenberg 1988).

The mainland salt marshes have a clearly different character than the island salt marshes; due to coastal protection activities the artificial mainland salt marshes show a higher proportion of the pioneer zone compared to the islands.

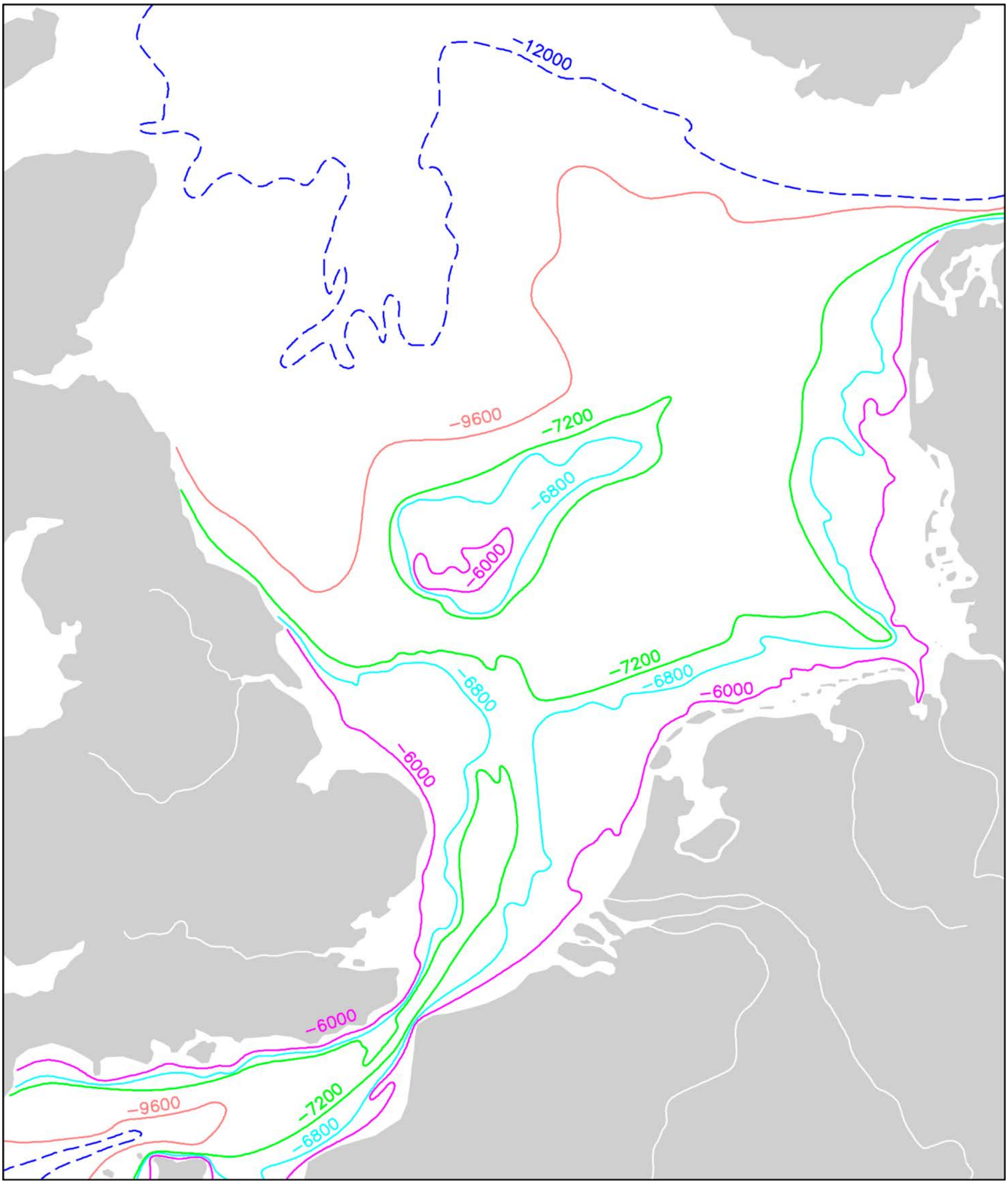
Settlement and Cultural History of the Wadden Sea area in Lower Saxony

The Wadden Sea area is characterized by strong tidal changes and sediment movements. Since the end of the last glacial period this amphibian landscape has gone through innumerous changes, and is still in motion. It was used by humans until the Holocene inundation took place. Contemporary sediment shifts give the opportunity to get insight into sunken settlements and palaeolandscapes but may also destroy the rich geological and archaeological record. In recent years, increasing coastal protection and offshore industries threatens the cultural heritage higher than ever.

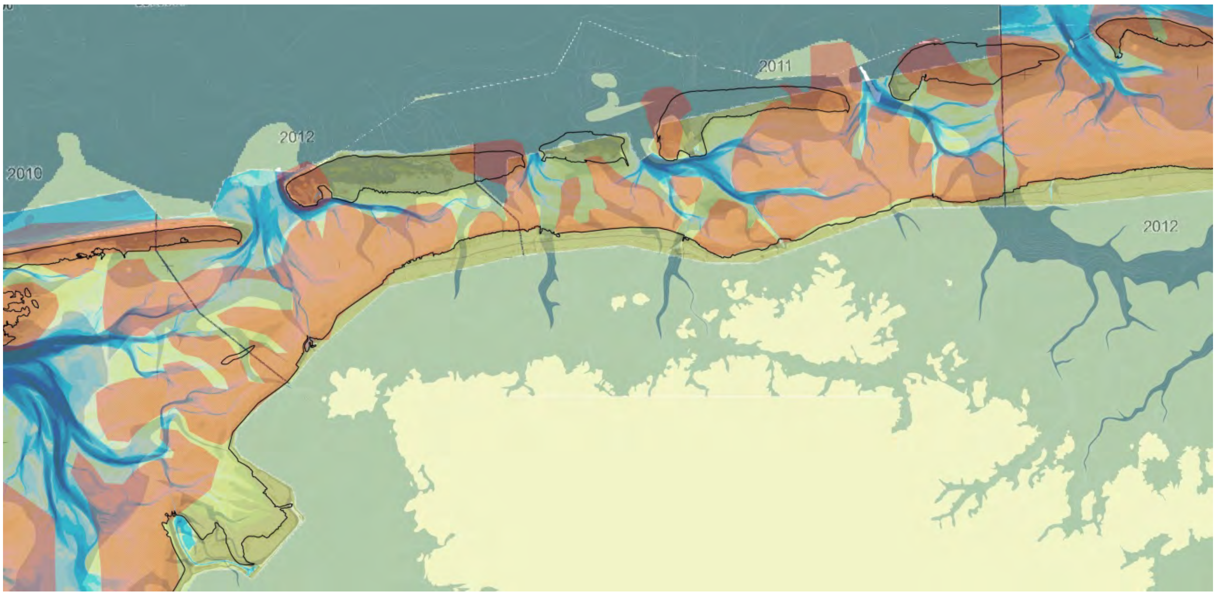
The project "Settlement and cultural history of the Wadden Sea area in Lower Saxony" aims to document the cultural heritage of the Lower Saxon Wadden Sea which covers a territory of 3,525 km². In this region, during low tide the seafloor falls dry and surveys are possible without diving equipment.

By analysing a variety of basic geological data, palaeogeographical changes of the modern coastal area will be reconstructed in order to identify zones of particular archaeological interest. The recording of known, the prospecting of new sites and the investigation and consecutive monitoring of both shows the research potential of this tidal region and will help saving the cultural archive before erosion destroys it. By this means the project aims to get new insights into the development and anthropogenic use of the Wadden Sea area.

Field work in the Wadden Sea area



Sea Level Rise and Changes on the North Sea coast since the last Ice Age (Behre 2008).



Work in progress example for areas with high potential of detecting archaeological finds in the Backbarrier Tidal Flats of Langeoog and Spiekeroog.

Wooden tidal outlet gate from late medieval times of Seriem, Backbarrier Tidal Flats of Langeoog (Niederhöfer 2010).

Human remains from burial ground near Ostbense, 5th century AD, Backbarrier Tidal Flats of Langeoog (Niederhöfer 2011).

Geomagnetic survey in the Wadden near Schillig

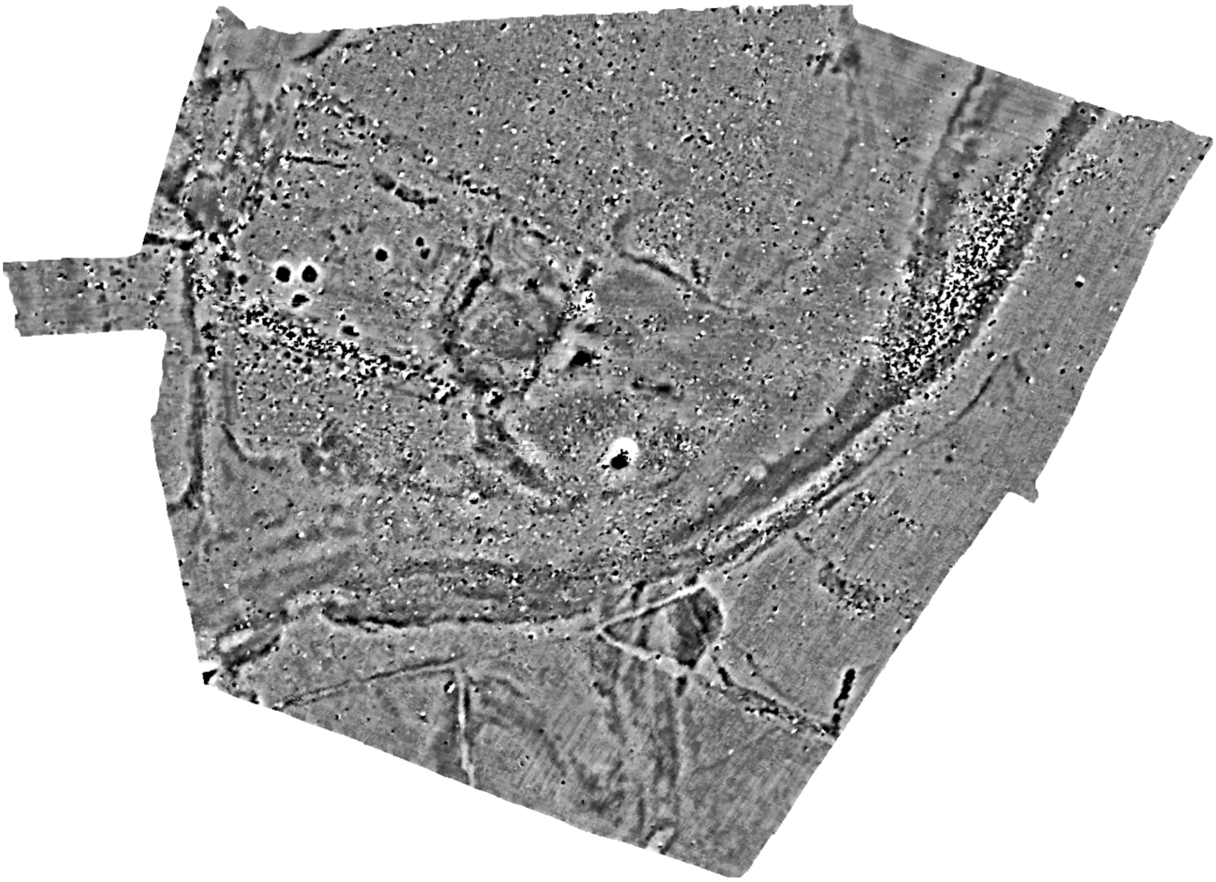
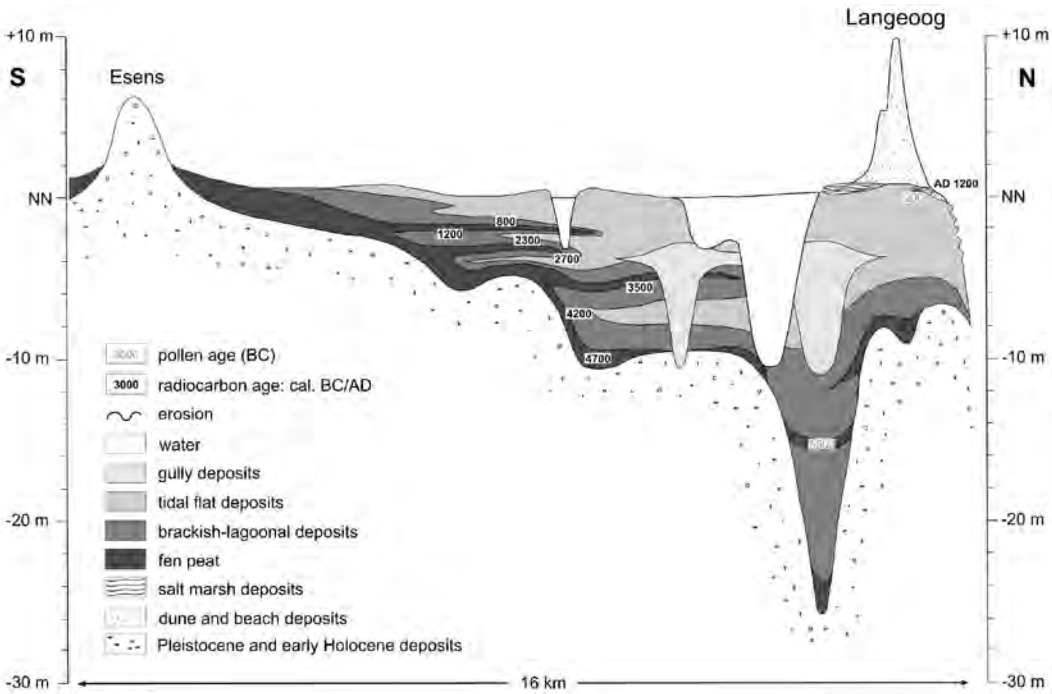


Chart of geomagnetic survey at a destroyed farm stead in the Wadden near Horumersiel

Fragments of „Werraware“, 16th-17th century, found at the farm stead in the Wadden near Horumersiel

Tidal flat development during the last 15 years

The German North Sea Coast



The coastal Holocene, schematic: Pleistocene high/plateau underneath the island, on top tidal flats, beach deposits and finally dunes (after STREIF 2004 and Bungenstock & Schäfer 2009)

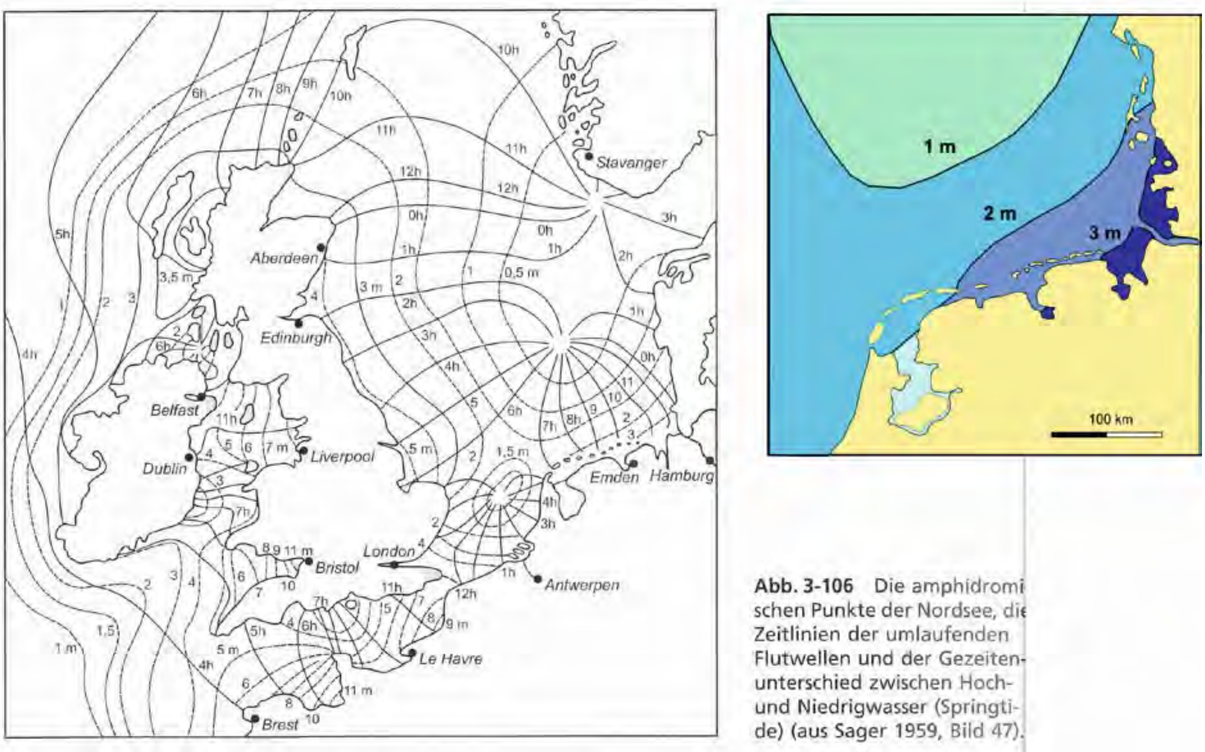
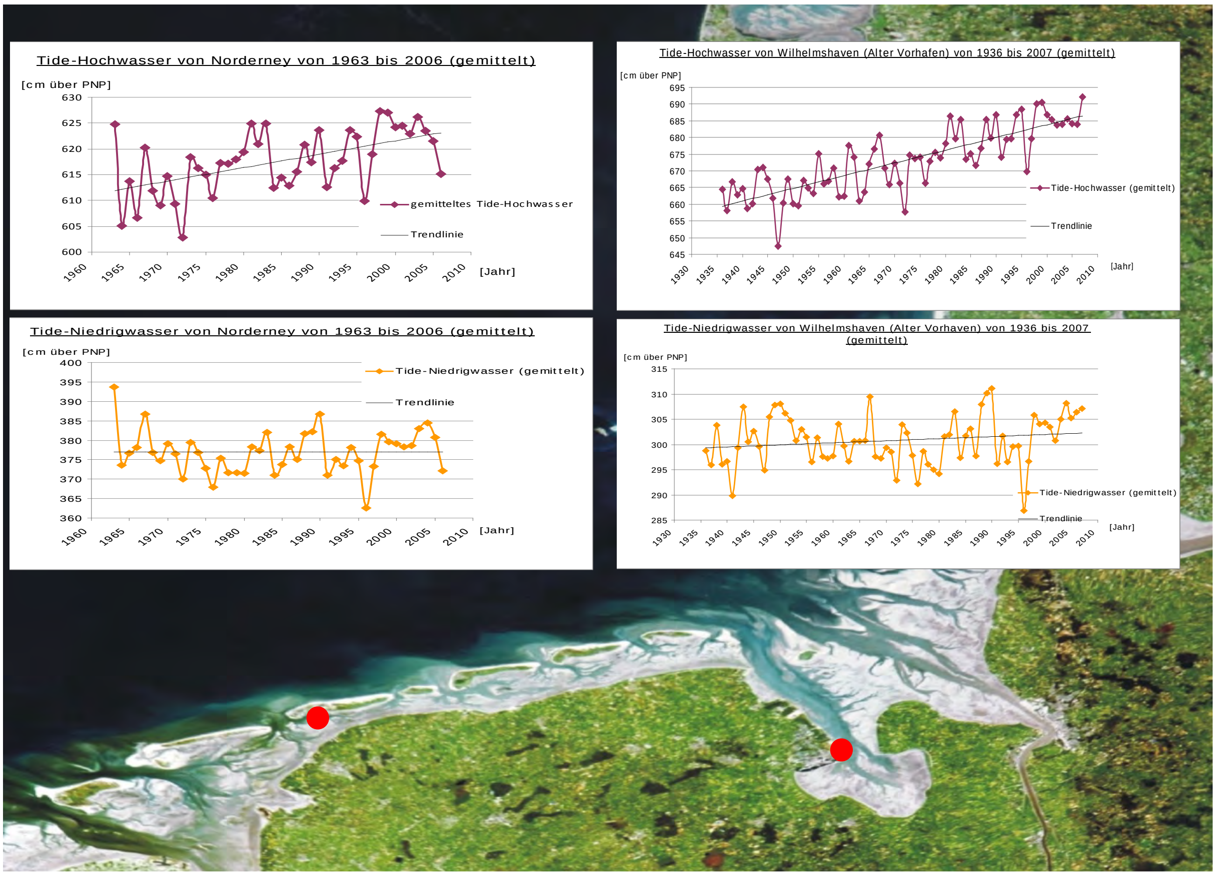
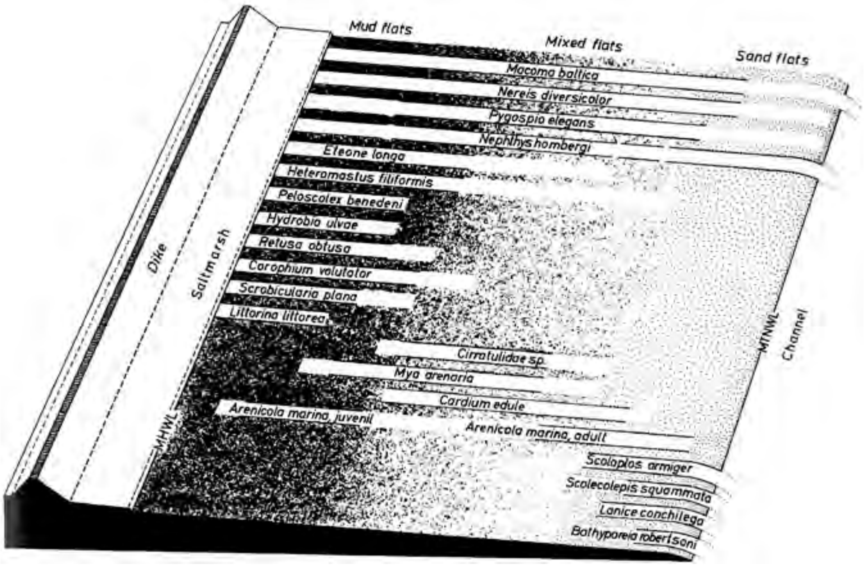


Abb. 3-106 Die amphidromischen Punkte der Nordsee, die Zeitlinien der umlaufenden Flutwellen und der Gezeitenunterschied zwischen Hoch- und Niedrigwasser (Springtide) (aus Sager 1959, Bild 47).

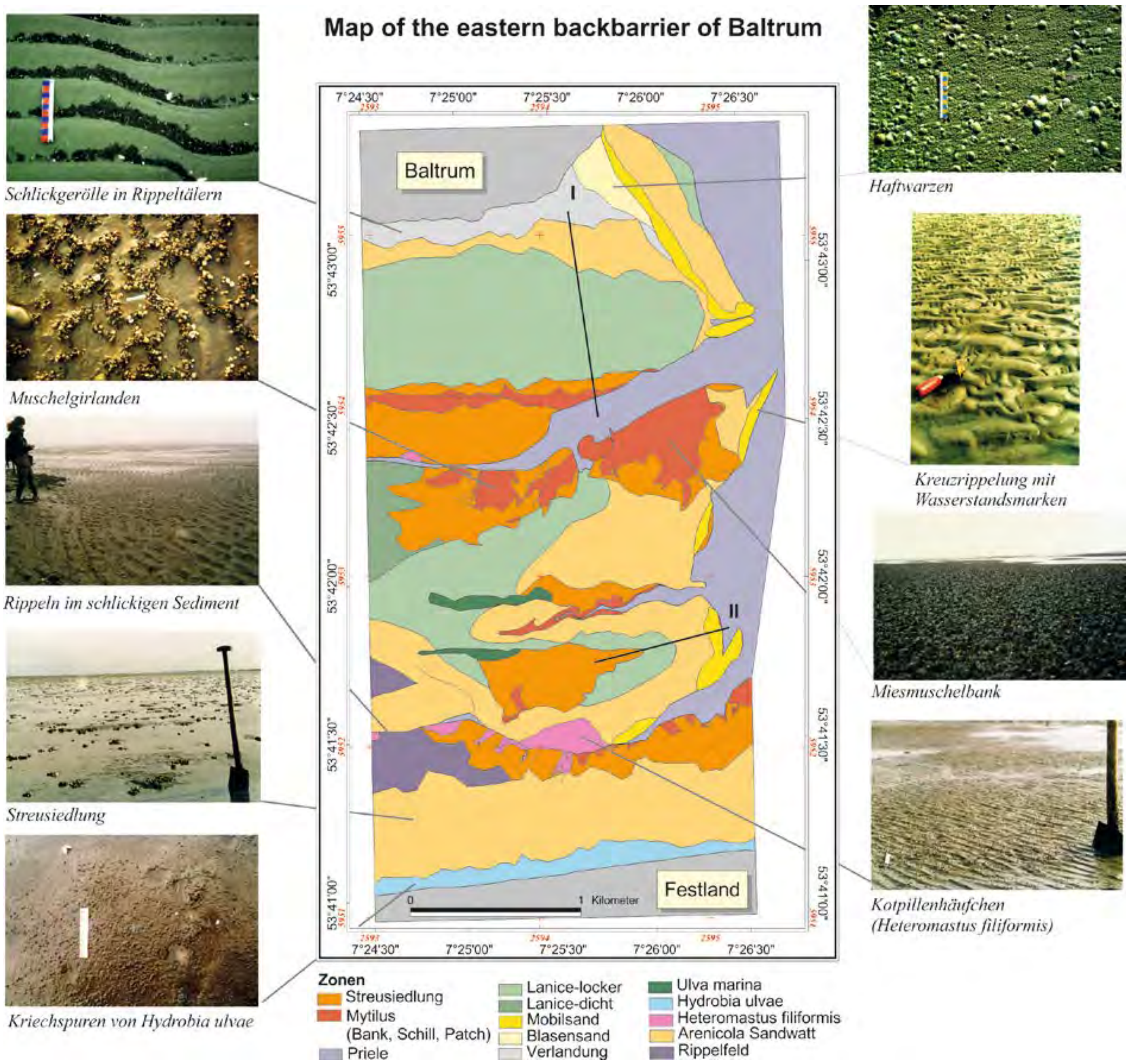
Amphidromic points and tidal ranges of the North Sea



