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Soils and Landscapes in Schleswig-Holstein and Hamburg

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M Soils and Landscapes in Holstein

L Marshland Soils of Nordfriesland

K Soils of the Sachsenwald

I Freshwater-marsh of the Elbe-river

C o n t e n t s

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Agriculture, Landscapes, and Soils of Schleswig-Holstein

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General Information on Schleswig-Holstein

Population: Schleswig-Holstein is inhabited by almost 2.4 mio people, the population density is 156 persons per km^2.

Area: The total area is 15,658 km^2; it is devided into three landscape units: the Eastern Hills (6,107 km^2, 39 %), the "Geest" (7,046 km^2, 45 %), and the Marshland (2,505 km^2, 16 %). About 70 % of the area (11,000 km^2) is in agricultural use (of this 39 % tilled land, 20 % pastures, 10 % meadows, and 1 % horticulture and orchards). Woods and forests cover only 1,370 km^2 (9 %) of the area, thus Schleswig-Holstein is one of Germany's regions with the least proportion of woodland. Lakes and rivers comprise 293 km^2 (1.9 %), roads, housing and industrial areas cover 1941 km^2 (12.5 %); these areas are sealed to a high degree. Natural or near-natural areas without or with hardly any land use such as uncultivated bogs, heaths, fallow land, dunes, and hedges make up to 579 km^2 only (3.7 %), of these areas 0.6 % are protected natural reservates. The highest elevation is the Bungsberg in the Eastern Hills (168 m a.s.l.), in the Marshlands some areas below sea level occur.

Climate: The mean annual temperature is 7.9° C (7.7° C in Schleswig to 8.1° C in Lübeck), the coldest month is January (mean temperature 0.4° C; -0.3° C in Neustadt to +0.6° C in Kappeln), the warmest month is July (mean temperature 16.4° C; 15.9° C in Kappeln to 16.8° C in Lübeck). An average