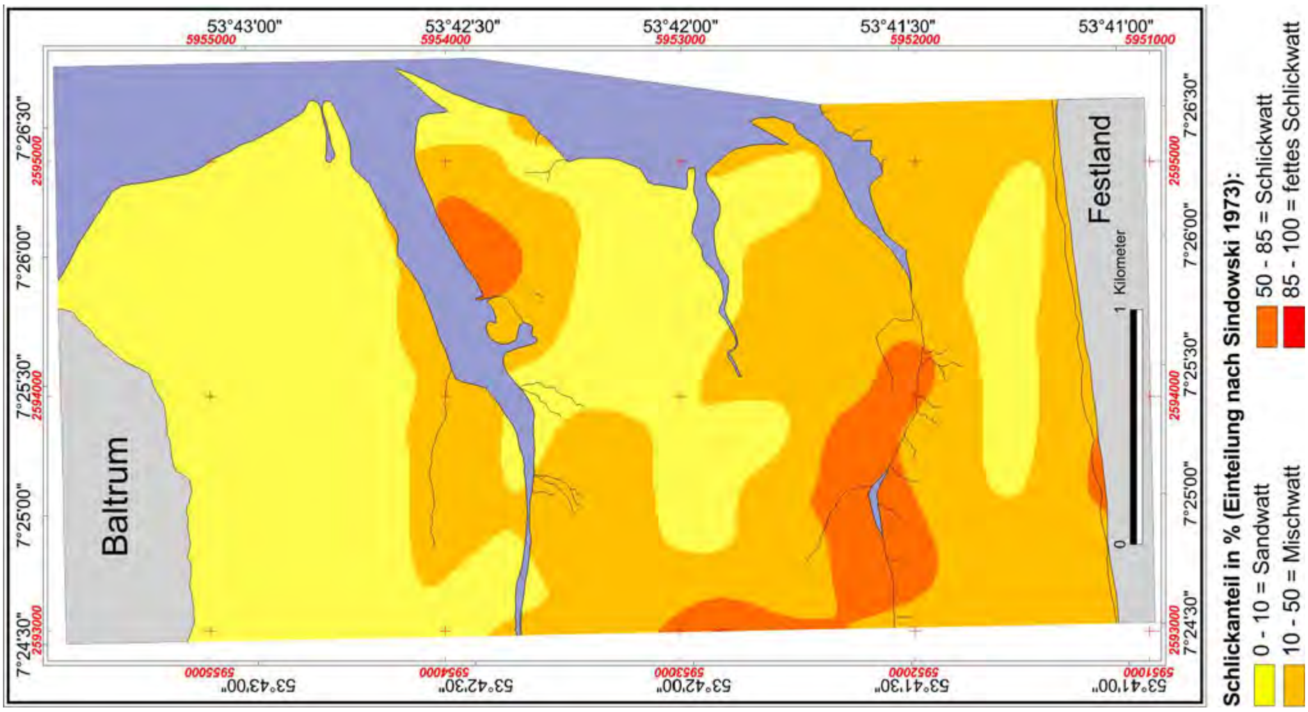
Data from the tide gauges 1963–2006 Norderney and Wilhelmshaven (Wasser- und Schifffahrtsamt, WHV)



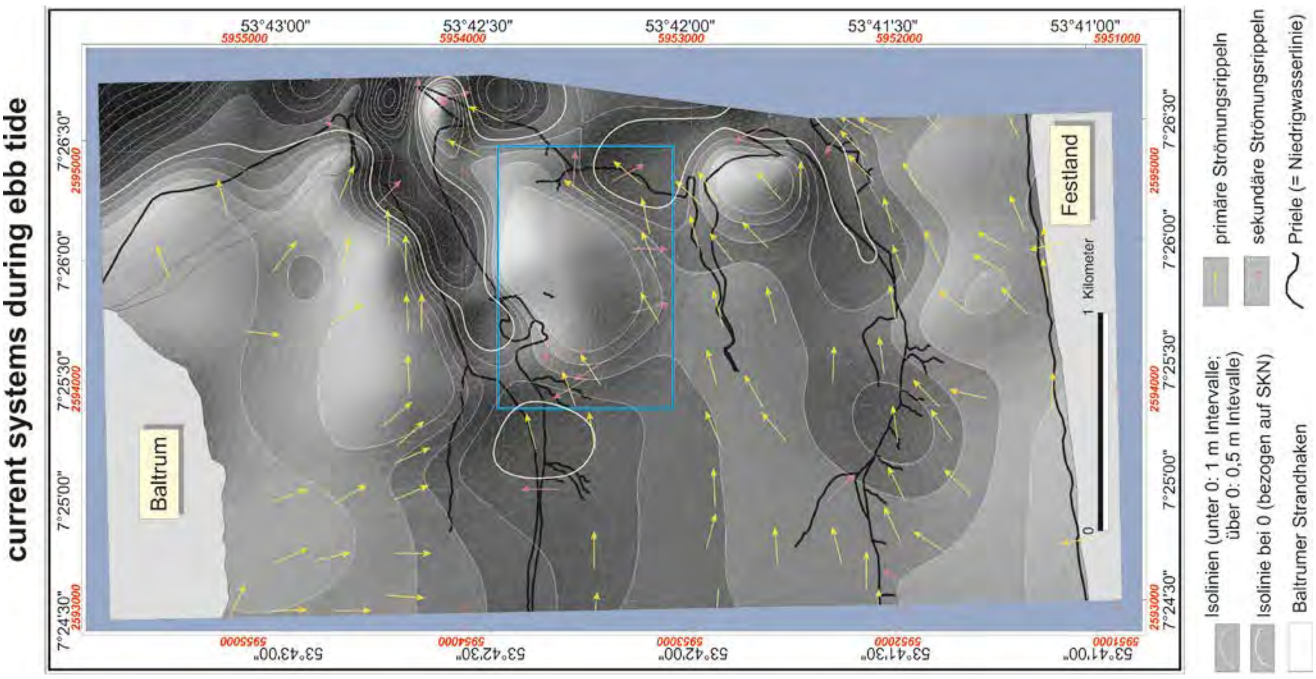
Biofacies at the North Sea coast (Dörjes 1978)



Facies zones of the backbarrier tidal flats of Baltrum, BUNGENSTOCK (2000)



Sediment distribution in the backbarrier tidal flats of Baltrum, Bungenstock (2000)



Ebb tidal currents in the backbarrier tidal flats of Baltrum, nach Bungenstock et al. (2002)

Table 2. Records of *Crassostrea gigas* specimens found in the backbarrier area of the East Frisian Islands, southern North Sea, between August 1998 and May 2000 during field survey. – Habitat number from MILLAT & HERLYN (1999). * pers. comm. mussel farmer W. CHRISTOFFERS.

Date	island	site	habitat / no.	shell length [mm]	shell width [mm]	remarks
18 Aug 1998	Baltrum	Steinplate	*Mytilus* bed #60	89	67	1 living specimen
19 Aug 1998	Baltrum	Dornumer Nacken	Bivalve clusters #68	81	50	1 left valve
25 May 1999	Juist	Nordland	*Mytilus* bed #21	57±18	no data	13 living specimens
23 Aug 1999	Borkum	Randzel	*Mytilus* bed #3	20; 50	no data	2 living specimens
Jan 2000	Juist	Kopersand	sublit. *Mytilus* culture	> 100	no data	1 living specimen*
04 May 2000	Baltrum	Steinplate	*Mytilus* bed #61	43	38	1 living specimen
May 2000	Juist	Nordland	*Mytilus* bed #21	5 to 90	no data	2-10 ind./m^2

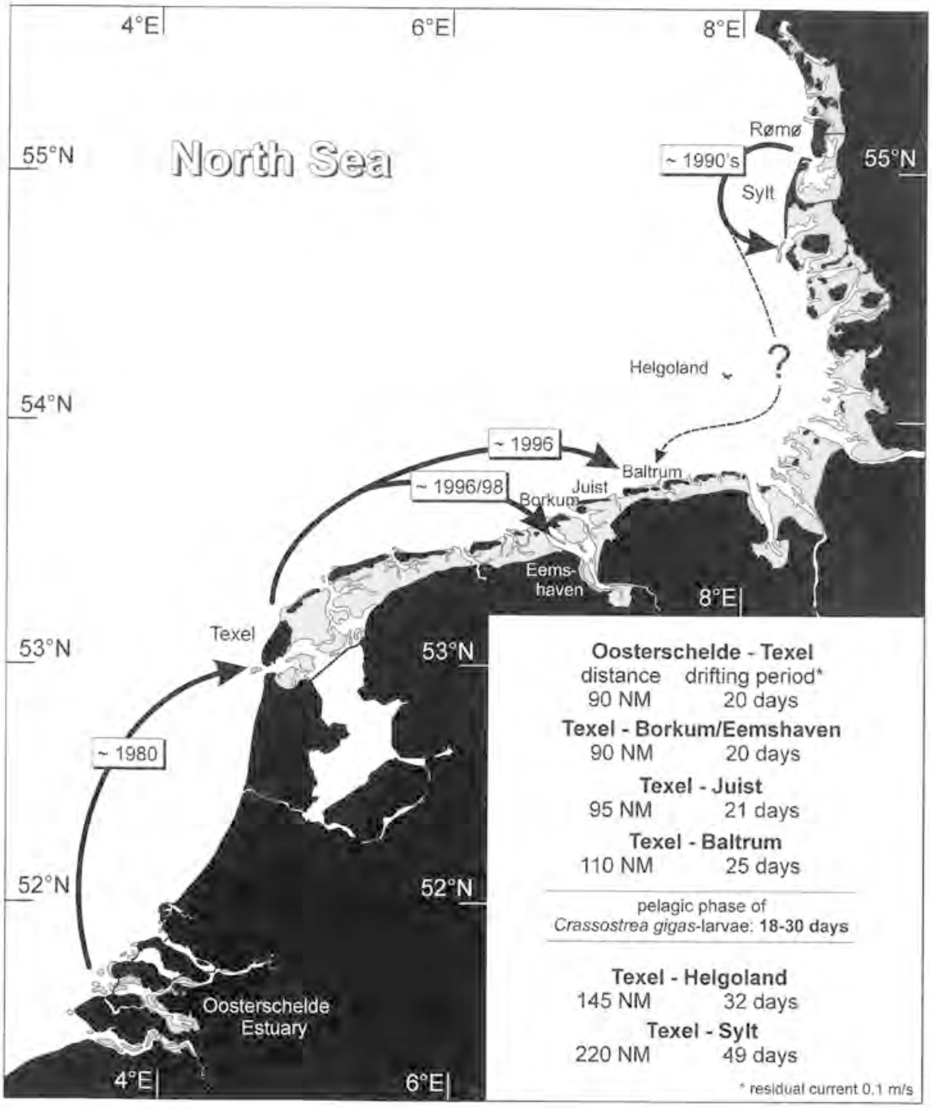


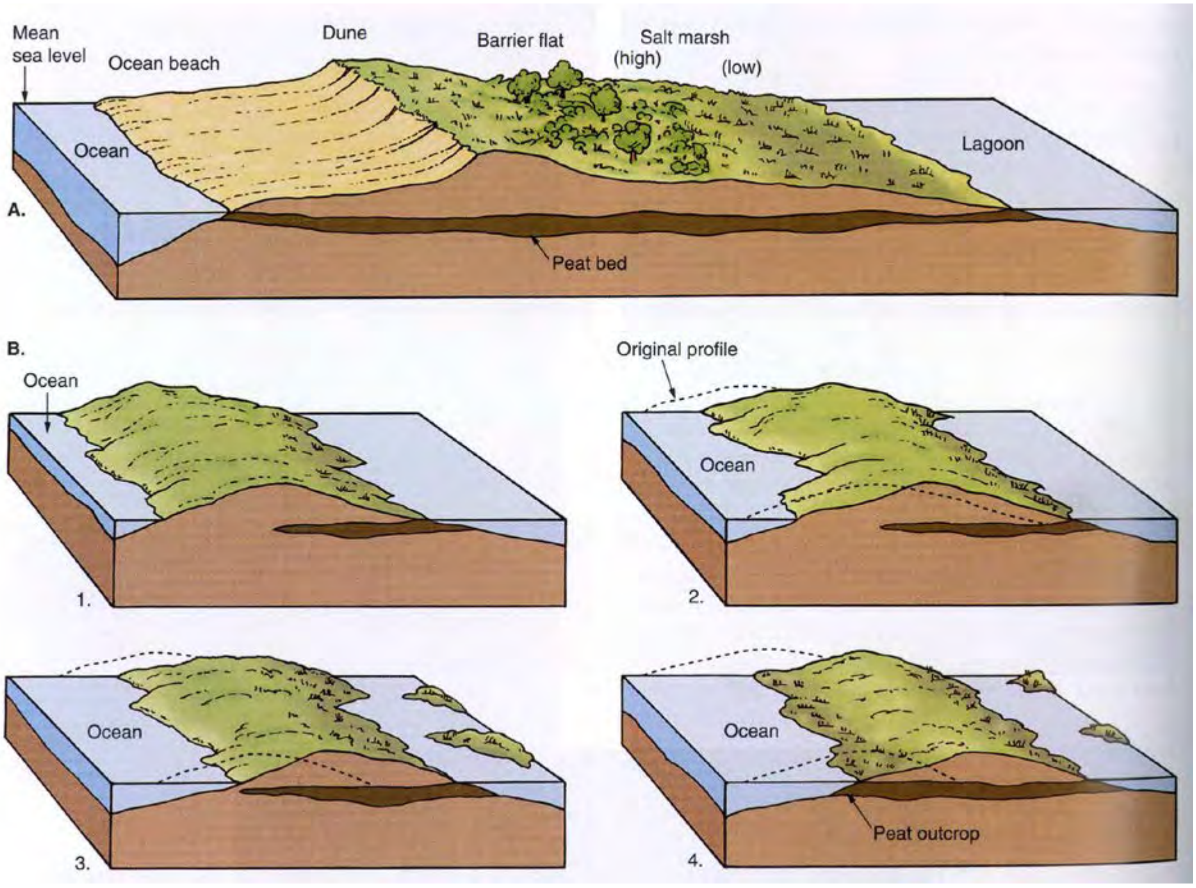
Fig. 2. Potential drift ways and year of invasion of *Crassostrea gigas* larvae from the known culture plots and wild populations of the Oosterschelde estuary and Texel into the backbarrier area of the East Frisian Islands, southern North Sea. – Because of the prevailing meteorological and hydrographic conditions an origin from the Sylt population is unlikely. So far, the southernmost record of *C. gigas* is 45 NM away from Sylt (REISE 1998).

Distribution history' of *Crassostrea gigas* along the Southern North Sea coast, Wehrmann, Herlyn, Bungenstock, Hertweck & Millat (2000)

Mechanisms and timing of the barrier island genesis at the East Frisian coast

The Southern North Sea coast is characterized by a 250 km long chain of 17 barrier islands from the west in The Netherlands to the east in Germany to the Inner German Bight. The islands are situated in about 10 km distance north of the coastline.

Since 2009 the islands backbarrier tidal flats are part of the wadden sea UNESCO world heritage as one of the largest connected tidal flat areas of the world. The NL-D barrier island chain is not only essential for the existence of the backbarrier tidal flat system but also the most effective protection for the mainland during storm surges. The islands are classified as mixed wave/tide dominated (Fitzgerald & Van Heteren 1999, Stutz & Pilkey 2011). The tidal range varies from 1.40 m in the west at Texel/The Netherlands up to 3 m at the easternmost island Minsener Oog/Germany. Due to the ratio of relative sea level rise and sediment supply these islands are retrograding, which means they are consistently migrating landward over time. In the North the islands are characterized by up to 18 m high dunes building the natural protection of the islands during storm floods. Dunal breaches and washover fans are typical. Behind the northern dunal part, in the south of the islands there are muddy salt marsh deposits, the so called 'Inselgroden'. These organic rich layers crop out at the northern side of the islands underneath the dunes at the beach as the result of the southward migration of the island, the so called barrier rollover (Freund & Streif 2000).



The principle of barrier rollover

Subfossil salt marsh horizons at the northern beach of the Eastfrisian island Juist

Hypotheses of barrier island genesis

The genesis of barrier islands in general has been a topic of scientific debate in the past (e.g. Schwartz 1973, Streif 1990, Flemming 2002). Schwartz (1971) suggests the “multiple causality principle” as no single mechanism will find general acceptance. For the islands of the Southern North Sea, there are altogether 4 hypotheses for their genesis:

The first one, the coastal barrier hypothesis, was firstly formulated by Penck (1894) analogous to the coastal development at the Baltic Sea. Penck describes the East Frisian islands as relicts of a former coastal barrier. Gripp (1944) also uses the term coastal barrier, but describes the East Frisian islands as an early form of a coastal barrier system developing from an open tidal flat system to a closed coastal barrier. This implies a west to east expansion of the tidal flats which is not concordant with the geological record and today’s observations which show a simultaneous accumulation of the tidal flats along the coast.

Lüders (1953) publishes the beach barrier hypothesis describing an elongated beach barrier system interrupted by several tidal inlets as initial phase (see also Fisher 1967; Hoyt 1967, 1968). This hypothesis is quite similar to the palaeogeographical maps published by Oele et al. (1979). These maps show for the coastline west of Amsterdam to the Ems estuary a beach barrier system for the time slides of 7500, 5000 and 2000 BP. Streif (1990) notes for this hypothesis that not only today but also during early stages of the Holocene sea level rise different tidal amplitudes have to be supposed along the coastline of the Southern North Sea. This means that elongated beach barriers, barrier islands and sandbars have existed simultaneously and no uniform morphological picture has to be necessarily expected.

The third hypothesis, the sand bar hypothesis, is described by Ordeman (1912), Keilhack (1925) and later by Barckhausen (1969) who takes the island of Langeoog as a model region.

Barckhausen describes the development of the East Frisian islands as a result of currents, wave surge and wind. According to the view of King (1959) after Barckhausen the islands evolved from periodically flooded sand bars over beach barriers to the final stage of barrier islands.

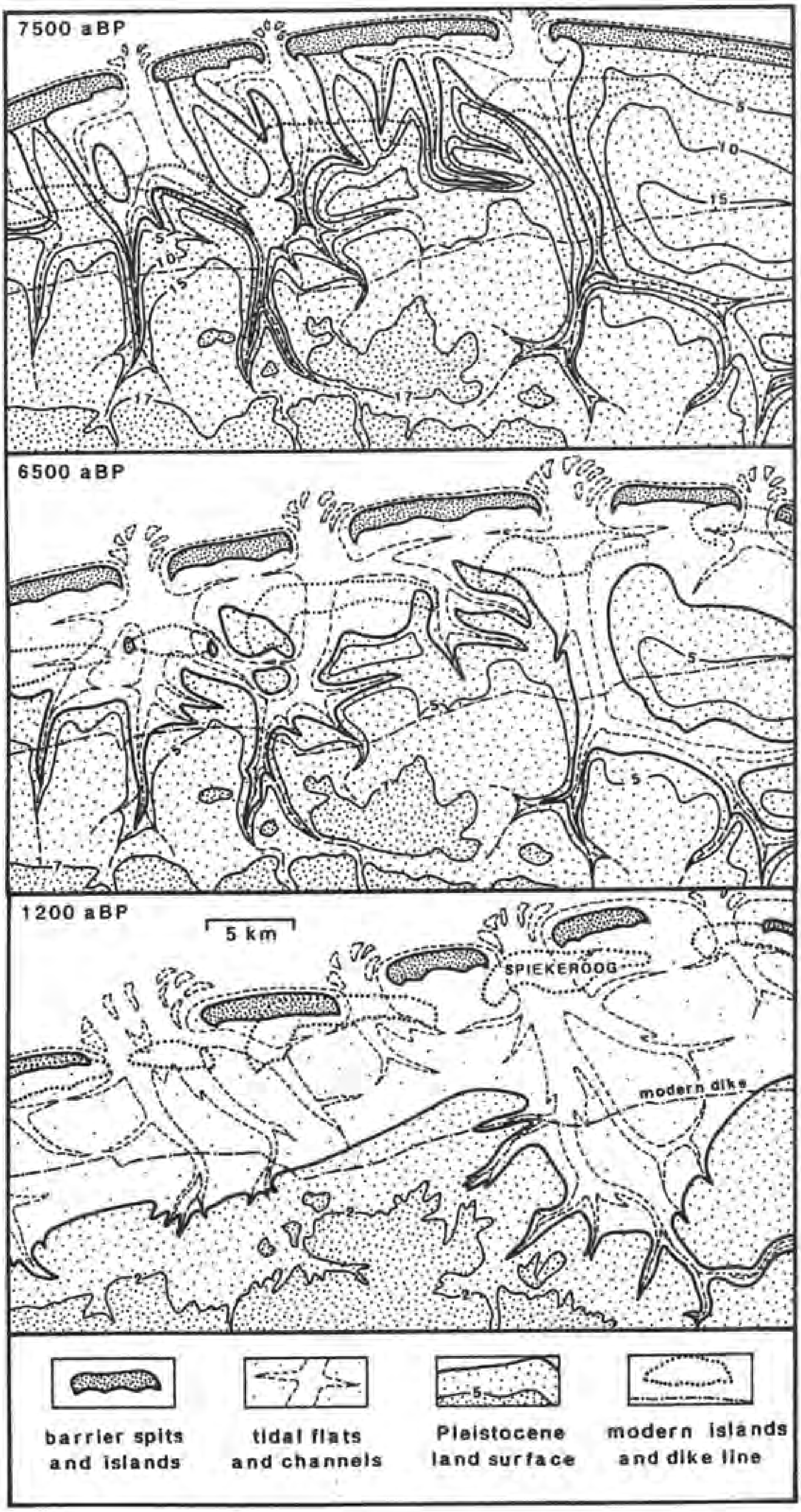
These three hypotheses do not take into account the fact that 6 of the 8 East Frisian barrier islands are situated on top of a Pleistocene high (Griffel et al. 2013). Streif (1990) supposes that the islands originally developed as so called 'Geestkerninseln', which means islands with a Pleistocene core that protruded the tidal flat sediments of the area. Around 6000 BP these cores were covered by marine sediments during sea level rise and transformed later (around 2000 BP) to the today's barrier islands (Streif 1990). This explains the Pleistocene high underneath most of the islands but does not directly link genetically the stage of the 'Geestkerninsel' and the stage of the barrier island.

Flemming & Davis (1994) describe the East Frisian barrier islands as initial several longshore grown barrier spits. They developed from around 7500-8000 BP onwards when the postglacial sea level reached the base of the modern shoreface at approximately 20-25 m below NN, the German ordnance datum (Flemming 2002). At this stage several northward directed Pleistocene ridges being part of the late Pleistocene drainage system characterized the landscape. The seaward edges of these ridges were reworked by wave action and finally shore-parallel sandy spits were built (Flemming 2002). During the following Holocene transgression the spits where separated from the mainland and transformed into barrier islands (see also Zagwijn 1986, Vos & van Kesteren 2000).

This hypothesis leads to the second question, when the islands developed. After Flemming (2002) their initiation as barrier spits began when the Holocene sea level reached the shoreface of 7500-8000 BP, which is about 7500-8000 BP. The transformation of the barrier spits to the actual barrier islands was probably completed around 6000 BP when the rate of sea level rise declined (e.g. Behre 2007, Bungenstock & Schäfer 2009). This corresponds with the chronological model for the development of the barrier islands in the Netherlands (see Zagwijn 1986).

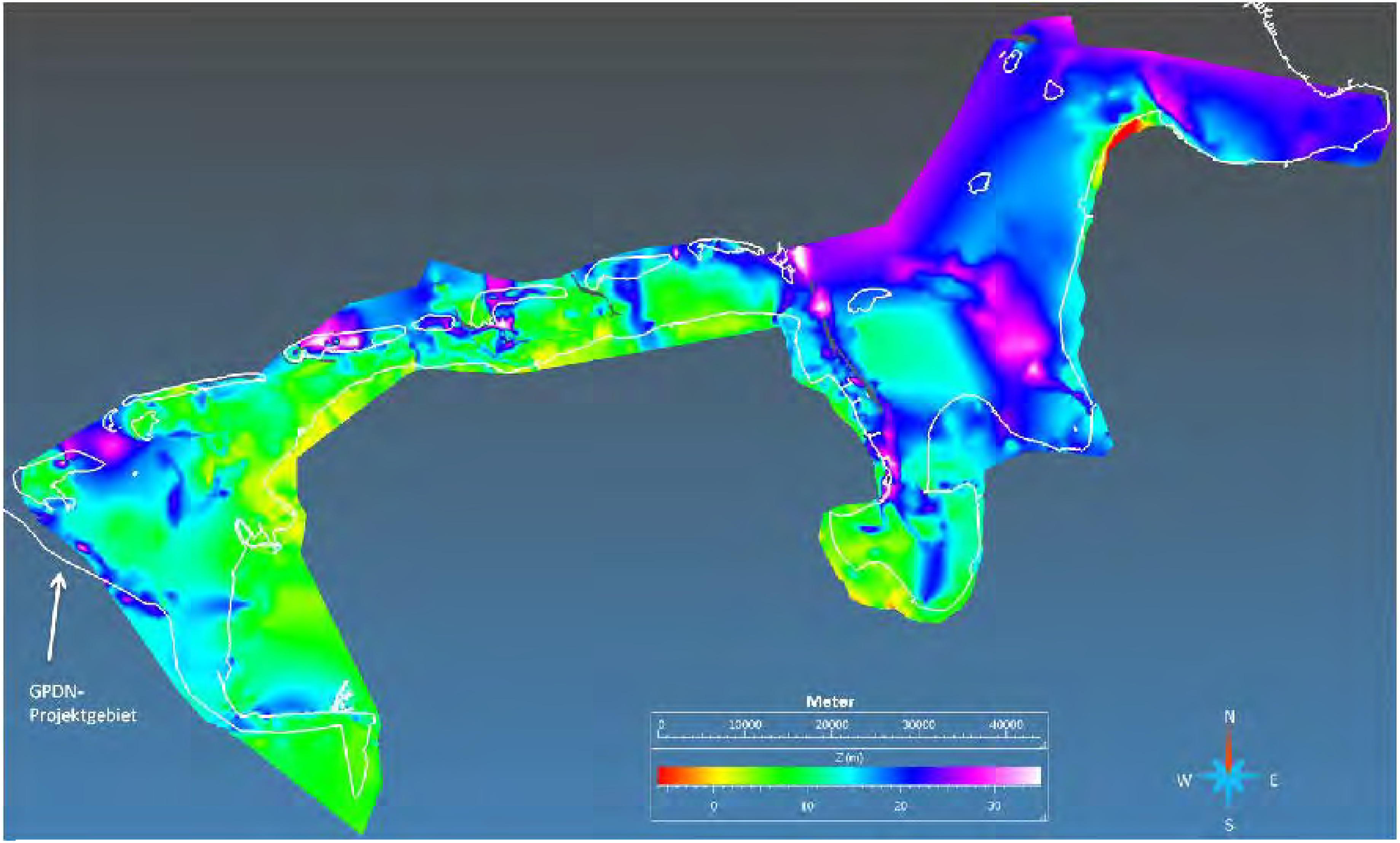
Vos & Van Kesteren (2000) and Vos et al. (2011) suppose an existence of the islands as original barrier islands since about 8000 BP. They argue that with a tidal range of only 1 m (Franken 1987) the sediment supply could keep pace with sea level rise of 0,80 to 1 m per century.

Streif (1990) describes that the East Frisian islands as initial 'Geestkerninseln' could develop after 7500 BP at earliest. After submergence of the Pleistocene cores some thousand years later the barrier islands developed. The oldest salt marsh horizons supporting the picture of a protected backbarrier area and therefore the existence of a barrier island are dated on the island of Juist to about 2000 BP (Streif 1986).



Hypothetical Holocene evolution of the East Frisian coast over the past 7,5 ka (modified after Flemming and Davis 1994)

Maps from the Paleogeographical Atlas of the Netherlands in the Holocene, Vos et al. 2011)



Holocene base at the Lower Saxony coast (GOCAD®, Z(m)=depth in metres).
Result from the project 'Geopotenzial DeutscheNordsee' (BGR, LBEG and BSH).
GRIFFEL, ASPIRON & ELBRACHT (2013)

Ebb tide and flood tide currents

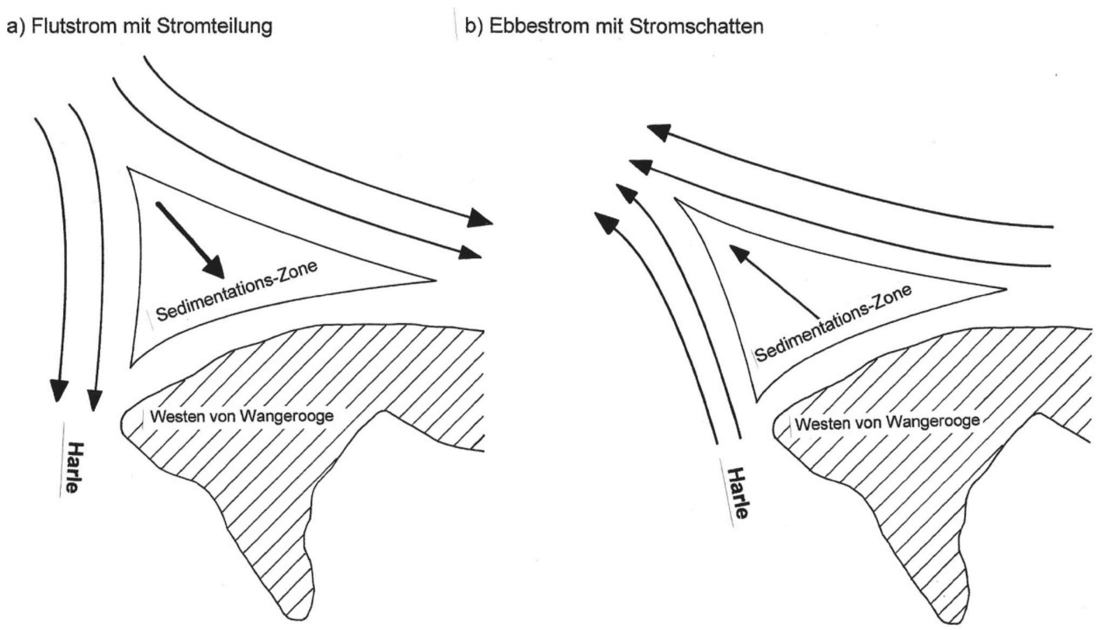


Abb. 56 a,b: Riffbildung in der Stromteilung und im Stromschatten

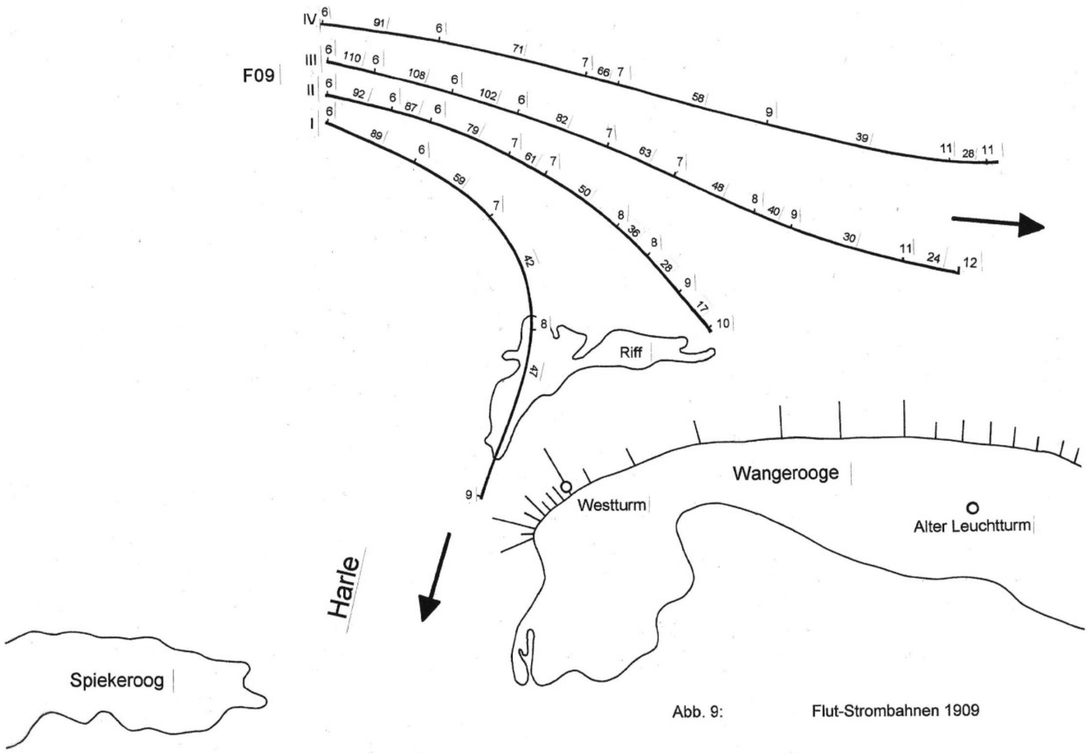


Abb. 9: Flut-Strombahnen 1909

Ysker, in prep.

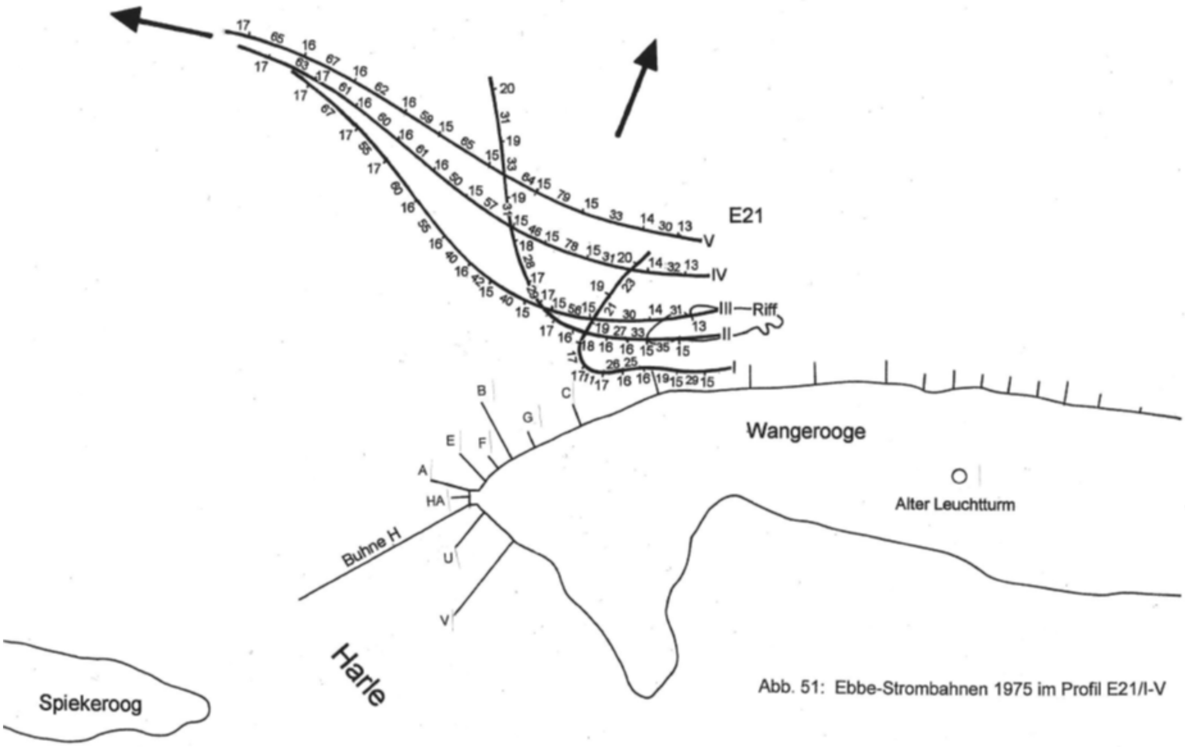


Abb. 51: Ebbe-Strombahnen 1975 im Profil E21/I-V

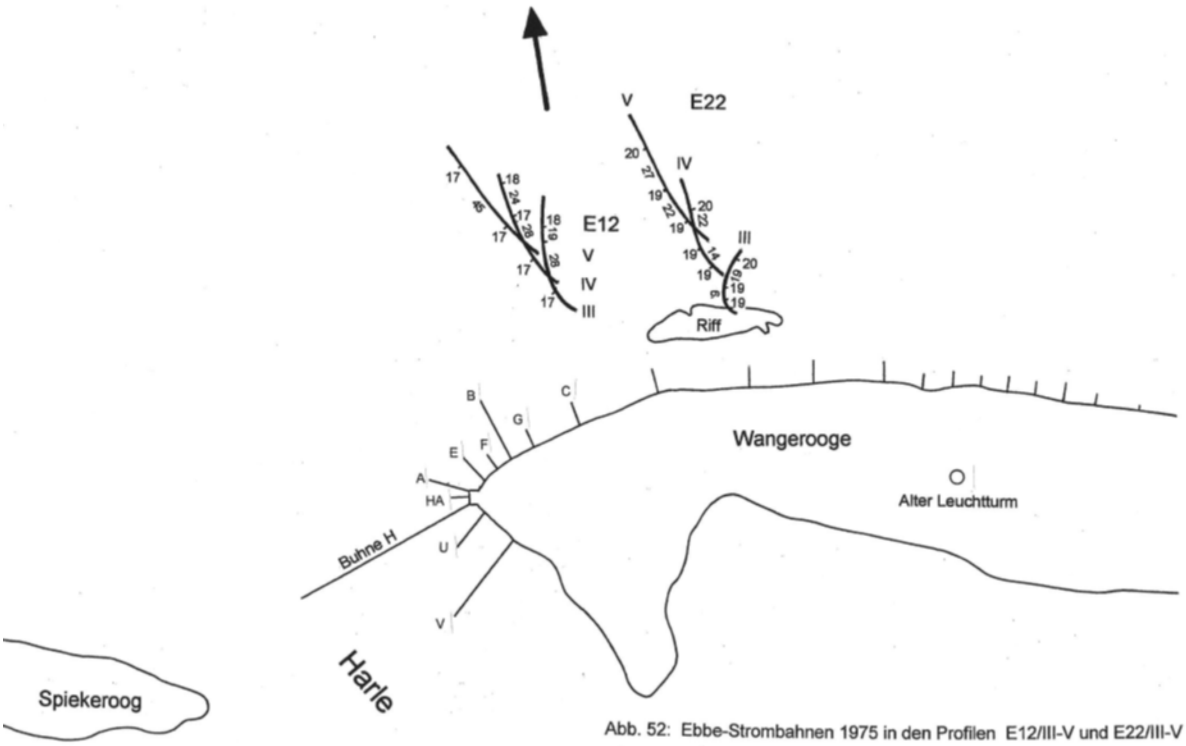


Abb. 52: Ebbe-Strombahnen 1975 in den Profilen E12/III-V und E22/III-V

Ysker, in prep.

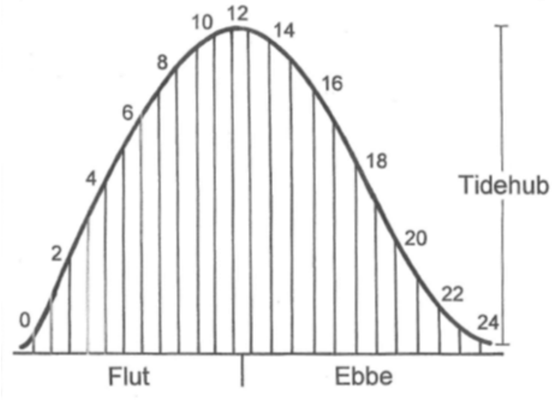
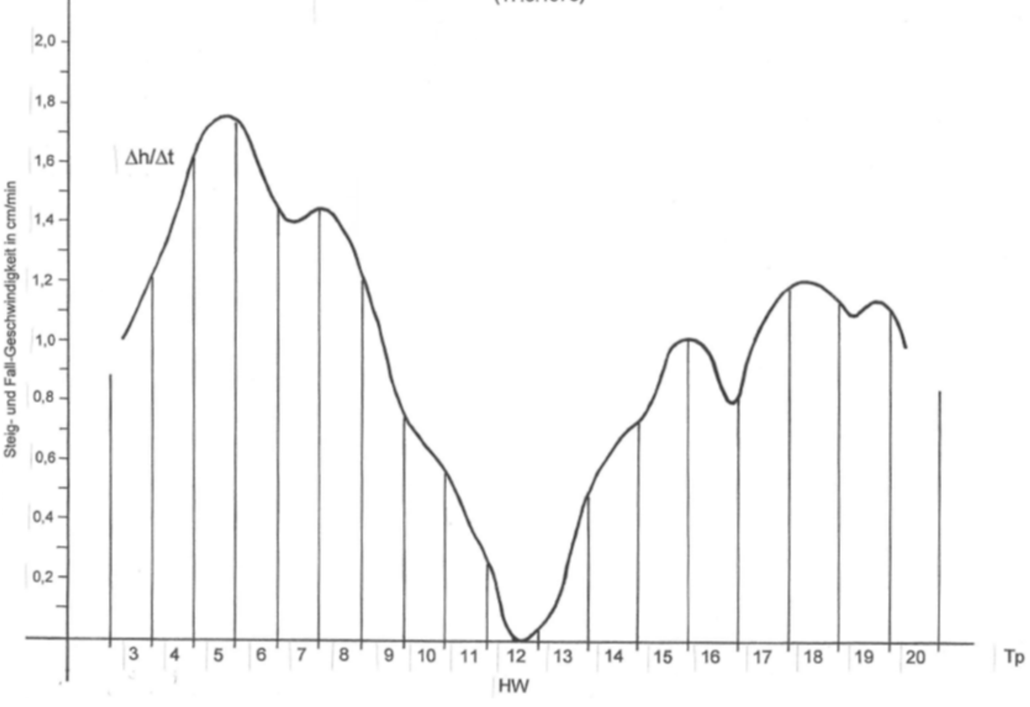


Abb. 3: Zeitteile der Tide

Abb. 16: Steig- und Fall-Geschwindigkeit der Tide am Pegel Wangerooge/Ost (17.6.1973)



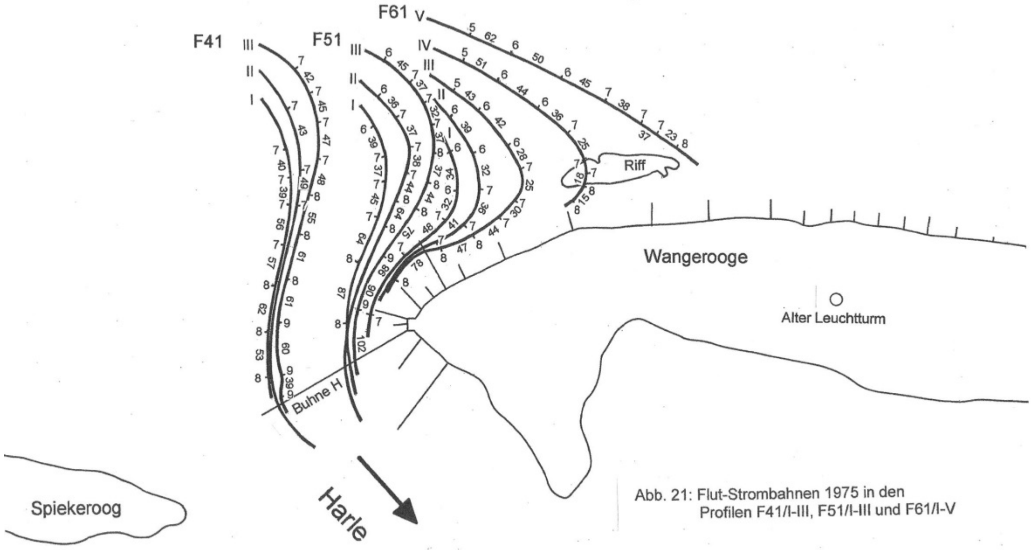
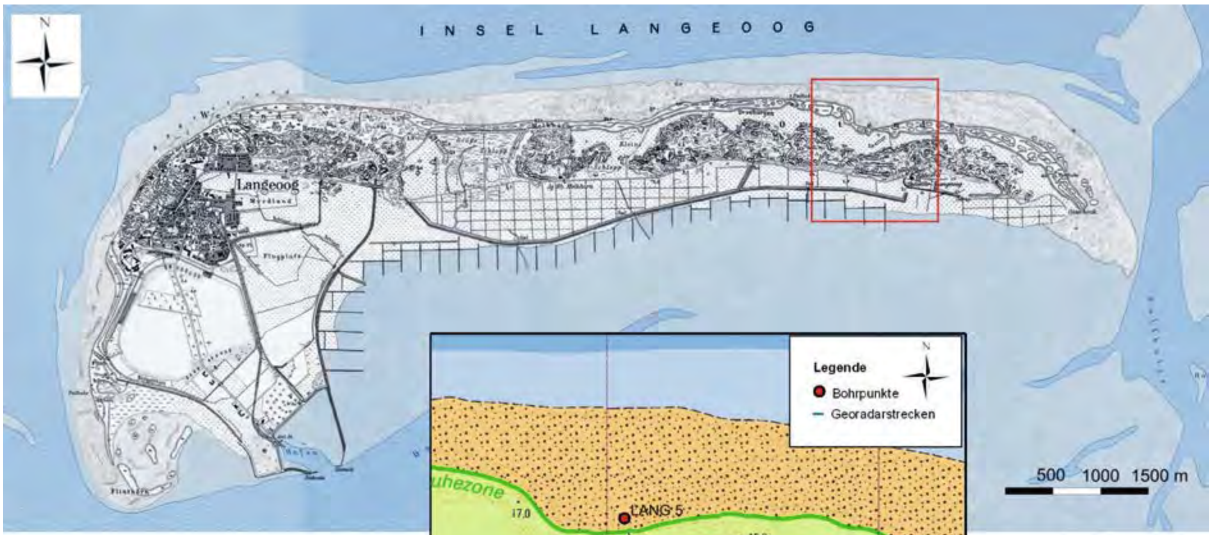
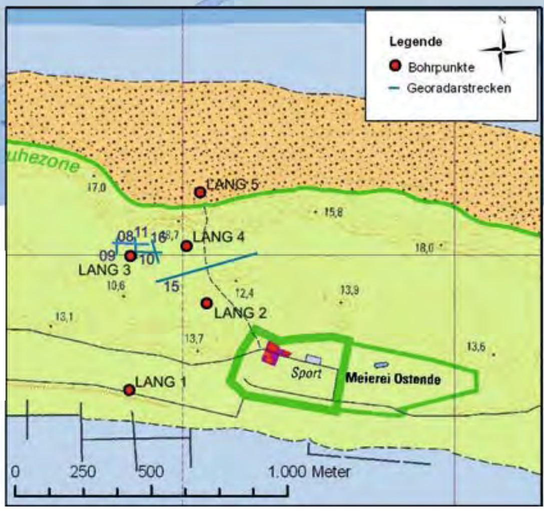


Abb. 21: Flut-Strombahnen 1975 in den Profilen F41/I-III, F51/I-III und F61/I-V

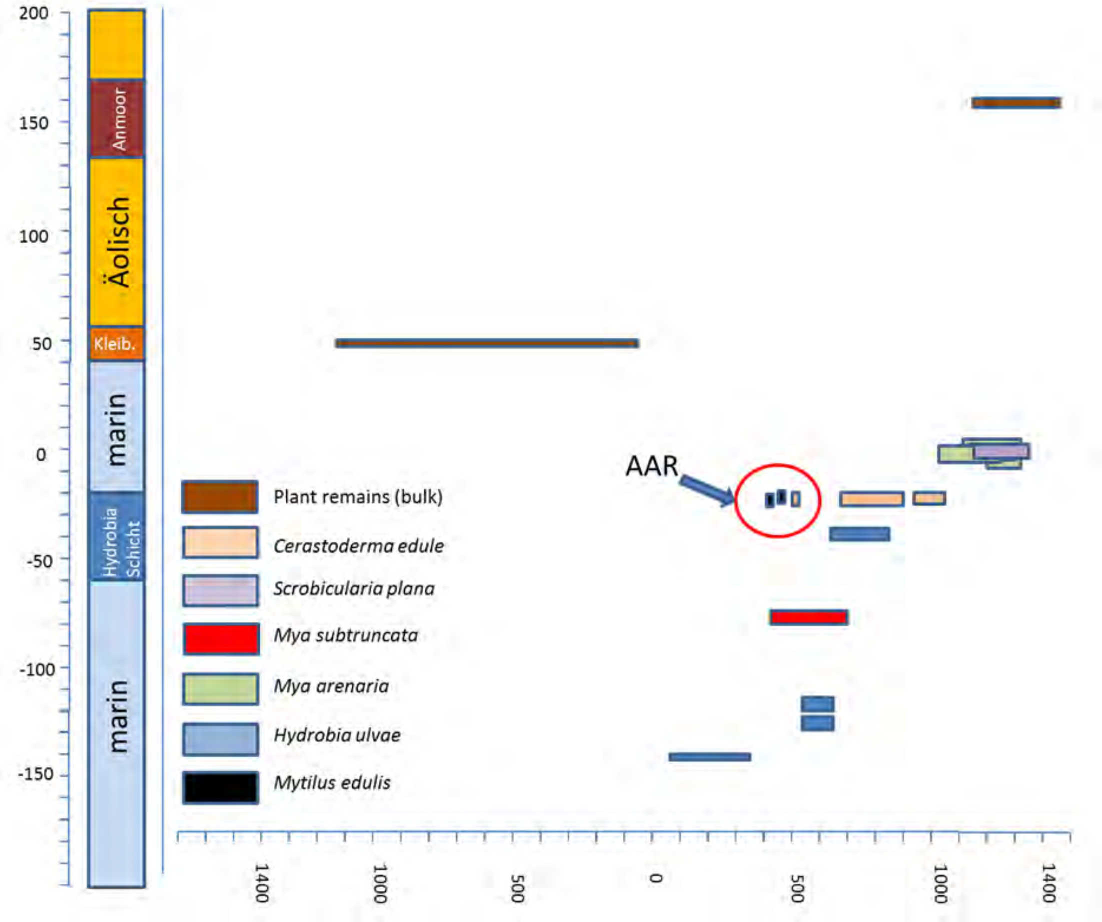
Ysker, in prep.

Research on the island of Langeoog

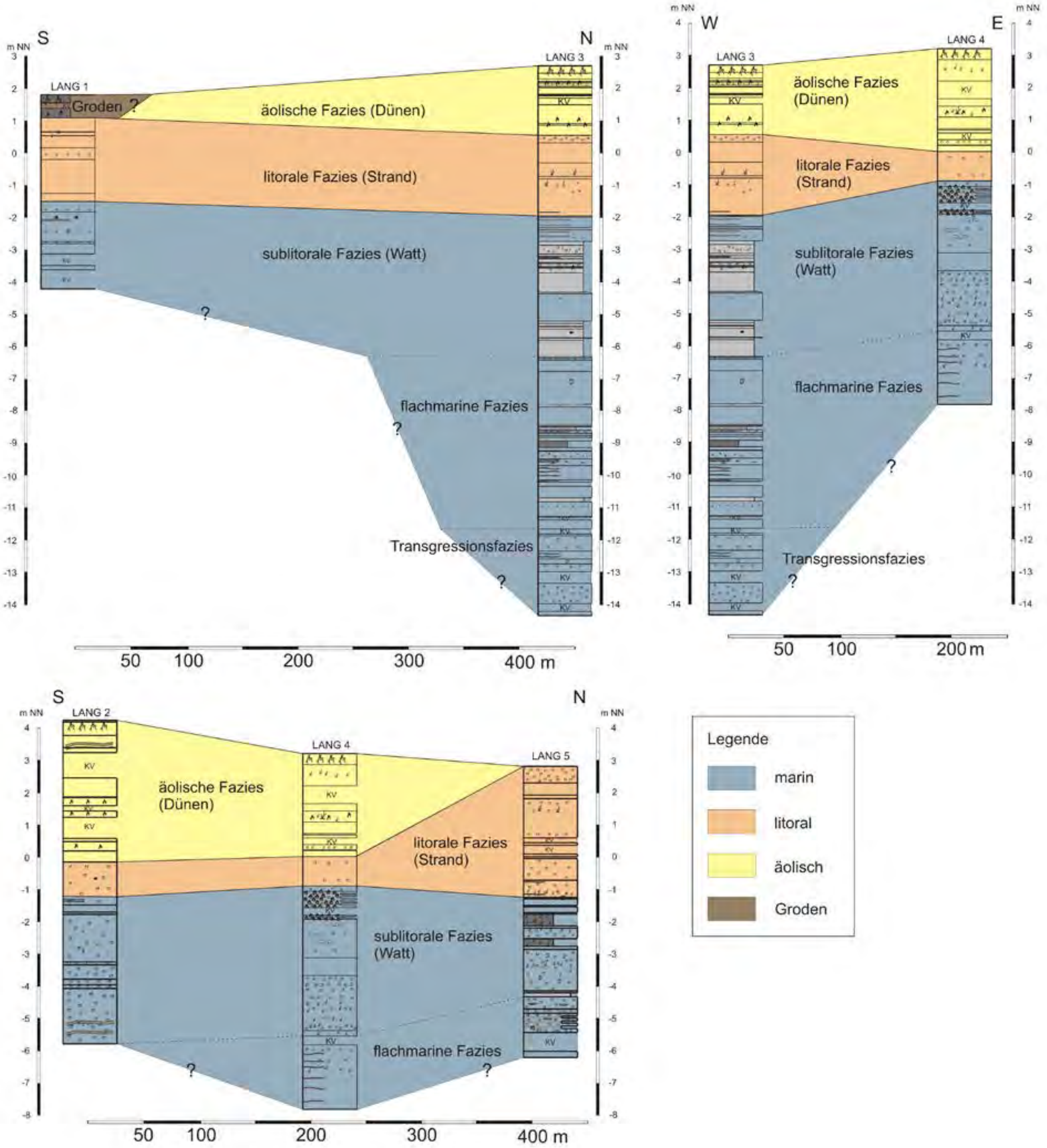




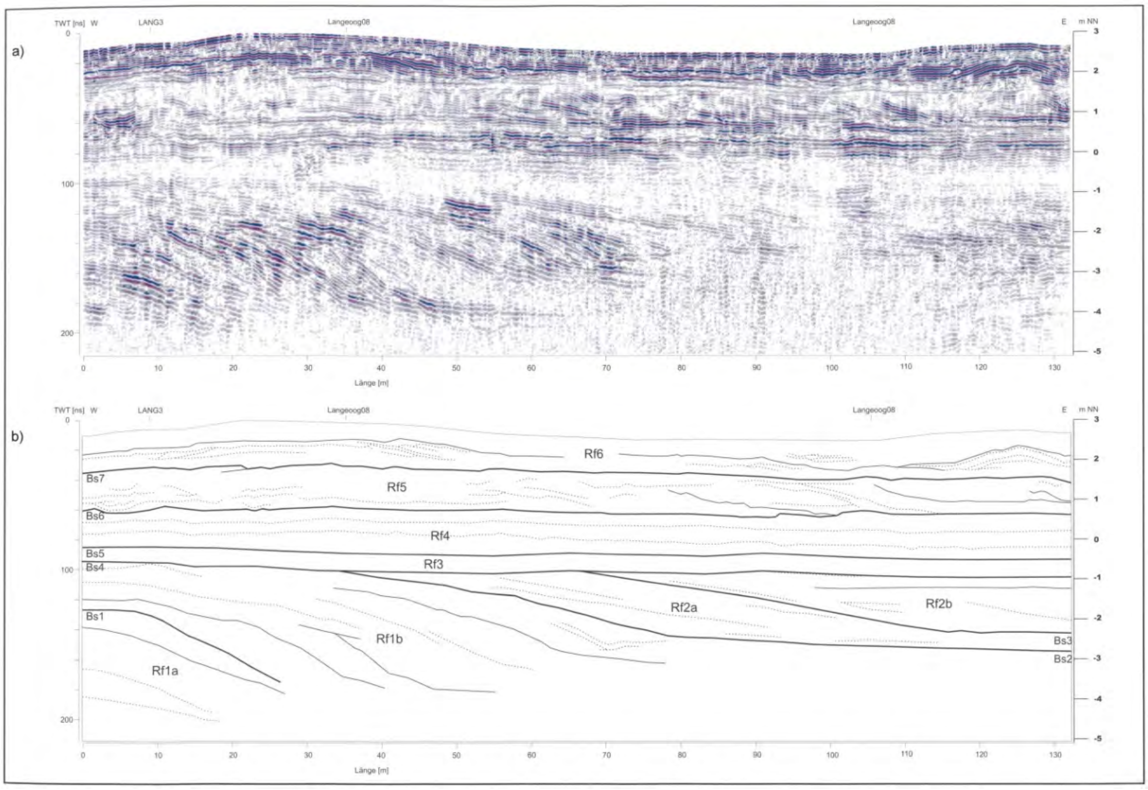
The island of Langoog and the study area in the eastern part of the island



Chronostratigraphy for Langeoog, first draft, Bungenstock et al., in prep.

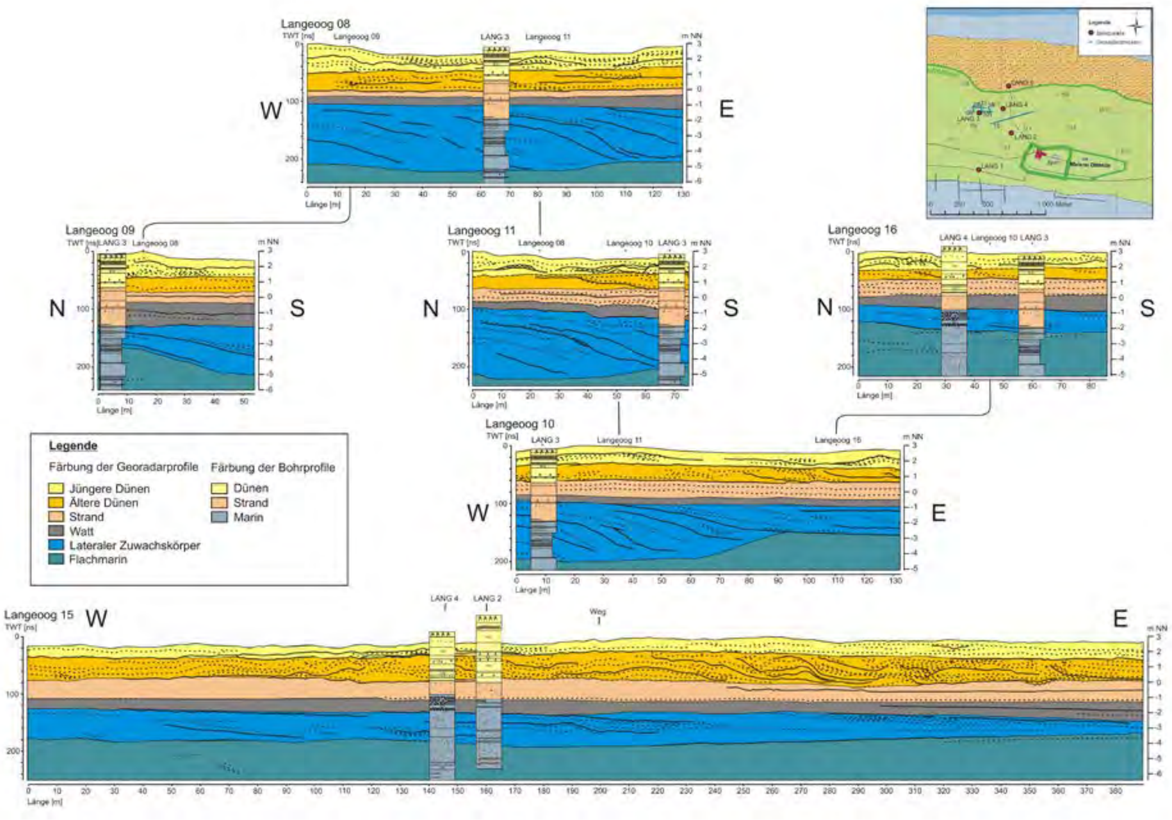


The corings from the ‚Groden' in the South to the beach in the North with subdivision in different facies zones (KLAFFKE 2007).



a) GPR profile Langeoog 10

b) Definition of boundary horizons und subdivision in radarfacies (KLAFFKE 2007)



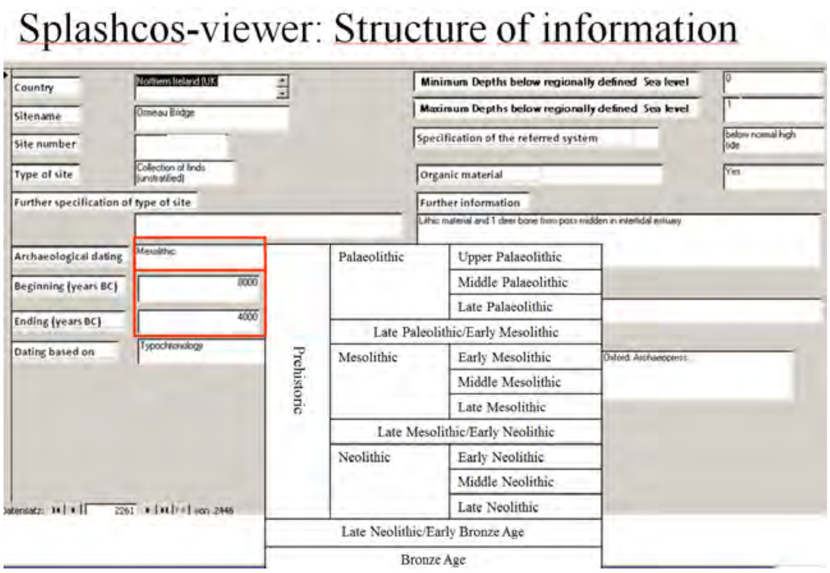
The GPR profiles and the corings (projected) (KLAFFKE 2007).

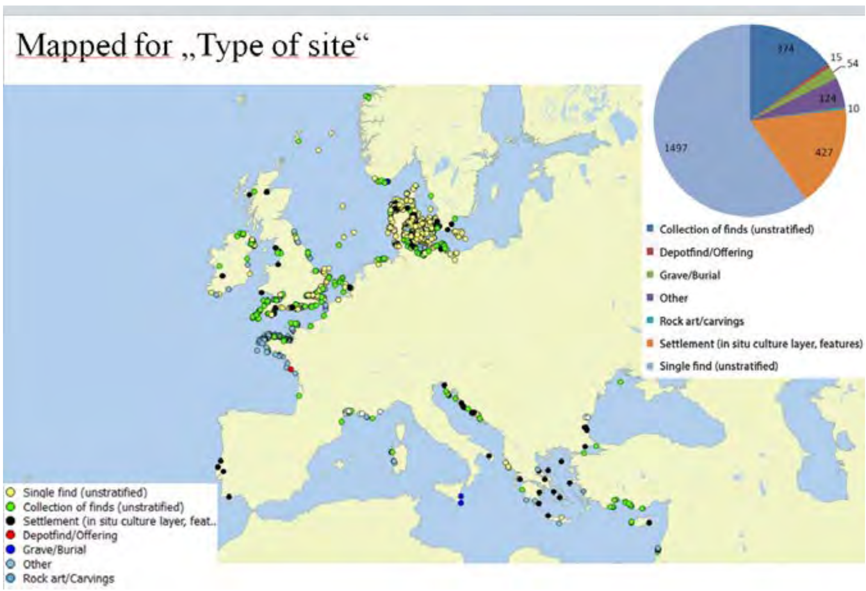
Submerged prehistoric landscapes of the North Sea

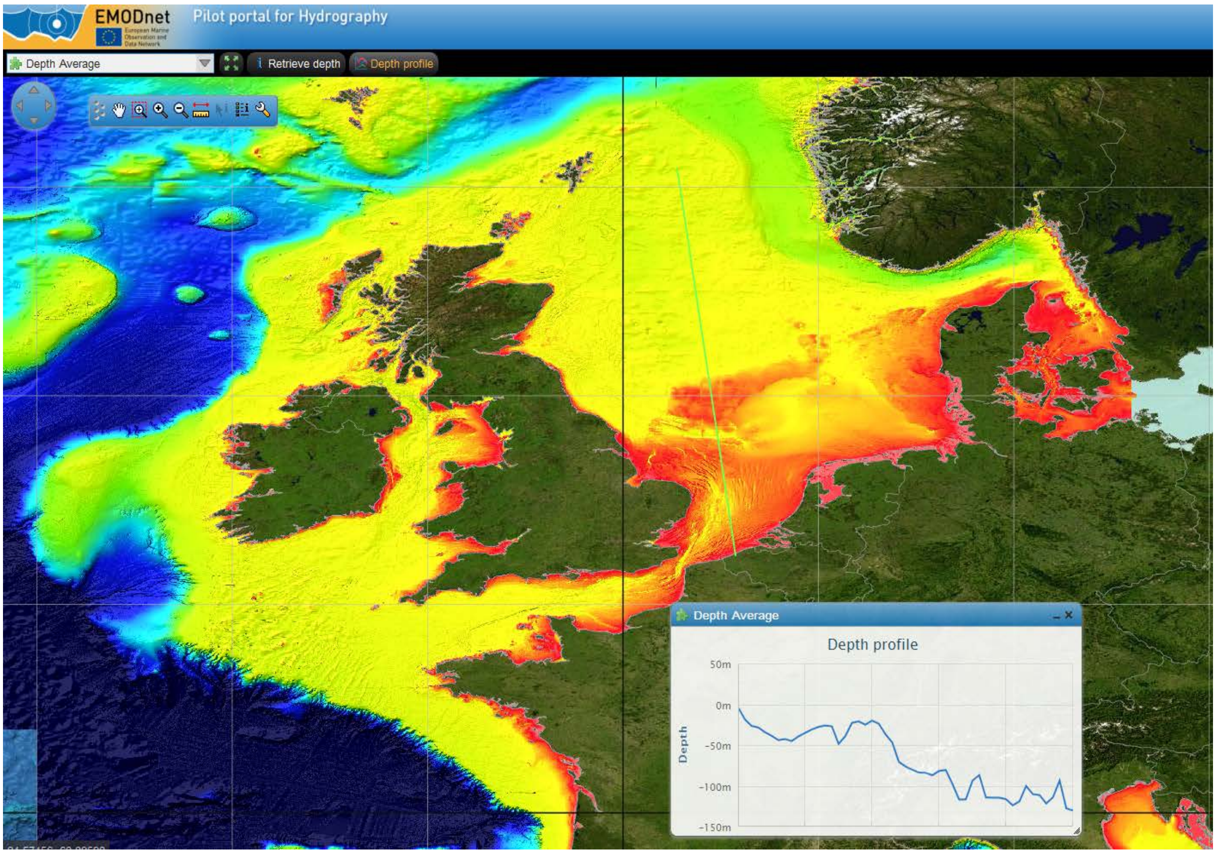
Discover the submerged prehistory of Europe – aims, methods and outcomes of the European SPLASHCOS-network

From 2009 to 2013 the European Commission funded the research network SPLASHCOS – Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf - under its COST programme. This aimed to bring archaeologists, marine geoscientists, heritage agencies, and commercial and industrial organizations together, these being people or bodies interested in researching, managing and preserving the archives of archaeological and palaeoclimatic information locked up on the drowned prehistoric landscapes of the European continental shelf (see http://www.splashcos.org/).

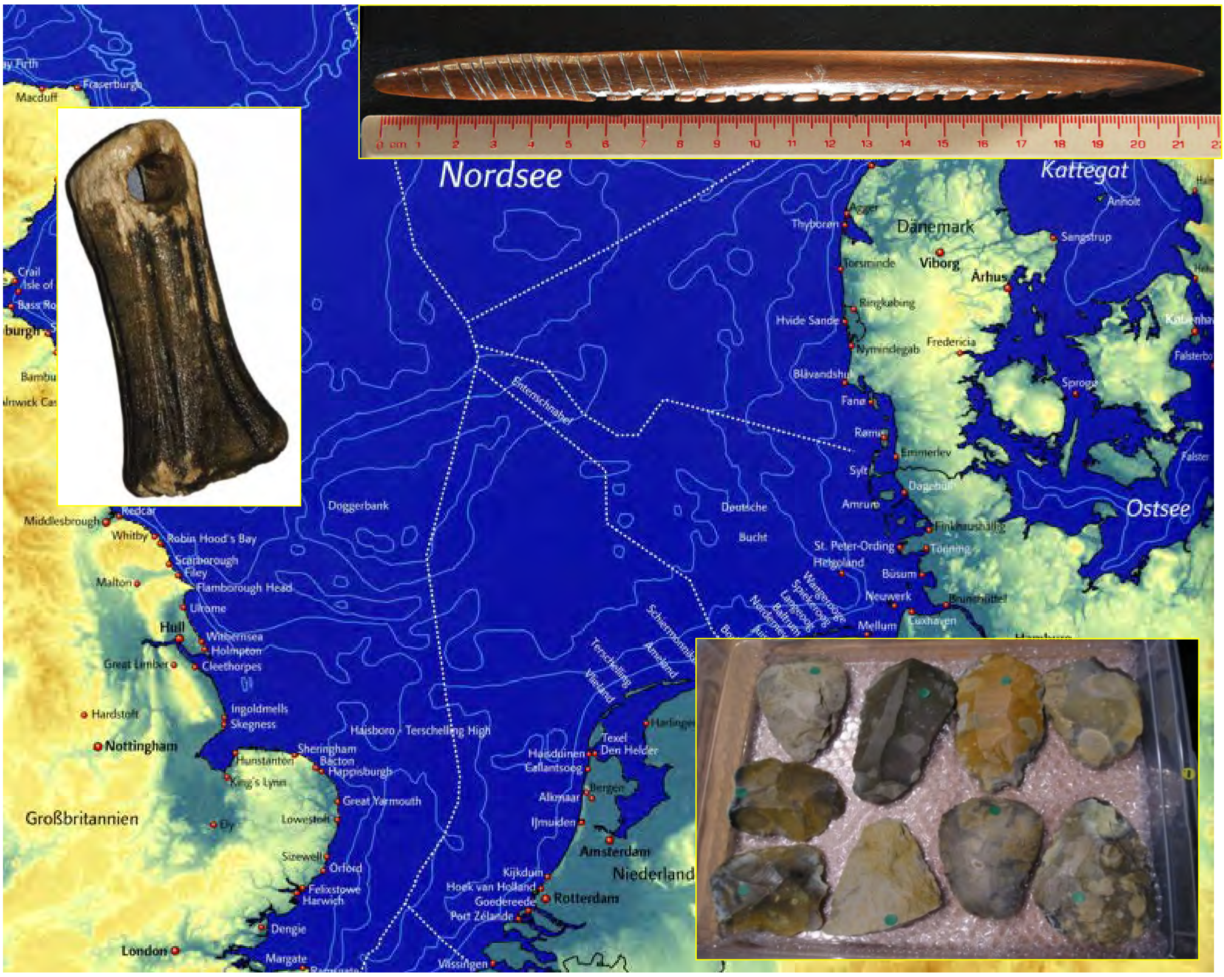
Researchers from almost all European countries with coastal areas became members of SPLASHCOS and contributed with their knowledge and experience in discussions, field schools, seminars, projects and publications, addressed both to the scientific community as well as the general public. The web-based information-tool "Splashcos-viewer" makes basic scientific information available, such as maps, images and references about all sites which the SPLASHCOS-network is working on as well as addresses of institutions and researchers in charge. This in particular is expected to raise the public awareness of the submerged part of the common cultural heritage of Europe.



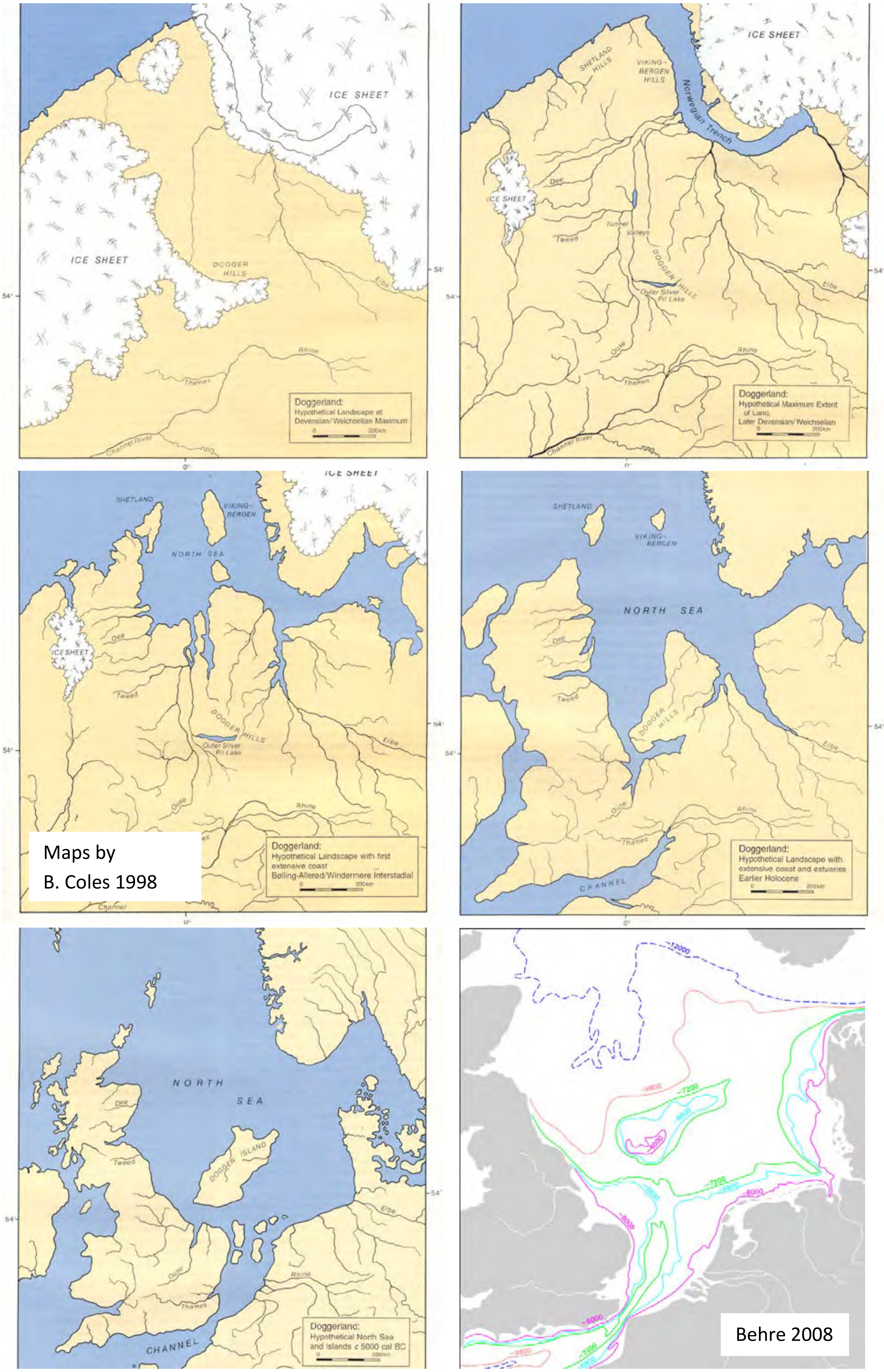




Bathymetry of the North Sea



Exclusive economic zones of the North Sea and archaeological artifacts



The development of Doggerland

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Quaternary International 112 (2004) 37–53

Coastal development, sea-level change and settlement history during the later Holocene in the Clay District of Lower Saxony (Niedersachsen), northern Germany

Karl-Ernst Behre

Niedersächsisches Institut für historische Küstenforschung, POB 2062, Wilhelmshaven D-26360, Germany

Abstract

This paper focuses on the last 4000 years of coastal evolution and settlement in Niedersachsen (Lower Saxony). Due to a decrease in the rate of sea-level rise during the later Holocene, regressions took place, which included calmer phases, during which intercalated peat developed. The first marked regression started at ca. 1500 BC (calibr.). As a result, peats formed which can be traced into the tidal flats far beyond the present coastline. During the following Dunkirk I transgression period, several bays were created and the coast took on its present-day outline. Shortly before the Birth of Christ, a second pronounced regression occurred, which resulted in soil formation and led to a far-reaching human occupation in the Clay District, i.e. the so-called *Marsch*. For this time, and also for the period around AD 800 as well as for around AD 1500, the entire coastlines have been reconstructed. Increase in storm-flood level from the 1st century AD onwards was responded to by the local population by the construction of dwelling mounds, i.e. *Wurten*. Diking started in the 11th century and by the 13th century a continuous system of winter dikes had been created. The cutting-off of the hinterland by diking resulted in higher storm-flood levels. Severe breaches of the Medieval dikes led to the formation of large bays such as the Dollart, Ley Bay, and Jade Bay as a result of higher storm-flood levels which, in turn, were caused by diking. The formation of these new bays resulted in large-scale changes in hydrographic conditions in the hinterland and, as a consequence, existing bays sometimes silted up. The consequences of short-term storm flood events are compared with the long-term effects of the changing drainage system.

Keywords: North Sea; Germany; Lower Saxony; Holocene; Sea-level changes; Former coast lines; Occupation history; Diking history

1. Introduction

The history of coastal development is a research topic with a long tradition in Lower Saxony. In the early stages, i.e. in the first decades of the 20th century, it was mainly the field of amateur scientists such as H. Schütte and D. Wildvang. They carried out thousands of corings in the Clay District (*Marsch* as opposed to *Geest*, i.e. the higher Pleistocene sandy ground) and also collected many observations in order to draft a first picture of the coastal history. Though an early stage in the research, they combined information on the geological record as well as evidence for human occupation.

There are few areas in Europe where habitation is so dependent on developments in the natural landscape as in the Clay District of the southern North Sea. Both landscape changes and settlement history were determined by sea-level changes. During the early decades of research in this new field, the opinion prevailed that it was the land that subsided, due to tectonic crustal movements. It was only in the 1930s that the view changed as a result of comparisons with sea-level change in other regions and also repeated levelling in the coastal region. Now it is generally accepted that tectonic decline contributes only a very small part compared with that ascribable to sea level rise.

In 1938, the Niedersächsisches Institut für historische Küstenforschung (Lower Saxony Institute for Historical Coastal Research) was founded by W. Haarnagel in Wilhelmshaven, with the object of carrying out coastal research in a professional way. From its foundation, the Institute was concerned not only with Holocene geology but also settlement archaeology and environmental history informed by botanical/palaeoecological research. Together with the Niedersächsisches Landesamt für Bodenforschung (Geological Survey) in Hanover

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1040-6182/03/$ - see front matter
doi:10.1016/S1040-6182(03)00064-8

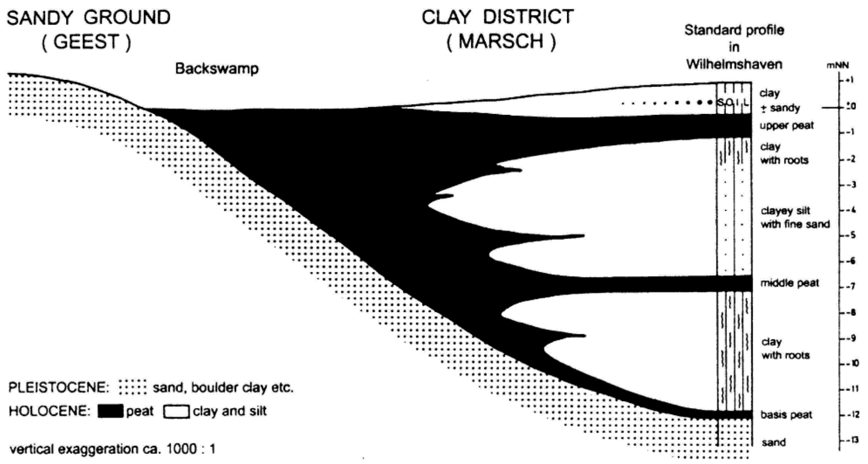


Fig. 1. Schematic representation of Holocene deposits in the Wilhelmshaven area showing a typical sequence of marine and brackish deposits with intercalated layers of peat, formed under freshwater conditions.

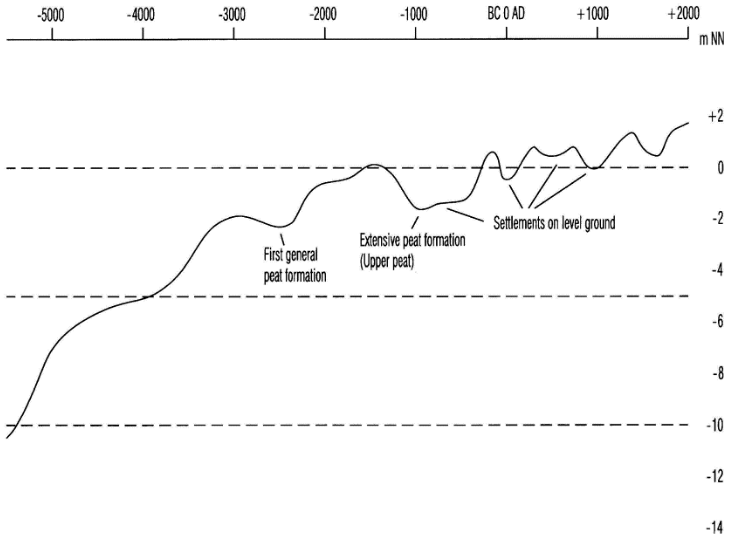


Fig. 2. Sea-level curve (mean high water level) for the middle and late Holocene in the North Sea coastal region of Germany. Age in calendar years.

of the sea level and a large-scale regression of the North Sea took place (Behre, 2003). In this time, the so-called Upper Peat was formed over extensive areas in the German coastal region (Fig. 1).

The formation of the Upper Peat (Figs. 1, 2 and 4) is an important feature in the landscape history and the corresponding sea-level decline has also consequences for the history of habitation. Below the Upper Peat there is, according to the diatom flora, a transitional zone from salt and brackish to freshwater conditions during which clay was still deposited. Here rhizomes are encountered, which come from the *Phragmites* peat above. This reedswamp peat is another part of the regressive development and in typical successions it is followed by sedge and carr peats (Fig. 4). The beginning of the Upper Peat formation dates to ca. 1500 BC with somewhat earlier dates in landward areas (ca. 1700 BC).

In many places, the formation of fen peat stopped and was succeeded by raised bog vegetation which resulted in the formation of *Sphagnum* peat (Fig. 4). This strongly suggests that the initial lowering of sea level has taken place which lead to a decline of groundwater level in the coastal area. This had consequences for mire development insofar as fens are dependent on groundwater, while raised bogs are ombrotrophic, i.e. rainwater dependent.

The extent of the Upper Peat is well known because its upper surface is only 1–2 m below the present-day clay surface and is often encountered in field investigations as well as during construction of buildings and

GLACIAL SEDIMENTS AND POST-GLACIAL SEDIMENTATION OF THE DOGGER BANK, NORTH SEA

Stribrny, B.[1], Sonnewald, M.[1], Türkay, M.[1], Uhl, D.[1], Wilmsen, M.[1], El Afty, H.[1], Wolters, S.[2]

[1]Senckenberg Gesellschaft für Naturforschung, Frankfurt am Main, Germany, [2]Niedersächsisches Institut für historische Küstenforschung, Wilhelmshaven, Germany

The Dogger Bank is a sandy shoal of the central North Sea which currently lies about 15 m to 40 m below sea-level. It has a southwest north-east striking length of approx. 320 km and a width of approx. 120 km. In 2011 an expedition was carried out on board of the research vessel "FS Heincke"(Stribrny et al. 2012). Benthos and coarse sea bottom sediments (> 1 cm in diameter) were sampled at 37 stations on the bank and in an adjacent trench called "Silver Pit"(station T1, depth 76 m). The highest sample weights (0.01-30 kg) and the coarsest pebble sizes (1 to 35 cm) are linked to the bathymetric highest elevations. In the northeastern part of the bank, gravel of crystalline rocks predominate. Here, granites, syenites, gneisses, porphyritic rhyolites, quarzites and quartz pebbles are present. However, also minor contents of flints, chalk and sandstones occur. In the southwestern part of the bank flints, basalts and sandstones predominate and might stem from the British Islands. In sample T1 basalts are the most common rocks, but flints are totally absent. Due to this, scouring of the "Silver Pit" trench seems to be younger than glacial transport and sedimentation of the flints on the Dogger Bank. A limestone from station T1 with crinoid fragments with an inferred late Ordovician to Carboniferous age may be derived from the Oslo Graben. A charcoal and sulfide bearing sandstone (T1) yielded an assemblage of terrestrial palynomorphs of late Jurassic age. Ventifacts are present in a number of stations on the bank. They document that this area must have been a land surface during the last glaciations. Moreover, well rounded shells of the fossil marine oyster *Gryphea*, which are of Jurassic age, must have been abraded at a shore line. Post-glacial sedimentation on the Dogger Bank is documented by peat samples. The oldest peat samples date in the early Holocene (11,500 years before today). This is proven by pollen analyses and investigations of fruits and seeds of birches, poplars and pines. Immigration of hazel, elm and oak approx. 8,000 years before today is documented in peat samples as well. So it can be concluded that moraine material has been deposited during the Saale and Weichsel glaciations, and polished by wind and sand on a peri-glacial land surface (100,000 to 10,000 years before present). The gravels are of British (e.g., basalts) and of Scandinavian origin as shown by limestones and porphyric rhyolites with rhombic feldspars of the Oslo Graben. From 11,500 to 8,000 years before today, peat was deposited and about 8,000 years ago, the island of the Dogger Land was flooded by the rising level of the North Sea.

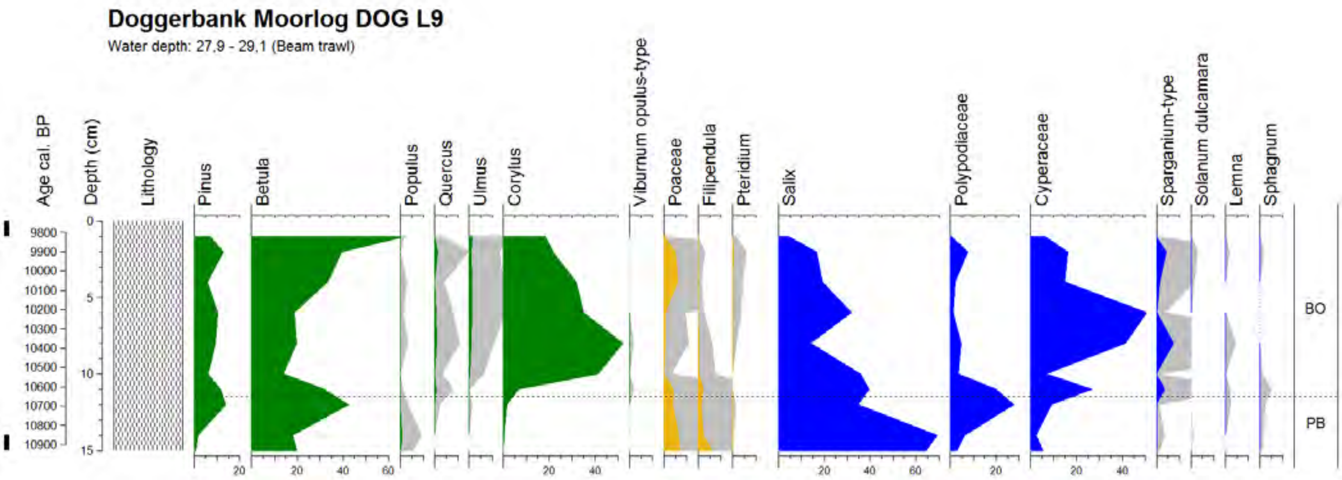
Acknowledgements:

This survey was supported by the Hessische Landes-Offensive zur Entwicklung Wissenschaftlich-ökonomischer Exzellenz (LOEWE).

Reference:

Stribrny, B., Sonnewald, M., Türkay, M., Uhl, D., Wilmsen M., Wolters, S., 2012. Die Doggerbank - Gerölle erzählen eine Klimageschichte. Natur, Forschung, Museum, 142, 36-43.

Moorlog (Torfgeröll)

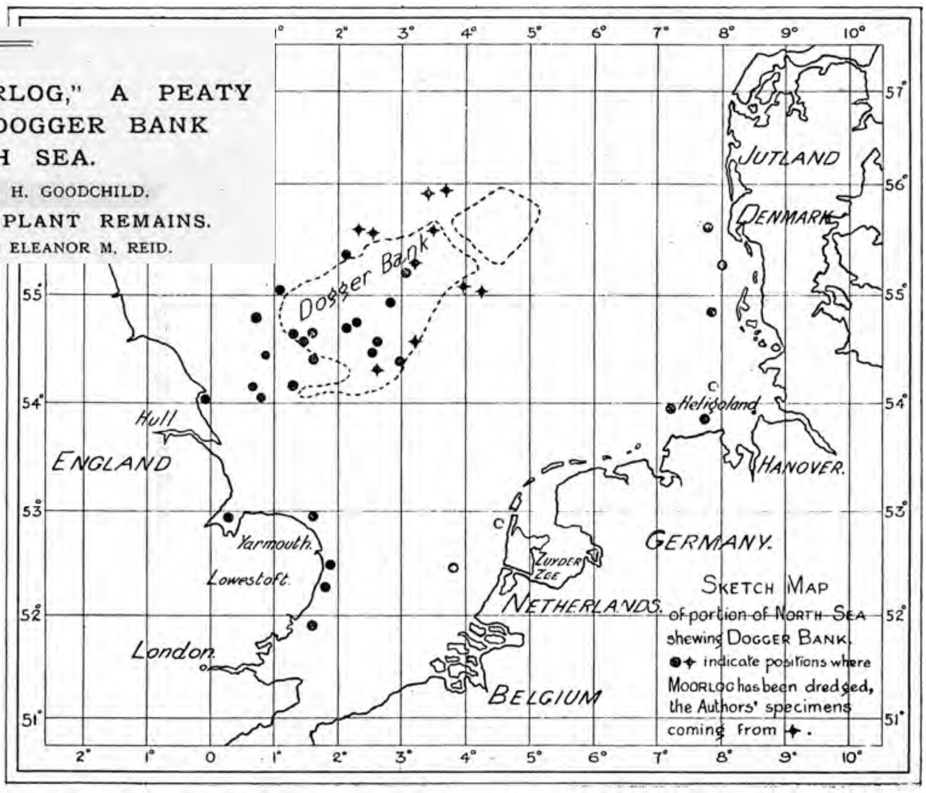


SOME NOTES ON "MOORLOG," A PEATY DEPOSIT FROM THE DOGGER BANK IN THE NORTH SEA.

By HENRY WHITEHEAD and H. H. GOODCHILD.

WITH A REPORT ON THE PLANT REMAINS.

By CLEMENT REID, F.R.S., and (Mrs.) ELEANOR M. REID.



According to the different tidal amplitude (Behre 2003), the MHW differs along the coast and from the coastal zone to inland where it is also influenced by additional morphological and hydrological factors, so the data from the coast itself are the most reliable. In compiling data from the various coastal areas, all depths had to be corrected to a standard tide gauge, for which Wilhelmshaven was chosen. In the curves presented in Figs 1, 3 and 7, the symbols always show the local MHW as given by the original authors, while the curve itself is based on corrected data that are indicated by crosses. As the tidal range is dependent on coastline configuration and bathymetry, there must have been a considerable deviation from the modern tidal range during the early Holocene, in particular before the connection of the North Sea with the English Channel, and during the existence of the Dogger Bank. Recent considerations on former tidal ranges have been made by Austin (1991) and Shennan *et al.* (2000). According to their models, the difference

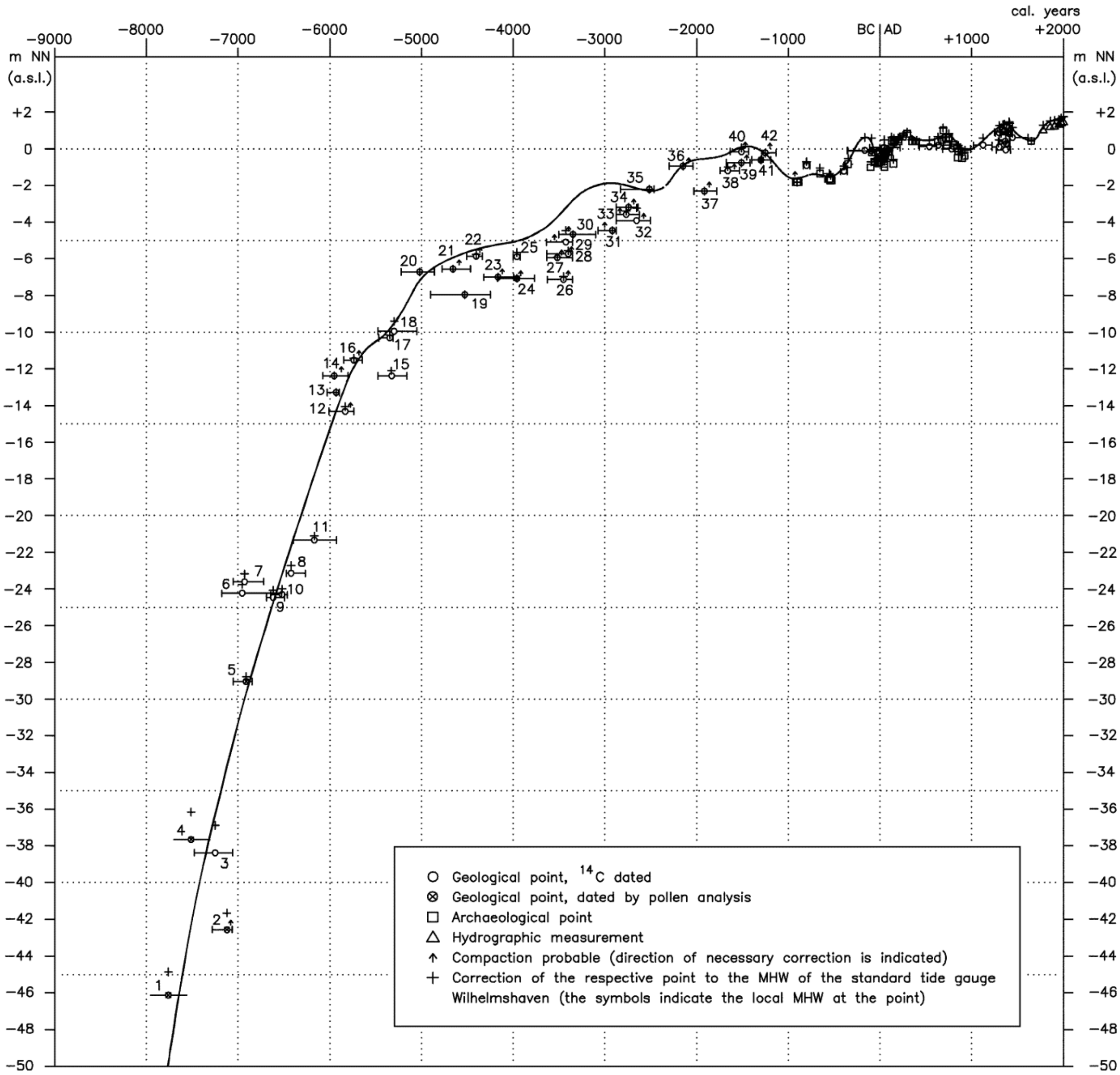


Fig. 1. New curve showing sea-level changes (MHW) in the southern North Sea. Horizontal lines with short vertical lines at the ends show calibrated ^{14}C dates and the 1σ range of the calibrated date, which is often asymmetrical after calibration. Where there are no vertical lines, age as estimated by pollen analytical or archaeological dating is indicated. The curve is based mainly on the position of the + symbols. Possible compaction effects and transgression and regression trends that can be fixed only in time have also been considered. For numbering of the points in the later part of the curve, see Fig. 3.

A new Holocene sea-level curve for the southern North Sea

KARL-ERNST BEHRE

BOREAS

Behre, K.-E. 2007 (January): A new Holocene sea-level curve for the southern North Sea. *Boreas*, Vol. 36, pp. 82–102. Oslo. ISSN 0300-9483.

A new sea-level curve (MHW, mean high water level) for the southern North Sea is presented, spanning the last 10 000 years and based on new data recently obtained along the German coast. The 118 dates were selected from basal as well as intercalated peats of the Holocene sequence and archaeological dates from the last 3000 years. Because of different MHW levels along the German North Sea coast, all data were corrected to the standard tide gauge at Wilhelmshaven to make them comparable. Special advantages of this area for sea-level reconstructions are negligible tectonic and isostatic subsidence and the absence of coastal barrier systems that might have mitigated or masked sea-level changes. Changes of water level had therefore immediate consequences for the facies and could be dated exactly. The chronostratigraphic Calais–Dunkirk system has been improved and adapted to the new data. Altogether seven regressions (R 1–R 7) have been identified, each of them characterized by a distinct decline in sea level. These fluctuations are in accord with the evidence from other parts of the North Sea region. A draft of former North Sea shorelines is presented on the basis of this sea-level curve.

Karl-Ernst Behre (e-mail: behre@nihk.de), Niedersächsisches Institut für historische Küstenforschung, Viktoriastr. 26/28, D-26382 Wilhelmshaven, Germany; *received 29th August 2005, accepted 29th May 2006.*

The rise in sea level as a consequence of global warming is a topical issue for both specialists and the wider public. In areas where shallow seas predominate, the consequences of changing sea levels can be enormous, and shallow coasts such as in the southern North Sea region provide excellent sources for the documentation of geological and historical sea-level changes.

After several predecessors such as Nilsson (1948), the first sea-level curve to rely only on radiocarbon ages was published by Jelgersma (1961). It became a benchmark work not just for The Netherlands but also adjoining areas. As in the case of the North Sea, sea-level curves were also constructed for other parts of the world (Pirazzoli 1991). They looked rather different and gave rise to the highly debatable question whether eustatic changes are best reflected by a smooth or an oscillating curve.

The area around the North Sea offers the highest density of sea-level data in the world. In Germany, in particular, both the amount and the quality of data have greatly increased in recent years. Much information has been provided by geologists working in the Clay District, but many new data also derive from archaeological investigations in the coastal region. The latter provide a good time resolution for the younger part of the curve. Two important features of the southeastern North Sea make this area particularly suitable for evaluation of regional eustatic sea-level changes. First, the southeastern margin is the most stable one in the North Sea area with respect to tectonics and isostatic movements and, second, the coastline is open and without beach barriers, so it is particularly sensitive to sea-level changes, which are readily registered.

The article presents a carefully evaluated body of critically selected, available and unpublished data resulting in a new sea-level curve. For further details as to the data used, as well as the methods employed, the reader is referred to Behre (2003).

The Calais–Dunkirk system

Although the appropriateness of the Calais–Dunkirk system has been discussed by some authors (e.g. Baeteman 1999), it is the only one that can be used for supraregional contexts because it is based on dated transgressive and regressive trends, and it has the only terminology that is applicable throughout the southern North Sea. In this contribution, the definition of these terms used hitherto has been changed in some details and – most importantly – regression phases have been inserted.

The terms used in the Calais–Dunkirk system have their origin in the Belgian–French coastal region. Modifications of the system, which was first introduced in 1924, have been compiled by Roeleveld (1974); see also Baeteman (1981) and Ervynck *et al.* (1999). Initially, the system was based solely on lithostratigraphy. In particular, Dubois (1924), Tavernier (1948) and Tesch (1930) described the basic outline for a stretch of coast extending from NE France through Belgium to the SW Netherlands. At the base is the so-called ‘basis peat’, overlain by the mainly clastic Calais series which is separated by a peat layer from the following Dunkirk series which is also

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DOI 10.1080/03009480600923386

Int J Earth Sci (Geol Rundsch) (2010) 99:1707–1719
DOI 10.1007/s00531-009-0477-6

ORIGINAL PAPER

Early Holocene environmental history of sunken landscapes: pollen, plant macrofossil and geochemical analyses from the Borkum Riffgrund, southern North Sea

Steffen Wolters · Manfred Zeiler · Friederike Bungenstock

Received: 29 September 2008 / Accepted: 19 July 2009 / Published online: 21 August 2009

Abstract A vibrocore from the sea floor of the southern North Sea provides a ~1,500-year record of early Holocene vegetation history and mire development in a landscape now 33 m below sea-level. Pollen, plant macrofossil and geochemical analyses of an AMS ^{14}C dated sand–peat–marine mud sequence document the paludification on Pleistocene sands ~10,700 cal BP, the subsequent development of eutraphentic carr vegetation and the gradual inundation by the transgressing sea ~9,350 cal BP. *Pinus–Corylus* woodland prevailed on terrestrial grounds after hazel had immigrated ~10,700 cal BP. *Salix* dominated the carr vegetation throughout 1,300 years of peat formation, because *Alnus* did not spread in the Borkum Riffgrund area until 9,300 BP. Brackish reed vegetation with *Phragmites* established after inundation and siliciclastic marine sediments were being deposited. This article also examines the detection and suitability of key horizons indicative of marine influence. XRF-Scanning provides the most detailed results in the briefest possible time to pinpoint spectra best suitable for AMS ^{14}C dating of classical key horizons such as start of peat formation and transgressive contact. The combined application of botanical and geochemical methods allows determining new key horizons indicative of marine influence, namely the earliest marine inundation and the onset of sea-level influence on coastal ground water level.

Keywords North Sea · Holocene · Pollen analysis · Geochemistry · Carr vegetation · Sea-level index points

Introduction

An increasing interest in submerged landscapes on the European continental shelf area, their nature and their human occupation and exploitation (Bailey and Flemming 2008; Coles 2000; Hazell 2008; Mol et al. 2006) has created a renewed demand for palaeoenvironmental reconstructions of vegetation changes on sunken land areas and along former coastlines. These reconstructions have a long tradition and were enabled by analysis of peat deposits originating from the floor of the North Sea (Erdtman 1925; Whitehead and Goodchild 1909). Pollen and macrofossil investigations of so-called *moorlog*, i.e. peat lumps brought up by the trawls of fishing vessels characterized the research on Holocene vegetation change on today's sea bed and its correlation to sea-level rise for more than half a century (Godwin 1943, 1945; Jelgersma 1961). From the end of the 1960s peat layers from marine cores have replaced *moorlog* as investigation material (Behre and Menke 1969; Oele 1969) and nowadays peat is regularly cored from the floor of the North Sea.

However, in recent years peat has rarely been used for the analysis of pollen or plant macrofossils in terms of vegetation history but virtually exclusively for dating Holocene sea-level changes (Shennan et al. 2000; Vink et al. 2007). In fact only few palynological investigations have been carried out to track Late Glacial and Holocene vegetational changes and successional processes on the today's sea bed (Behre and Menke 1969; Behre et al. 1985; Ludwig et al. 1979; Menke 1968; 1996) and most of them lack precise ^{14}C-based time control. Accordingly our

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knowledge about terrestrial landscape history on the northwest European continental shelf area is fragmentary. That also applies to the patterns of peat formation and mire development under the influence of rapid sea-level rise and—with a view to prehistoric research—the change of natural resources of Stone Age hunter-gatherers against the background of sustained land loss. Therefore, we need more detailed and well-dated pollen and macrofossil analytical studies of submarine peat deposits to reconstruct Holocene coastal paleolandscapes.

Peat also plays a major role in the dating of Holocene sea-level change in the southern North Sea. Numerous dates greatly improved our knowledge of sea-level change and coastal development for at least the last 8,000–9,000 years. Extensive sets of data for the southern North Sea have recently been presented by Behre (2007), Bungenstock and Schäfer (2009), Vink et al. (2007) and Ward et al. (2006; see also Hazell 2008; Kiden et al. 2002; Shennan et al. 2000). But these latest compilations of data also show that only few investigations cover the period of early Holocene sea-level rise. Beside the low number of early Holocene sea-level dates there are also considerable differences in dating accuracy, mainly due to the application of dates gained in times when ^{14}C dating was still in its infancy or has only economically been employed. The range goes from palynostratigraphic datings of *moorlog* (Jelgersma 1961) over palynostratigraphic dates obtained from peat layers in cores (Behre and Menke 1969; Ludwig et al. 1979) and eventually to ^{14}C-based datings of basal peats (Behre et al. 1985; Jelgersma et al. 1979; Ludwig et al. 1979, 1981; Menke 1996; Shennan et al. 2000; Vink et al. 2007). However, the majority of ^{14}C datings of North Sea peats result from bulk samples which bear the risk of contamination (Törnqvist et al. 1998) and yield dates with larger age ranges than AMS ^{14}C dates. Additional uncertainties arise from the fact that peat erosion does occur regularly but is difficult to discern without reassuring application of microfossil analysis (Waller et al. 2006). Thus, only few of the ^{14}C-dated basal peats of the southern North Sea represent sea-level index points derived from well-dated key horizons such as the onset of basal peat growth or the transgressive contact of inundating clastic sediment on the non-eroded top of basal peat which is indicative for mean sea-level and for mean high water, respectively.

In this article, we present an AMS ^{14}C-dated pollen diagram with associated macrofossil and geochemical analysis. The main objective is to provide new data of vegetation development on terrestrial and semi-terrestrial habitats under rising marine influence in a landscape now ~30 m below sea-level. A robust ^{14}C chronology based on selected macrofossils offers new age details on immigration and spread of native deciduous trees. Secondly, we present a combined approach to identify datable key horizons in submarine peat–silt sequences indicative of marine influence by correlation of lithostratigraphical, palynological and geochemical methods and give new data for sea-level reconstructions in a time slice still poor in sea-level index points.

Geographical setting and geological background

The core location (54°06.0′N, 06°46.7′E) lies in the area of the Borkum Riffgrund north of the East Frisian barrier islands Borkum and Juist and west of Heligoland at a water depth of 33.0 m (Fig. 1). According to Behre (2007) this depth approximately corresponds to the palaeoshoreline of 9,000 cal BP reached during the second phase of the North Sea transgression.

Streif (2004) subdivides and characterizes three major phases of the late Weichselian and Holocene North Sea transgression. The first phase lasted from about 20,000 cal BP till the early Holocene (~11,500 cal BP) and comprises the relative sea-level rise from the lowstand of about 130 to 72 m below the present-day sea-level. The inundation progressively covered the North Sea basin, palaeochannels were filled and brackish water entered into the southern North Sea between the English coast and the Dogger Bank.

The second phase (11,500–8,000 cal BP) is characterized by a continuous transgression from 72 to 25 m below present sea-level occurring with a rapid, unidirectional landward shift of the shoreline. In that course the early Holocene woodland landscape was inundated by the sea. The marine Holocene deposits of the southern North Sea area are relatively thin, usually less than 5 m thick. Locally, limnic mud and peat remnants are situated at the base of Holocene sequences, showing that limnic and semiterrestrial facies units originally had a wider distribution. They also indicate that, for some time, peat formation, followed by clastic sedimentation in tidal flat environments could keep pace with the sea-level rise until peat was inundated.

The present-day coastal landscape with its barrier islands, tidal flats and coastal marshlands developed during the third phase (from 8,000 cal BP to present) which is characterized by 25 m of sea-level rise to the present-day elevation and the formation of a wedge-like sediment body along the coast of the German Bight.

Methods

Coring

The core "VC 2068" was taken during a shallow seismic survey cruise of the research vessel "GAUSS",

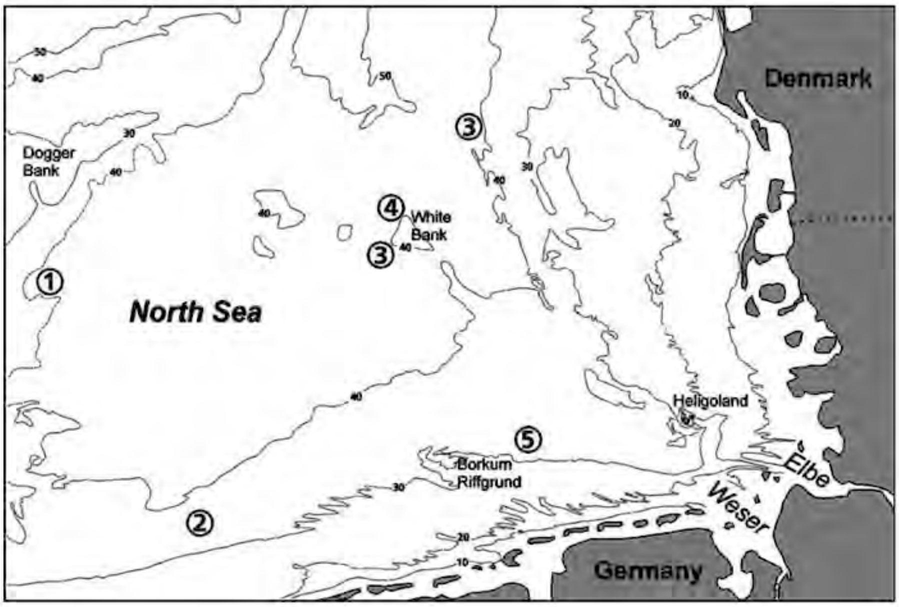


Fig. 1 Map of the study area showing the location of sampling sites of the present and of important former palynological investigations. *1* Behre and Menke (1969), *2* Behre et al. (1985), *3* Ludwig et al. (1979), *4* Menke (1996), *5* present study

Interpretation of the seismic lines enabled the detection of thick peat deposits and the determination of the coring position.

The drilling was carried out using a vibracore device "VKG-6" produced by Schmidt (Rostock) which employs a submersible, electrically driven vibrating head. The 6 m long, steely core tube contained a PE liner with an inner diameter of 100 mm.

The water depth measured at the coring location was corrected to nautical chart datum.

Pollen and macrofossil analysis

The core was sampled at 2 cm intervals throughout the peat and silt–clay sections. The samples were prepared for pollen analysis according to the standard techniques outlined by Moore et al. (1991). A *Lycopodium* spike was added to enable pollen concentration to be calculated. Pollen counting and identification was carried out at a total magnification of ×400 for routine counting and ×1000 for critical objects. In general a pollen sum of at least 500 was achieved, based on a total terrestrial pollen sum excluding *Salix* and all hydrophyte, helophyte and reed taxa (TTP). Nomenclature follows Beug (2004) for pollen grains and Moore et al. (1991) for spores. The pollen diagram was prepared using the TG View software by Grimm (2004). Palynostratigraphic division into pollen assemblage zones (PAZ) was aided by optimal partitioning with sum-of-squares criteria (Birks and Gordon 1985) facilitated by the program ZONE (Juggins 1991). The number of significant pollen zones was evaluated by comparison with the broken-stick model (Bennett 1996). Material retained in the sieve of mesh size 200 μm during the initial stages of pollen preparation was examined for macrofossils.

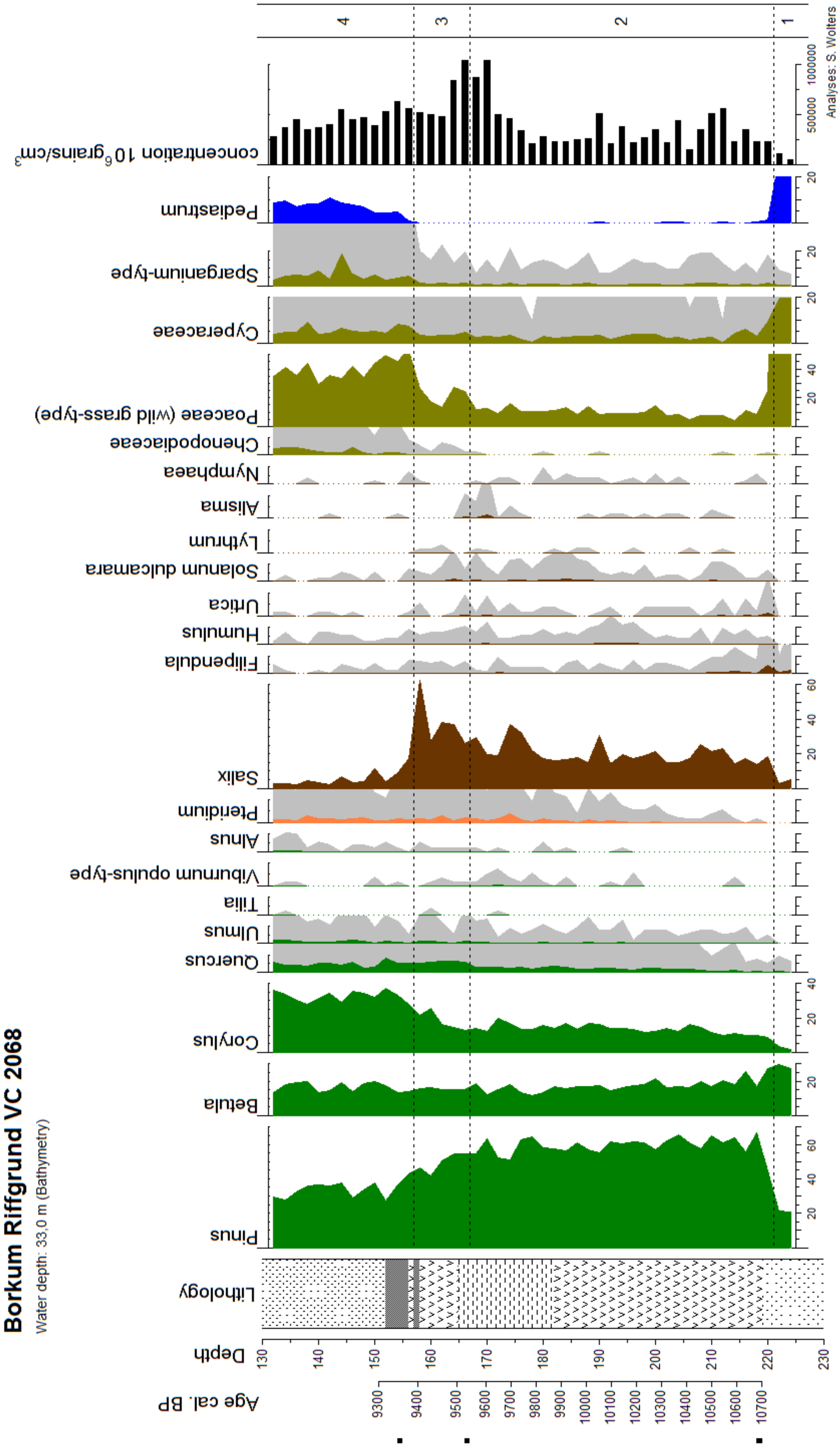
Radiocarbon dating

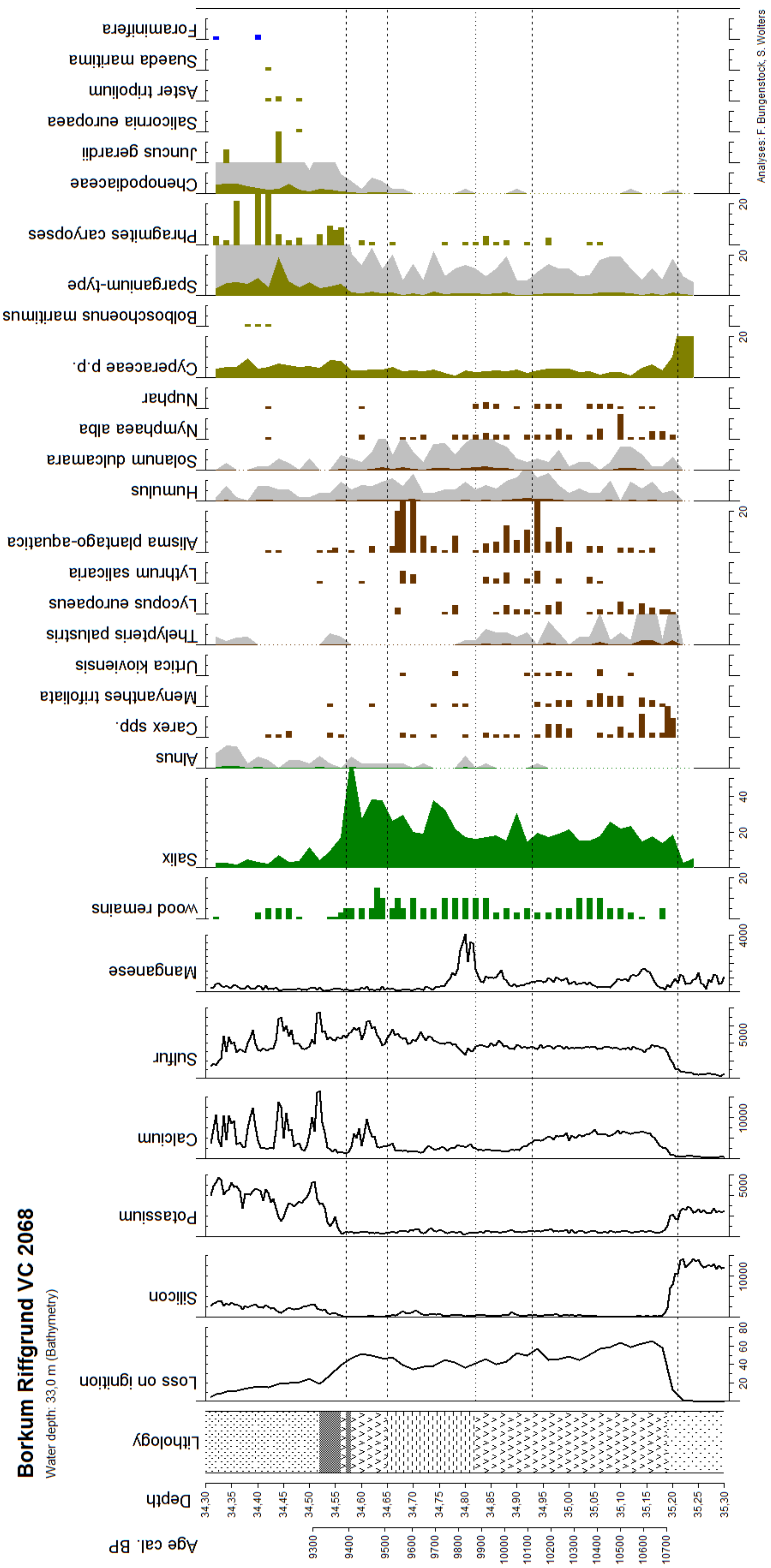
Plant macrofossils were selected for AMS ^{14}C dating from three levels, namely base and top of the peat layer and the rise of the curve of Chenopodiaceae as an indicator of halophilous vegetation and hence marine influence. Samples were submitted to the Poznań Radiocarbon Laboratory, Poland. The dates were calibrated with Calib 5.0.2 (Stuiver and Reimer 1993). The age model in the pollen and geochemistry diagrams results from the mean values of each calibrated date and linear interpolation and is provided by the TG View software by Grimm (2004).

Geochemistry

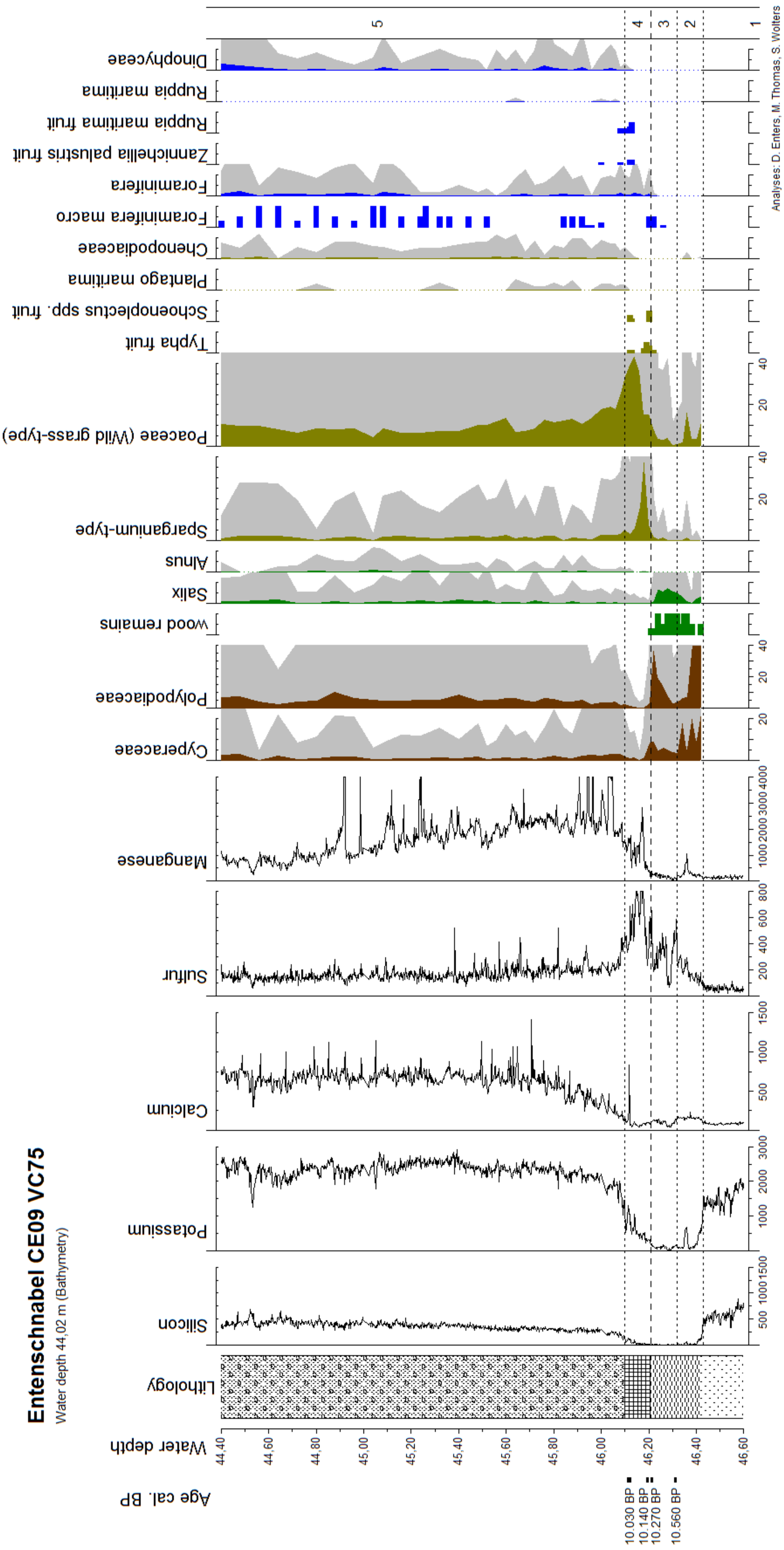
Geochemical element distribution was determined with an Avaatech X-ray fluorescence (XRF) core scanner (Richter et al. 2006; Tjallingii et al. 2007) at Marum, Center for Marine Environmental Sciences, Bremen University.

Light elements such as aluminium (Al), silicon (Si), sulphur (S), potassium (K), calcium (Ca), titanium (Ti), manganese (Mn) and iron (Fe) were measured at 5 mm spacing (instrument settings 30 s, 10 kV, 700 μA). The measurements are expressed in total counts. Heavy elements were measured as well, but element values with total counts less than 100 as in some parts of the curves of rubidium, strontium and zirconium are beneath the detectable zone and thus only of restricted use for interpretation. Additionally approximately 10 g of sample


Borkum Riffgrund VC 2068
Water depth: 33,0 m (Bathymetry)
Age cal. BP
Depth
Lithology
Pinus
Betula
Corylus
Quercus
Ulmus
Tilia
Viburnum opulus-type
Alnus
Pteridium
Salix
Filipendula
Humulus
Urtica
Solanum dulcamara
Lythrum
Alisma
Nymphaea
Chenopodiaceae
Poaceae (wild grass-type)
Cyperaceae
Sparganium-type
Pediastrum
concentration 10^6 grains/cm^3
Analyses: S. Wolters
Sand
Carr peat
Peat
Clay/peat
Clay
1
2
3
4



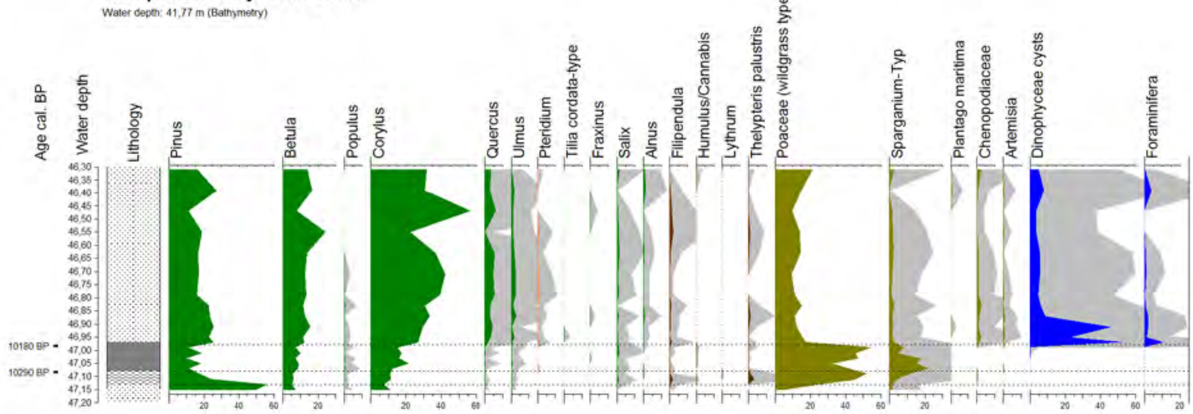
Borkum Riffgrund VC 2068
Water depth: 33,0 m (Bathymetry)
Age cal. BP
Depth
Lithology
Loss on ignition
Silicon
Potassium
Calcium
Sulfur
Manganese
wood remains
Salix
Alnus
Carex spp.
Menyanthes trifoliata
Urtica kioviensis
Thelypteris palustris
Lycopus europaeus
Lythrum salicaria
Alisma plantago-aquatica
Humulus
Solanum dulcamara
Nymphaea alba
Nuphar
Cyperaceae p.p.
Bolboschoenus maritimus
Sparganium-type
Phragmites caryopses
Chenopodiaceae
Juncus gerardii
Salicornia europaea
Aster tripolium
Suaeda maritima
Foraminifera
Analyses: F. Bungenstock, S. Wolters



Entenschnabel CE09 VC75
Water depth 44,02 m (Bathymetry)
Age cal. BP
Water depth
Lithology
Silicon
Potassium
Calcium
Sulfur
Manganese
Cyperaceae
Polypodiaceae
wood remains
Salix
Alnus
Sparganium-type
Poaceae (Wild grass-type)
Typha fruit
Schoenoplectus spp. fruit
Plantago maritima
Chenopodiaceae
Foraminifera macro
Foraminifera
Zannichellia palustris fruit
Ruppia maritima fruit
Ruppia maritima
Dinophyceae
Analyses: D. Enters, M. Thomas, S. Wolters
10.030 BP
10.140 BP
10.270 BP
10.560 BP
44,40
44,60
44,80
45,00
45,20
45,40
45,60
45,80
46,00
46,20
46,40
46,60
5
4
3
2
1

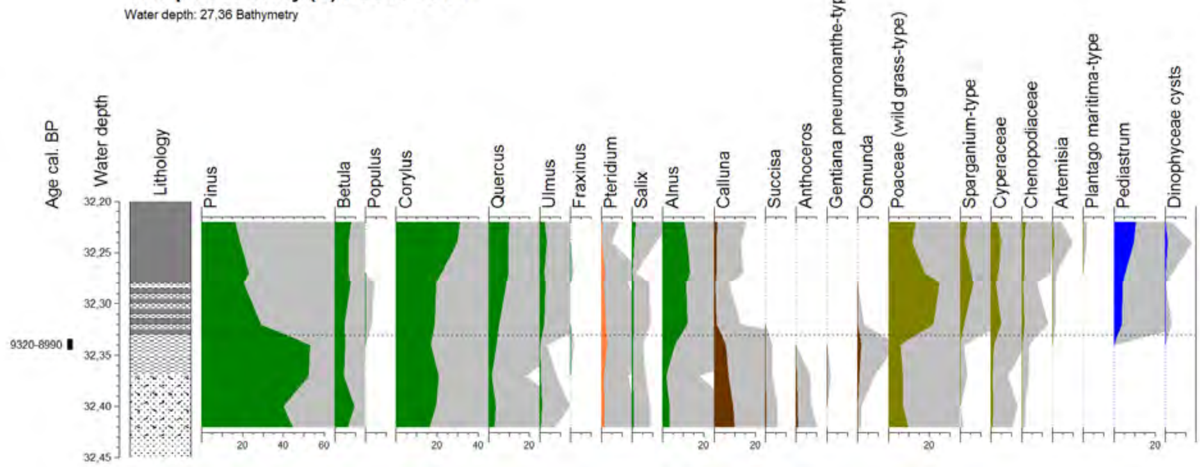
Elbe palaeovalley CE09 VC06

Water depth: 41,77 m (Bathymetry)



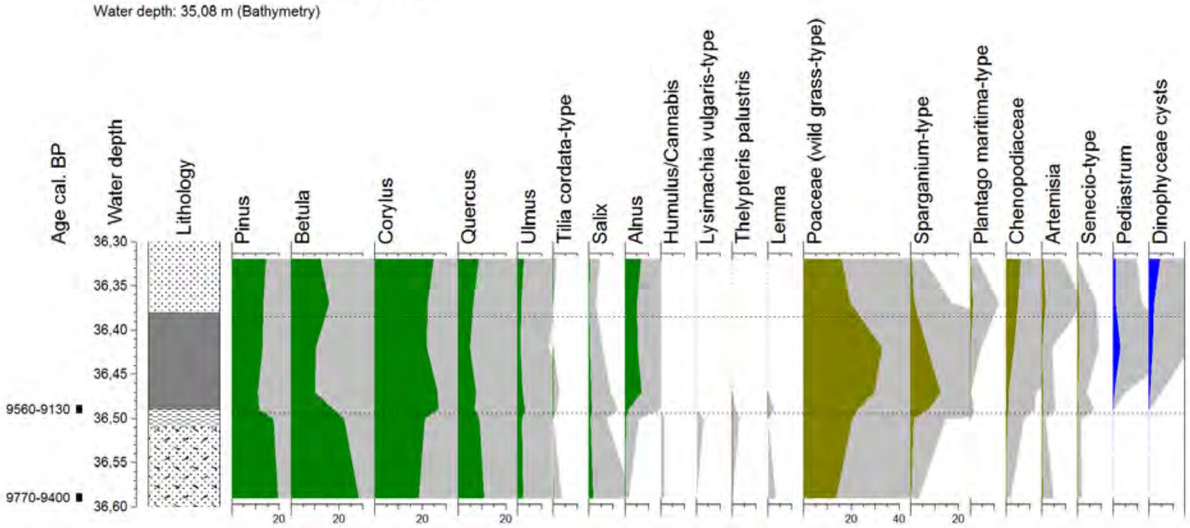
Elbe palaeovalley (S) HE242 VC14

Water depth: 27,36 Bathymetry



Northern grounds BSK VC15

Water depth: 35,08 m (Bathymetry)



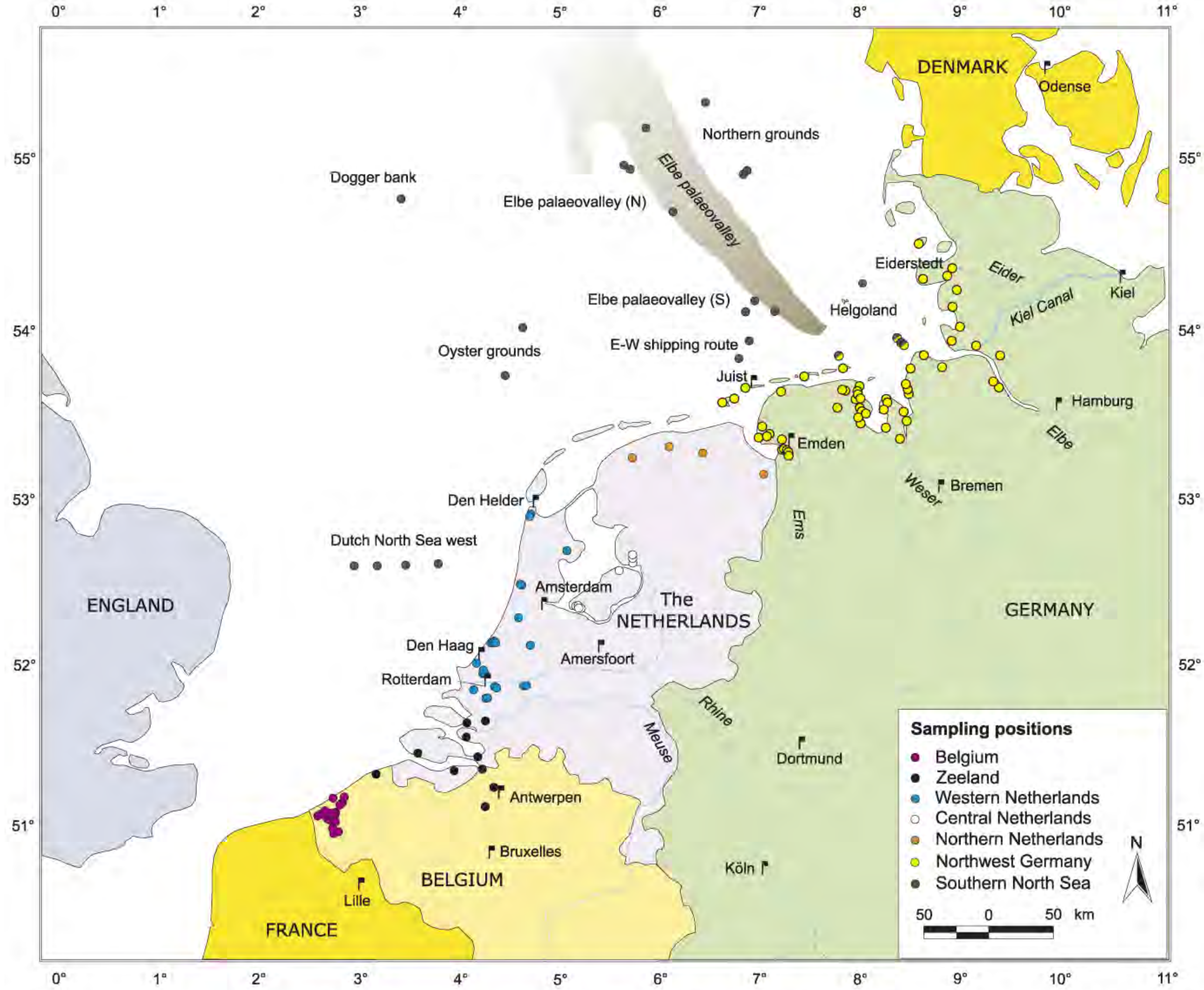


Fig. 1. Locations of index points used for the determination of Holocene RSL rise in Belgium, the Netherlands, northwest Germany and the southern North Sea. More than one index point can be derived from each sample site where several samples were taken from the same core/outcrop or where samples lie very close to each other.

2.2.2. *The Netherlands*

2.2.2.1. Zeeland. Sea-level index points (mostly bases of basal peats) derived from Zeeland and the adjacent estuarine flood plain of the River Schelde in northern Belgium have been obtained from Kiden (1995) and the publications cited therein, and were used to produce an error envelope for the upper limit of MSL for Zeeland covering the time period of approximately 8–4 cal. ka BP (Fig. 2B). As the peat samples were generally thin (2–5 cm) and came from the bases of the basal peats which rest directly on the sandy Pleistocene subsoil, compaction effects were considered to be negligible. However, Kiden (1995) found that a large number of his Zeeland index points exhibited relatively high but variable positions in comparison to the western Netherlands MSL envelope, and attributed this to the interaction between the pronounced local Pleistocene morphology and topography, differential palaeo-groundwater levels and the variable influence of floodbasin and river gradient effects on the altitude of peat growth. Nevertheless, samples derived directly from the Schelde palaeovalley (e.g. samples 4, 10, 11, 27) exhibited a relatively low time–depth position and appeared to have been influenced far less by local and regional groundwater effects (Kiden, 1995). He thus concluded that although a large number of the Zeeland sea-level index points had to be considered unreliable, the lowermost points could still provide a good estimation of MSL in the area. Twelve of these more reliable points have been included in this study (Appendix A; Fig. 2B).

2.2.2.2. Western and northern Netherlands. A relative (upper limit of) MSL curve for the western and northern

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Holocene relative sea-level change, isostatic subsidence and the radial viscosity structure of the mantle of northwest Europe (Belgium, the Netherlands, Germany, southern North Sea)

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Received 5 July 2006; received in revised form 4 April 2007; accepted 23 July 2007

Abstract

A comprehensive observational database of Holocene relative sea-level (RSL) index points from northwest Europe (Belgium, the Netherlands, northwest Germany, southern North Sea) has been compiled in order to compare and reassess the data collected from the different countries/regions and by different workers on a common time–depth scale. RSL rise varies in magnitude and form between these regions, revealing a complex pattern of differential crustal movement which cannot be solely attributed to tectonic activity. It clearly contains a non-linear, glacio- and/or hydro-isostatic subsidence component, which is only small on the Belgian coastal plain but increases significantly to a value of ca 7.5 m relative to Belgium since 8 cal. ka BP along the northwest German coast. The subsidence is at least in part related to the Post-Glacial collapse of the so-called peripheral forebulge which developed around the Fennoscandian centre of ice loading during the Last Glacial Maximum. The RSL data have been compared to geodynamic Earth models in order to infer the radial viscosity structure of the Earth's mantle underneath NW Europe (lithosphere thickness, upper- and lower-mantle viscosity), and conversely to predict RSL in regions where we have only few observational data (e.g. in the southern North Sea). A very broad range of Earth parameters fit the Belgian RSL data, suggesting that glacial isostatic adjustment (GIA) only had a minor effect on Belgian crustal dynamics during and after the Last Ice Age. In contrast, a narrow range of Earth parameters define the southern North Sea region, reflecting the greater influence of GIA on these deeper/older samples. Modelled RSL data suggest that the zone of maximum forebulge subsidence runs in a relatively narrow, WNW–ESE trending band connecting the German federal state of Lower Saxony with the Dogger Bank area in the southern North Sea. Identification of the effects of local-scale factors such as past changes in tidal range or tectonic activity on the spatial and temporal variations of sea-level index points based on model-data comparisons is possible but is still complicated by the relatively large range of Earth model parameters fitting each RSL curve, emphasising the need for more high-quality observational data.

1. Introduction

The nature and magnitude of relative sea-level (RSL) movement (i.e. rise or fall or a sequence of events involving both) in any particular coastal or estuarine area since the Last Glacial Maximum (LGM) is determined mainly by three regional-scale factors which interact with each other: (i) the climatically induced global/eustatic increase in ocean water volume, (ii) tectonic subsidence or uplift of the crust and (iii) the glacio- and/or hydro-isostatic adjustment of the lithosphere in reaction to the mass redistribution associated with spatially and temporally changing ice, water and sediment volumes (e.g. Lambeck, 1997; Shennan et al., 2000a; Shennan and Horton, 2002; Milne et al., 2005). In northwest Europe, the post-glacial isostatic component is related mainly to the rebound of Fennoscandia and/or water and sediment loading of the North Sea Basin. Eustatic sea-level rise is a function of time only, whereas tectonic and isostatic subsidence/uplift are

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doi:10.1016/j.quascirev.2007.07.014

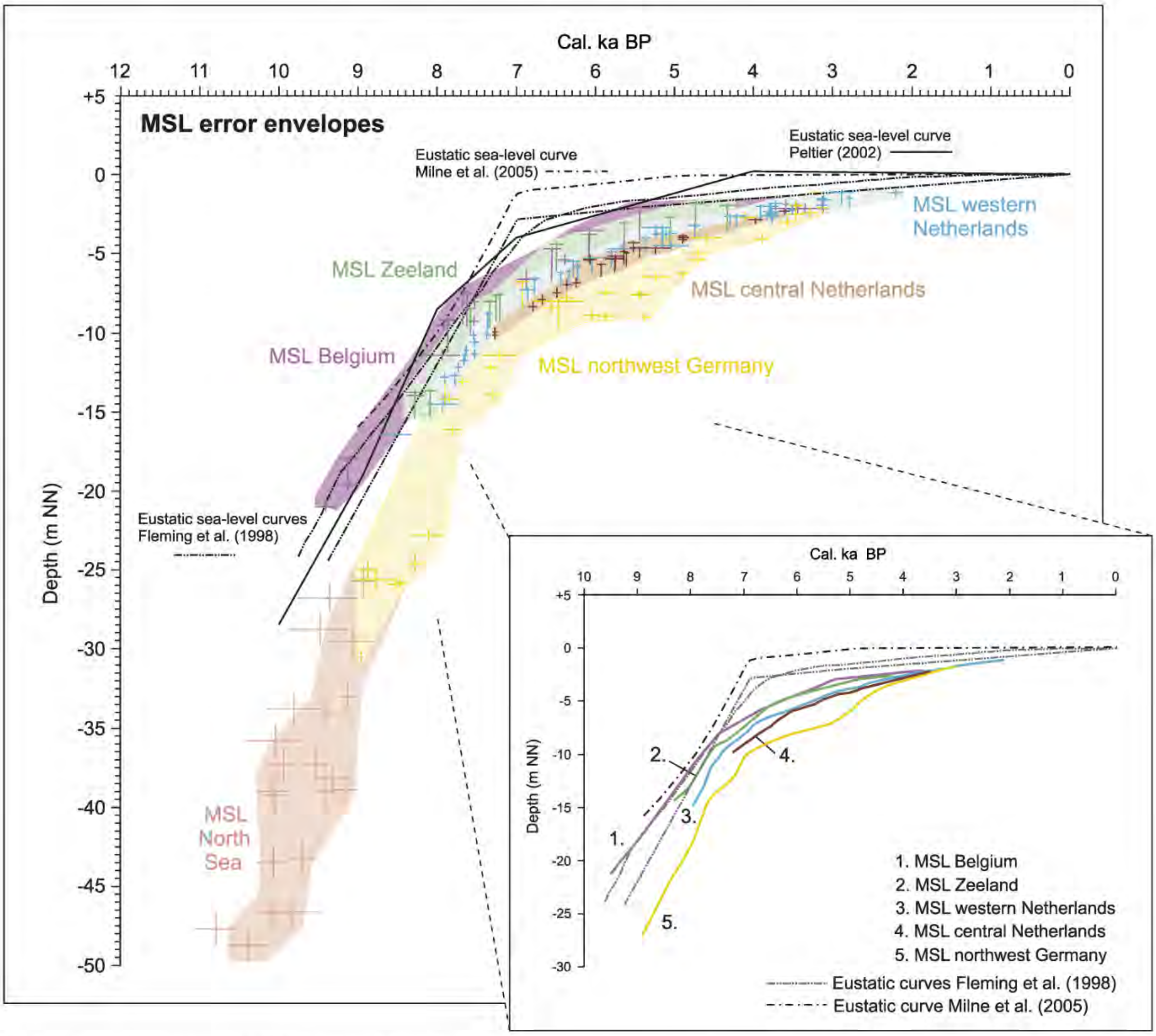


Fig. 6. Error bands of estimated MSL (determined from the local MHW/upper limit of MSL data as outlined in Section 3.1 and Appendix A) of Belgium, the Netherlands, Germany and the southern North Sea in comparison with the eustatic sea-level curves of Fleming et al. (1998), Peltier (2002) and Milne et al. (2005). The MSL curves depicted in the inset represent the mid-lines of the respective MSL error bands.

7 cal. ka BP (Fig. 7). Strictly speaking, the isostatic subsidence of the western Netherlands relative to Belgium may thus have been smaller than that predicted by Kiden et al. (2002). In reality, it is clear that our MSL data are probably biased by an overcorrection resulting from the use of large present-day (Belgian) tidal ranges, and the interpreted MSL curves used by Kiden et al. (2002) are likely to be more accurate than the data used to construct them, as is done here.

Interestingly, the MSL error bands of Belgium and northwest Germany show no overlap until ca 4.8 cal. ka BP when they finally converge, even after subtraction of the maximum tectonic component between the two areas (Fig. 7). This means that even when large present-day tidal ranges are used for correction to MSL, which most likely leads to an underestimation of isostatic subsidence as shown by the Belgian–Dutch data set, there is still no overlap between the MSL error bands of the two areas from 9 to 5 cal. ka BP. Thus, contrary to the belief that the German North Sea coast has remained tectonically and isostatically stable during the Holocene (e.g. Behre, 2003, 2007), these comparisons show that the northwest German coast has indisputably undergone considerable isostatic subsidence during the last 10 cal. ka BP. Assuming that tectonic activity has been adequately corrected for, we can tentatively provide a rate of isostatic subsidence relative to Belgium of ca 7.5 m over the last 8 cal. ka BP for northwest Germany and ca 2.5 m over the same time

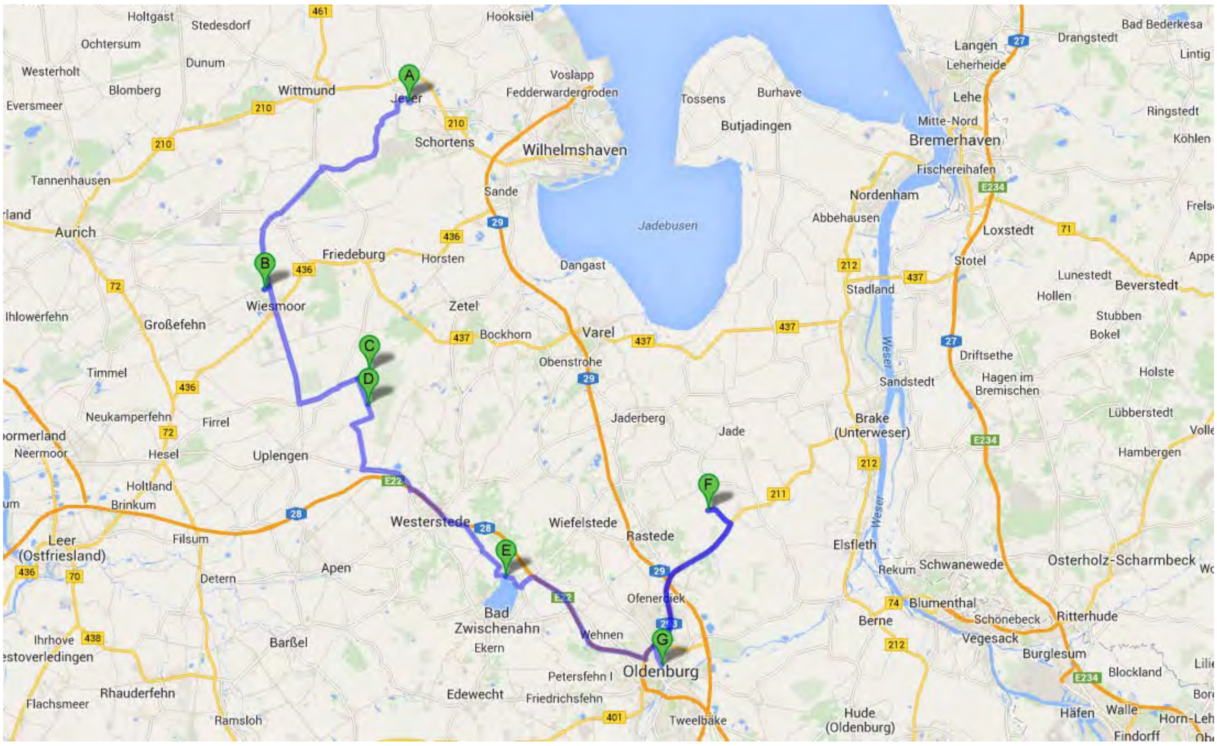
VII. Dataset southern North Sea:

1	German North Sea	Dogger bank	54.7683°	3.4617°	pollen	8750 ± 300	9474 - 10223	-46		±1	fen peat (0.05)
235	German North Sea	Elbe palaeovalley (N)	54.9433°	5.7500°	Hv 7095	8190 ± 140	9007 - 9399	-38.28		±1	fen peat (0.13)
235	German North Sea	Elbe palaeovalley (N)	54.9433°	5.7500°	Hv 7094	8485 ± 125	9295 - 9560	-38.38		±1	fen peat (0.13)
245	German North Sea	Elbe palaeovalley (N)	54.6967°	6.1917°	pollen	9000 ± 200	9887 - 10289	-46.1		±1	fen peat (0.05)
234	German North Sea	Elbe palaeovalley (N)	54.9567°	5.7083°	pollen	9000 ± 200	9887 - 10289	-42.9		±1	peat (0.08)
Gauss 1987/5	German North Sea	Elbe palaeovalley (N)	55.0773°	5.8282°	Hv 15375	9165 ± 230	10146 - 10642	-48.14	-48.1	±1	fen-wood peat (0.31)
172	German North Sea	Northern grounds	55.3233°	6.5167°	pollen	8400 ± 200	9125 - 9550	-37.58		±1	peat (0.03)
BSK VC-15	German North Sea	Northern grounds	54.9030°	6.8769°	Hv 25340	8440 ± 100	9302 - 9533	-33.46		±1	fen peat (0.03)
BSK VC-21	German North Sea	Northern grounds	54.9133°	6.9513°	Hv 25342	8840 ± 45	9778 - 10112	-36.66		±1	fen-wood peat (~0.4)
AU04-07-VC	German North Sea	Helgoland	54.2829°	8.0699°	Hv 25321	8065 ± 80	8780 - 9090	-24.53	-24.48	±1	fen peat (0.1)
H 15/2V	German North Sea	Elbe palaeovalley (S)	54.1696°	6.9830°	Hv 10336	8975 ± 90	9920 - 10219	-38.45		±1	fen peat (0.03)
H 18/3V	German North Sea	Elbe palaeovalley (S)	54.11°	6.92°	Hv 11603	8535 ± 150	9398 - 9714	-36.5		±1	fen peat (~0.1)
280	German North Sea	Elbe palaeovalley (S)	54.1183°	7.2133°	pollen	9000 ± 200	9887 - 10289	-38.05		±1	fen peat (0.1)
HE242-14VC	German North Sea	E-W shipping route	53.947°	6.944°	Hv 25406	8170 ± 70	9025 - 9251	-31.99		±1	wood peat (0.09)
HE242-15VC	German North Sea	E-W shipping route	53.845°	6.812°	Hv 25407	8140 ± 180	8778 - 9399	-28.54		±1	wood peat (0.03)
2	Dutch North Sea	Oyster grounds	53.74°	4.50°	Hv 12092	8750 ± 110	9557 - 9893	-42.5		±1	*Phragmites* peat (0.1)
2a	Dutch North Sea	Oyster grounds	54.00°	4.70°	GrN 5759	9445 ± 80	10557 - 11057	-47		±1	peat
5	Dutch North Sea	west	52.50°	3.80°	pollen A	8400 ± 300	9000 - 9771	-26		±1	peat
6	Dutch North Sea	west	52.50°	3.50°	pollen D	8500 ± 300	9127 - 9892	-28		±1	peat
7	Dutch North Sea	west	52.50°	3.25°	pollen C	8700 ± 300	9472 - 10180	-33		±1	peat
8	Dutch North Sea	west	52.50°	2.92°	pollen B	9000 ± 300	9691 - 10430	-35		±1	peat

Datings of sea level index points in the southern North Sea used in Vink et al. 2007

Saturday, 13.09.2014
The East Frisian Central Bog

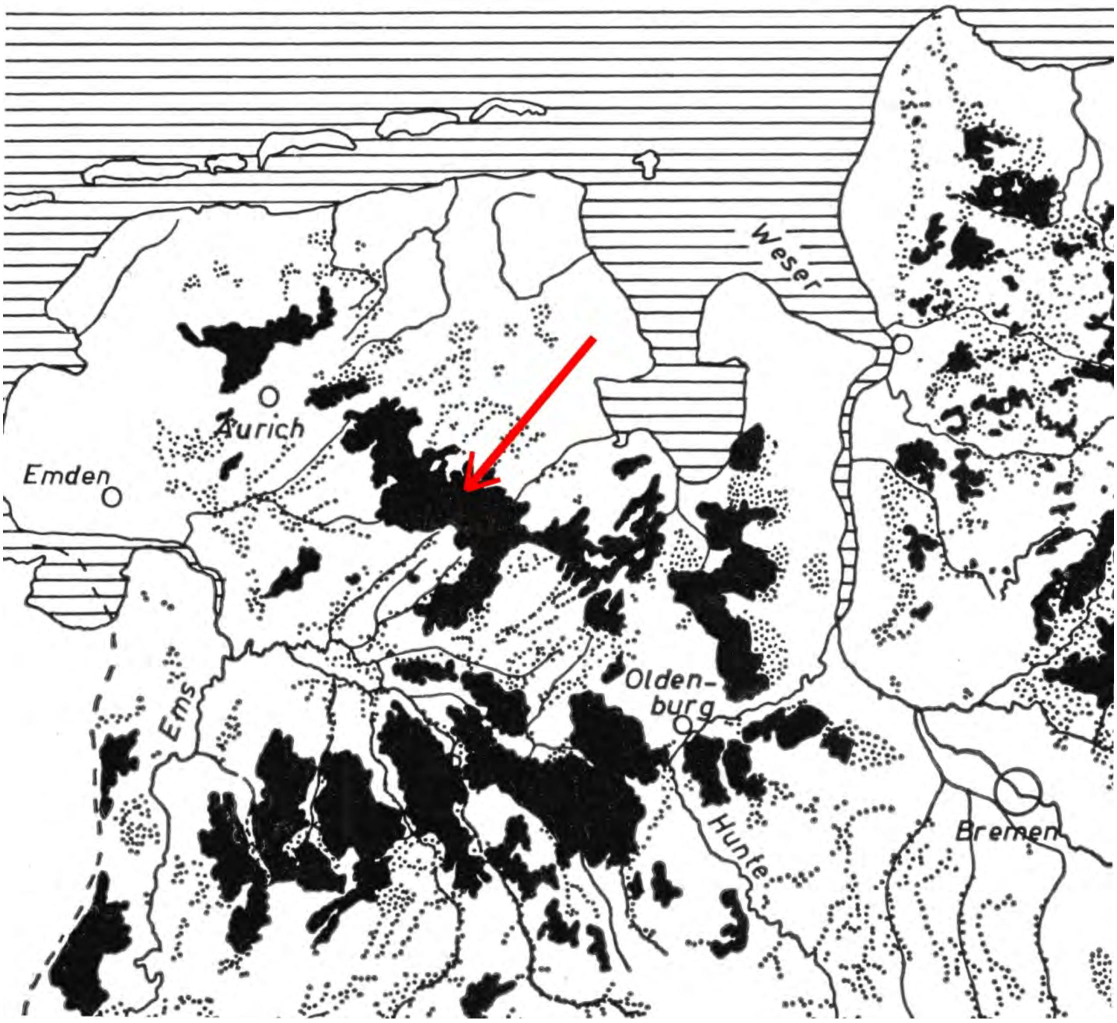
Fuel peat cutting in Wiesmoor (Guus van Berckel)
Bog renaturation at Stapeler Moor (Felix Bittmann)
Searching for the early Neolithic at Lake Zwischenahner Meer (Svea Mahlstedt)
Sphagnum cultivation at Hankhauser Moor (Silke Kumar)
Accomodation at hotels “Tafelfreuden” and “Sprenz” in Oldenburg



General introduction:
The East Frisian Central Bog – a fragmented archive of natural and anthropogenic landscape development

The East Frisian Central Bog is a vast complex of raised bogs located on the ridge of the *Oldenburgisch-Ostfriesische Geest* landscape in the northern part of Lower Saxony, a region which was once extremely rich in mires. Bogs and fens covered ca. one third of the territory of East Frisia as well as of Oldenburg, most of them being raised bogs. Despite continued cultivation Lower Saxony still boasts 2.500 km² raised bog, representing 73.5 % of Germany's total bog area.

The middle part of the East Frisian Central Bog complex is occupied by three adjacent nature reserves, namely the bogs Lengener Meer, Stapeler Moor and Spolsener Moor. Whereas Lengener Meer represents to some extent a near-natural bog relic with a large bog pond, Stapeler Moor shows the results of 15 year long renaturation efforts after industrial peat cutting was stopped in 1997. Spolsener Moor in the NE of the complex was affected by private farmers peat cutting.

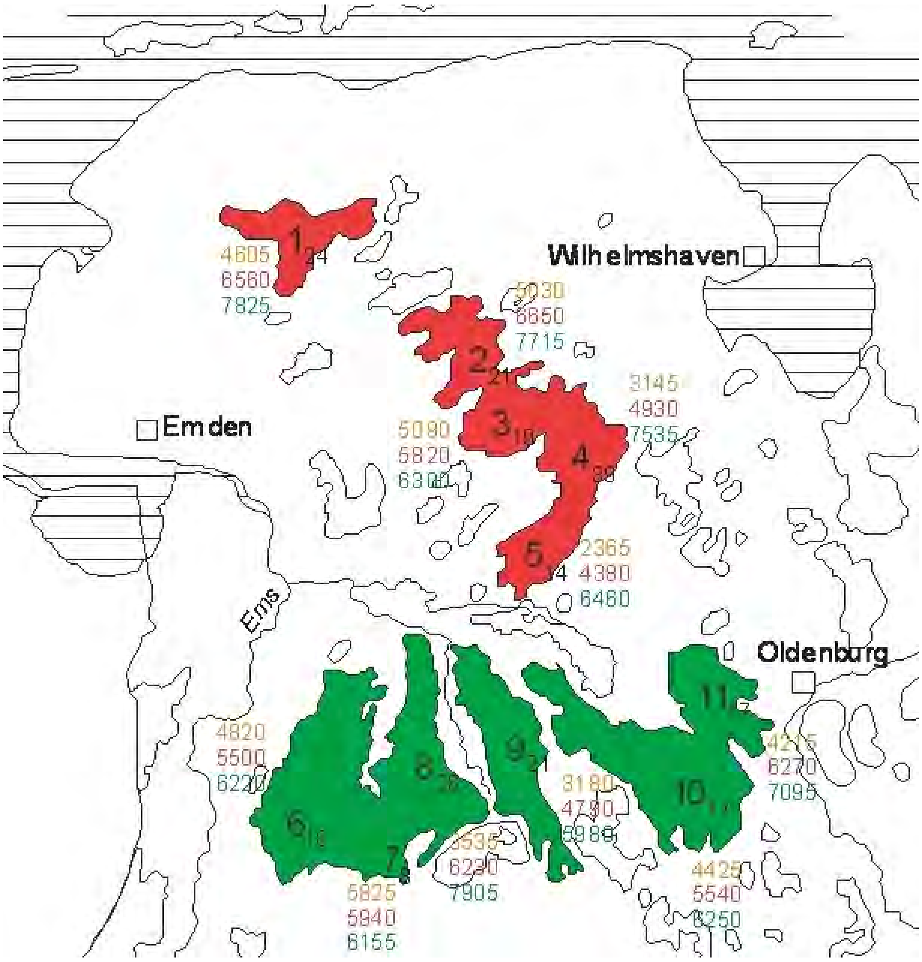


Distribution of bogs (black) and fens (dotted) in northwestern Lower Saxony and the East Frisian Central Bog

The mires of NW Lower Saxony fall into two distinct categories, namely fens (*Niedermoore*) and raised bogs (*Hochmoore*).

Most of the fens were initiated by the rising sea level and spread across large areas. Their growth was sometimes interrupted by the deposition of marine or brackish clay upon them. In the areas of greatest distance from the coast, i. e. along the *Geest* or Pleistocene margin, drainage is worst. Consequently, a fen belt follows this line and is referred to as *Geestrandmoore*. Fens also occur along small rivers, in many of the valleys, and in depressions on the *Geest*.

Northwestern Lower Saxony has been very much the land of raised bogs which occupied huge areas in the region. Their formation started in most places during the late Atlantic or in the Subboreal period. The initiation of ombrotrophic mire development was mainly triggered by changing climatic conditions at that time. It was not only, however, the effect of the beginning of a general climatic deterioration but, in this region, also the effect of the Flandrian transgression that had reached the position of the modern coastal area during the Atlantic period. In many places the raised bogs are preceded by fen peat. This suggests that the change to formation of *Sphagnum* peat is a clear indication of a changing water budget. In large areas the formation of raised bogs commenced directly on the mineral soil without an intermediate phase, i. e. the bogs replaced woodland. These raised bogs are referred to as *wurzelechte Hochmoore* which is literally 'raised bog genuine to the very roots'.



The Moorprojekt of the NIhK. The oldest, average and youngest start of raised bog formation is given in years cal. BP.

Fuel peat cutting in Wiesmoor

Peat bogs have been the main source for fuel in the coastal area for a long time. The Clay District and most of the *Geest* were almost treeless in the late Middle Ages and well into Modern times. Thus peat was urgently needed for fuel. The thermal value of the lower black peat is much higher than that of the overlying light-coloured peat, so that the peat diggers dug pits to recover the dark peat and then filled the holes with the light peat which was not used.

This unregulated peat cutting was continued until after World War II and is still practised in some remote areas

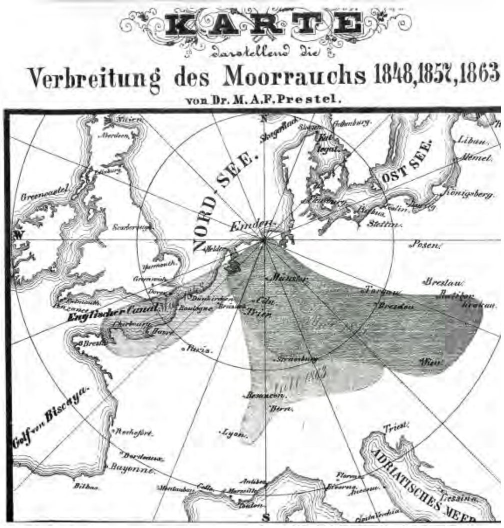
In the early 17th century another, more systematic way of peat cutting and subsequent cultivation was introduced from the Netherlands: the *Fehnkultur*. For this method of fuel production and cultivation, large areas of raised bogs were given to private companies. They drained the bogs with long canals, subdivided the area and gave the plots of raised bog to farmers as private property.

These colonists excavated the black peat, starting at the canals, and sold it in the neighbouring towns like Emden, Bremen, etc. The excavated parts, filled up with the light peat that remained after the cutting, were used for agriculture. Meadows and pastures as well as fields were established on these grounds. As bog moss peat is very poor in nutrients, the farmed soils had to be improved by the supply of suitable mineral and organic materials, which included sand, fluvial deposits, manure and litter. These materials were transported on the return trip of the boats which were used to export the peat. The farmers, like the bog plots they were given to farm, were extremely poor; the only crops they could grow on these soils were buckwheat and rye as well as some potatoes and oats. Nowadays, these so-called *Fehnsiedlungen* with their long and often branched canals and corresponding rows of farmhouses, form a characteristic part of the East Frisian landscape, their inhabitants being employed outside agriculture, e. g. in industry, shipping etc.

Another important form of utilization of raised bogs for arable farming has been the burning of the bog surface which came into use towards the end of the 17th century. The bogs were drained without preceding peat cutting and the surface burned after drying. Mainly *Fagopyrum* was grown, which was sown virtually into the ash.

This form of utilization could be continued for only 6 to 7 years in succession due to the exhaustion of the soil; after this a break of 30 years was necessary before a new phase of cultivation could be initiated. The Lengener Moor still shows distinct traces of this type of bog exploitation.

Peat burning was practised on such a large scale that air pollution during the burning season in May was registered in far distant places such as England and Poland. There were strong public objections against this practice and, already in the 19th century, the 'Bremen Association Against Bog Burning' was founded, which probably represents the first organised ecological (green) movement. Finally, this practice was outlawed in the early years of the 20th century but by then most of the raised bogs in Niedersachsen were affected by it.



From the last century onwards, modern techniques for the cultivation of raised bogs were introduced, developed and promoted by the famous *Moorversuchsstation Bremen*. The first was the 'mixed sand cultivation' (*Sandmischkultur*) that could be applied to bogs with a depth of up to 1.20 m of peat remaining. This included large areas which, after peat cutting, had remained as waste land. Using huge plough shares, the underlying sand was ploughed-up and mixed with the peat thus leading to a considerable improvement of the soil.

Bundesarchiv, Bild 183-R74645
Foto: o.Ang. | September 1948

Another method was the German raised bog cultivation or *Deutsche Hochmoorkultur* that was carried out on the virgin raised bog where no peat cutting had taken place. The areas were drained and had to be intensely fertilized. This was done first by the application of ordinary manure, and complemented by the growing of legumes to improve the nitrogen content and later by applying artificial fertilizers. *Sphagnum* peat has turned out to be a very suitable substratum for agricultural purposes and is valued even today, though it needs large quantities of fertilizers to maintain its productivity.

Fuel peat cutting became an industrial extent towards the end of the 19th century. A peat power plant was built 1908 in Wiesmoor which also burned fuel peat from the Stapeler Moor, a more or less unused raised bog at that time. Next to electricity the peat power plant produced heat for the numerous greenhouses in the region. It shut down in 1964. During peak production the daily demand of fuel peat added up to c. 400 tons.

After the decline of peat production for fuel some raised bog areas have been used on a large scale for the production of peat for gardens and for horticulture. In this case the light peat is removed, dried and prepared for horticultural use as 'peat moss' while the black peat is left untouched.

This industrial peat cutting is carried out in machined surfaces several km^2 in extent. The exploitation of such an area takes between 15 and 30 years, after which it must by law be cultivated or regenerated as bog.

Industrial peat exploitation at Saterland (left) and Vehnemoor (right); for comparison the city of Oldenburg at the right border, at the left the test track near Papenburg, longest diameter about 5 km

Aurich-Wiesmoor Torfvertriebs GmbH

The Aurich-Wiesmoor peat sales and distribution limited company (Torfvertriebs GmbH, AWT) is existing as an owner-operated company since 36 years. Peat exploitation takes place with currently 10 blue-collar workers plus 4 commercial employees and 2 trainees on about 150 ha, exclusively on formerly used peat bog grassland. The majority of the resource is exploited as milled peat (Frästorf). Only about 7% of the total volume consists of slightly decomposed sod peat. About 100.000 m^3 peat are sold per year by AWT.

There is no additional processing of the peat, where required it is milled and/or sieved in different fractions and sold as loose material to the clients. The transport is carried out by trucks and also by river boats via a terminal in the harbour of Emden.

The classic client is the producer of high quality substrates or first-class soils for the ambitious hobby gardener traded via specialist shops.

Also producers of mushroom substrates belong to the customers. The section of special-purpose machine service for mires and peat completes the business activities accounting for about 10% of the total annual turnover of 2-2.5 million EUR.

Bog renaturation at Stapeler Moor

For several years now all remaining bogs in Lower Saxony which, in general, are very limited in extent or form only tiny parts of former large bogs, are protected by law. New permissions for peat cutting or cultivation are not granted. In several places, regeneration measures in former raised bogs have been undertaken by the authorities in the interests of nature conservation – only the next generation can judge if these have been appropriate and successful.

Today, very few and then only small remains of more or less untouched raised bogs remain. In general they show the typical hummock-hollow morphology. It is not certain, however, whether this morphological feature is a natural primary one, because it is best developed when a certain amount of drying out has taken place.

Only few salient facts will be given regarding the modern vegetation of raised bogs. Under natural conditions *Sphagnum* species are dominant; in the area north of Bremen, *S. imbricatum* and, less frequently, *S. papillosum* are the main constituents of the light peat. At the latitude of Bremen there is a sharp boundary; south of this, *S. imbricatum* disappears and is replaced by *Sphagna acutifolia* while *S. magellanicum* and *S. cuspidatum* are present throughout the region. Investigations of modern raised bogs indicate that there has been a strong decline in the occurrence of *S. imbricatum* over recent decades.

Compared with more continental raised bogs it should be noted that the ombrotrophic bogs in the coastal area have a slightly higher content of minerals due to the salt which is blown in from the sea. Thus, for instance, *Eriophorum angustifolium* is regarded as a character species of typical raised bog vegetation in the north-western part of the region, while, in the Harz mountains, it indicates slight minerotrophic conditions compared with the more oligotrophic (and purer) stands in that area.

Three other bog species should be mentioned: *Erica tetralix*, *Narthecium ossifragum* and *Myrica gale*, all of them oceanic elements which are common in northern *Lower Saxony* but restricted to this area and not occurring south of Hanover. They normally expand after the bogs have been drained for some time.

Stapeler Moor with Lengener Meer

Spolsener Moor: Vegetation and land use history

Pollen analytical investigations were undertaken by O'CONNELL (1986) with a view to reconstructing vegetation and land-use history in the Neuenburg area, i. e. the Friesische Wehde. The profile was taken from a remaining small island of peat which is surrounded today by agricultural land reclaimed after peat cutting. At the time of maximum bog extension, the *Geest* (not covered by peat) lay some 2.5 km to the east of the sampling point.

The 368 cm long profile spans the period from late Atlantic (c. 5000 B.C.) to recent times. The basal 50 cm consists of sand overlain by *Phragmites* peat. The pollen spectra from the sand show high *Pinus* and *Alnus* values (c. 30%; all values as % A.P. excl. *Corylus*). Spectra from the *Phragmites* peat reflect mainly local mire vegetation with alder being replaced by birch carr which suggests a shift towards oligotrophic conditions.

With the transition to raised bog peat (pre 4000 B.C.), A.P. curves are no longer distorted by high local pollen producers. *Quercus* (presumably *Q. robur*) is the dominant tree of the mineral soils, *Corylus* is the main undershrub and *Alnus* is important, presumably in the wetter areas. The edaphically more demanding trees of the so-called mixed oak forest, namely, *Ulmus* (c. 4%), *Fraxinus* and *Tilia* (c. 3 and 2%, respectively) do not appear to have responded to the more favourable local edaphic conditions provided by the Lauenburger Ton.

The first major change in woodland composition is signalled by the rise in *Fagus* to over 1% and the initiation of a continuous curve for *Carpinus* at 2000 B.C. This signals a limited expansion of beech and the spread of hornbeam into the area. These two trees expand in a stepwise fashion, first at 900 B.C. and then at A.D. 200. and with *Fagus* achieving maximum representation at A.D. 800, i. e. prior to large scale Medieval woodland clearance.

Trees that show decline include *Ulmus* (but the Elm Decline is not well defined), *Tilia* and *Pinus*. Lime and pine probably became extinct, the former being re-introduced for bast lime in the Medieval period and the latter being widely planted from the earlier part of the 18th century onwards.

In the lower part of the profile, anthropogenic indicators are poorly represented. Occasionally Cerealia-type pollen is recorded in pre-Elm Decline levels but the significance of these records as indicators of arable farming and hence of a Neolithic presence is open to question. A continuous *P. lanceolata* curve begins above the level ascribable to the Elm Decline. In the middle and upper parts of the profile, the following features relating to land-use and human impact are noteworthy:

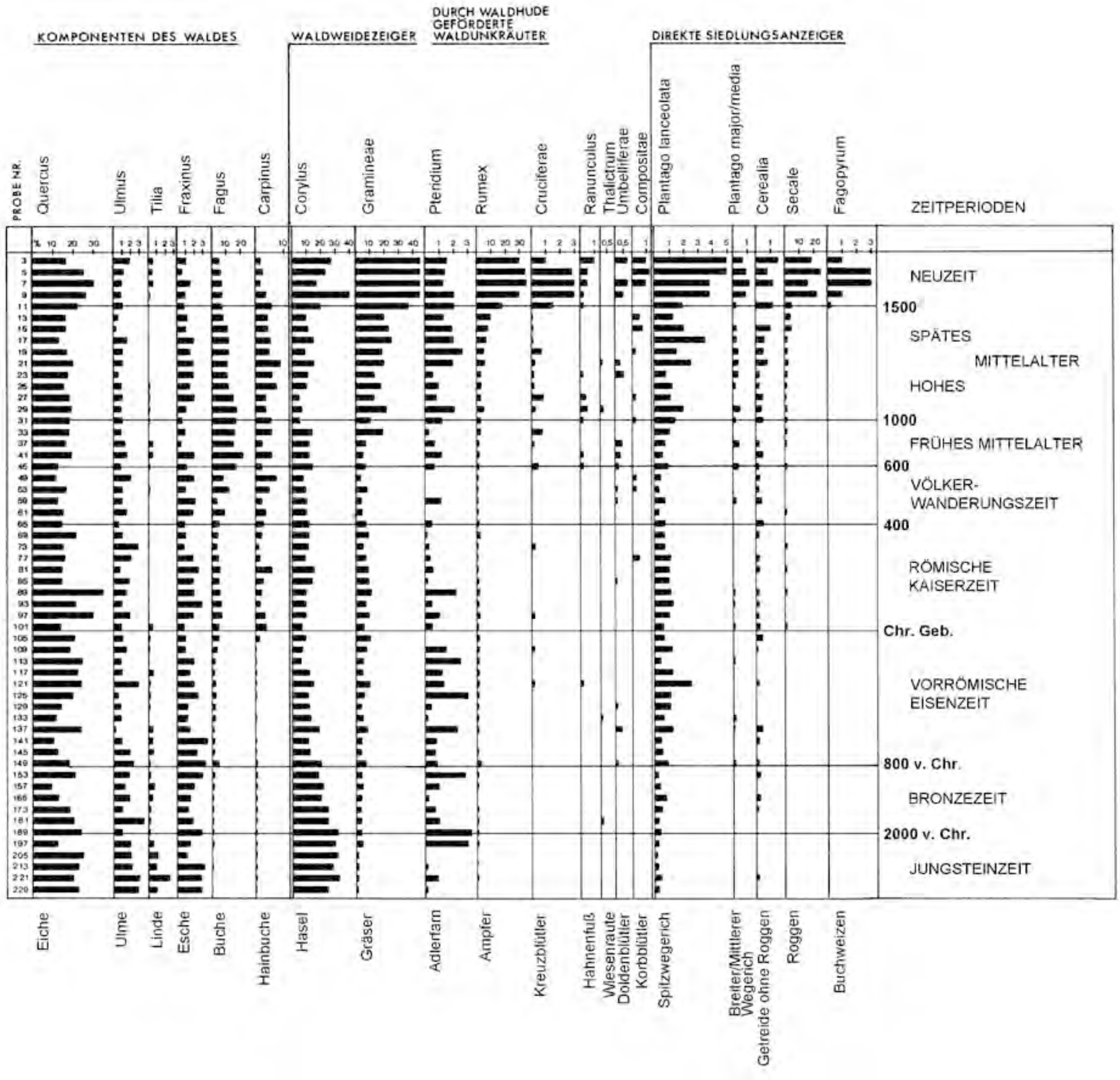
1. The decline in *Tilia* and the first expansion of *Fagus* and the spread of *Carpinus* (2000 B.C.) is seen in terms of Bronze Age interference with the previously more or less undisturbed *Quercus*-dominated woodlands (cf. *Pteridium* and *Artemisia*).

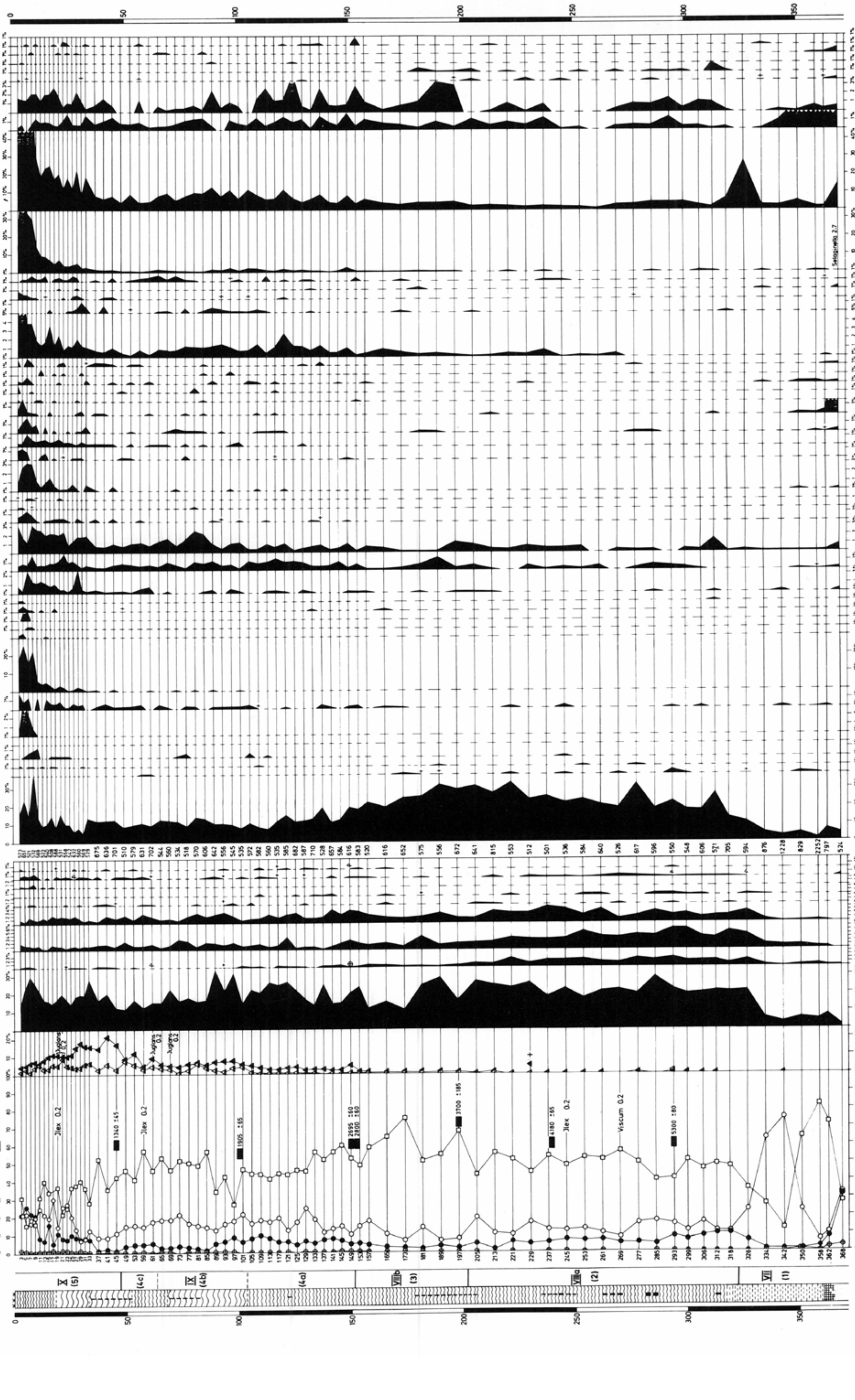
2. In the late Bronze Age/Early (pre-Roman) Iron Age, i.e. from 800 B.C. onwards , the diversity and representation of anthropogenic indicators increase (cf.. Cerealia-type, *Artemisia*, *P. lanceolata* and *P. major/media*) and woodland composition shifts in favour of beech, with a substantial decline in hazel. These woodland changes take place probably in response to anthropogenic activity.

3. A general trend towards increasing human impact is maintained until the 6th century A.D., when there is a noticeable decline in anthropogenic indicator curves (cf. *P. lanceolata*, *Pteridium* and Chenopodiaceae) and *Fagus* and *Carpinus* begin the final phase of expansion.

This is the so-called *Siedlungslücke* or 'habitation gap' when, in both the coastal *Marsch* area and the *Geest*, the population levels declined dramatically until the 8th century A.D. It is noteworthy that the Cerealia curve is uninterrupted which indicates that arable farming did not cease; the region cannot therefore be regarded as devoid of habitation.

4. In the uppermost PAZ (LEN V-5) a dramatic rise is recorded in the anthropogenic indicator curves (cf. *Secale*, *P. lanceolata* and *Fagopyrum*; also the *Cannabis*/*Humulus* curve) and A.P., except *Pinus*, decline. Here the intensive cultivation of rye, which began in the Middle Ages (c. A.D. 1000), and of buckwheat is clearly reflected in the pollen spectra.





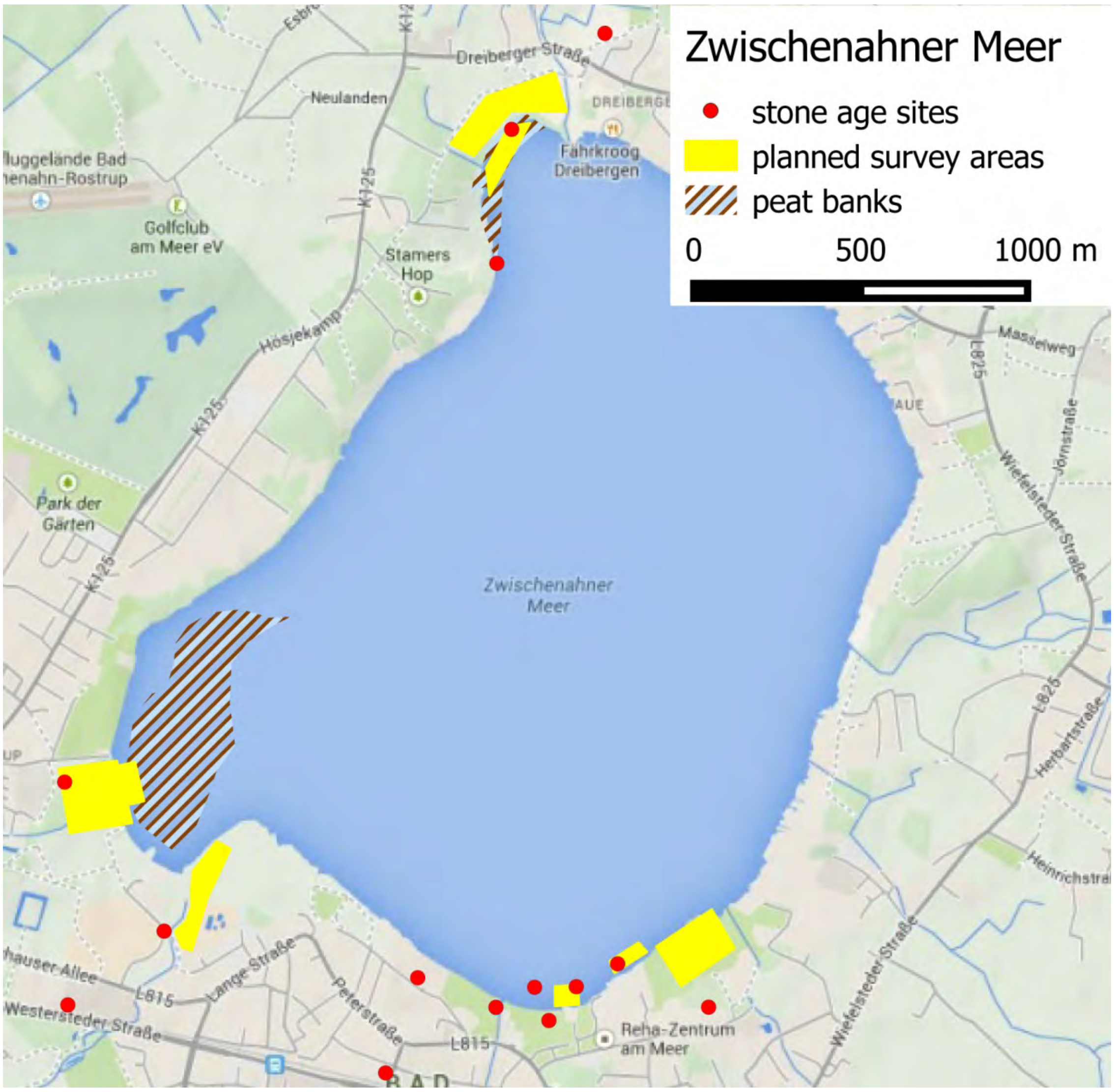
LEN V Spolsener Moor

Searching for early Neolithic at Zwischenahner Meer

Lake Zwischenahner Meer has developed as a landfall lake and for this kind of lake it is untypically shallow – only up to five meters. Taking into account additional 5metres of Holocene sediments the Pleistocene seafloor lies in a depth of ten meters.

Peat layers along the shore line indicate lower water levels in earlier times. From these peat banks very interesting finds from the period of the earliest Neolithic have been found already in the 1950ies. Up to now we are not able to reconstruct the process of Neolithisation for large parts of Lower Saxony, as finds from this period do not occur regularly. That makes a small concentration of finds of this period that were found in Lake Zwischenahner Meer even more interesting.

Since July 2014 the NIhK runs a project is evaluate the area around the lake in respect to its richness in well preserved early Neolithic sites. Intense surveys and some smaller excavations on the shore as well as in the shallow water areas are planned to get a first impression of the development of the Neolithic in that region.



Sphagnum cultivation at Hankhauser Moor

MOOSGRÜN

„Torfmoos (*Sphagnum*) als nachwachsender Rohstoff: Torfmooskultivierung auf Hochmoorgrünland"

Duration period: May 2011 – September 2013 + 1 year prolongation

Project aims:

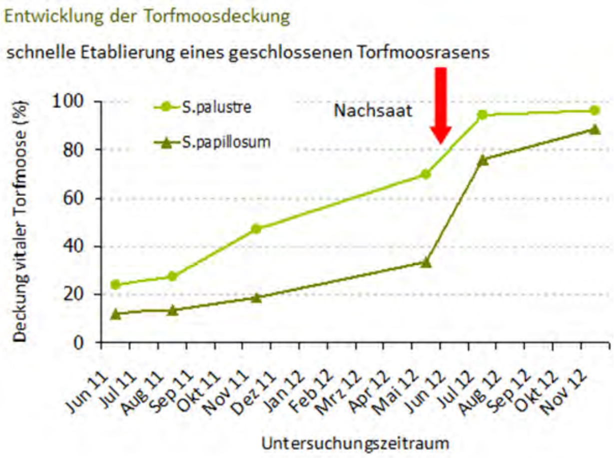
- sustainable Cultivation of *Sphagnum* mosses (*Sphagnum* as biomass)
- research into the use of *Sphagnum* mosses as a new agricultural crop plant
- long-term supply of the peat and humus industry with a raw material for growing media in horticulture

Implementation:

- 2 types of cultivation fields, one with, the other without dams + 3 fields for small scale trials.
- Use of machines for removing the topsoil (excavator), spreading the *Sphagnum* fragments (Snowcat) and maintenance (mower with triple tyres).
- Measurement of climate gas emissions (K. Albrecht, Universität Rostock).
- Monitoring of *Sphagnum* moss growth in length, cover and species (M. Krebs et al. Ernst Moritz Arndt Universität Greifswald
- Active water management to keep the water level in the fields and the ditches about 10 cm below *Sphagnum* heads.

Results:

- Quick establishment of *Sphagnum* cover (see graph below) Species*: Sph. palulustre, Sph. papillosum, Sph. fallax*,
- *Sphagnum* farming fields' emission rates of climate gases are quite similar to those of mires in natural state
- Water supply of most importance for establishment of *Sphagnum* species
- Maintenance (mowing) absolutly necessary in first years



M. Krebs EMAU Greifswald

Projektpartner: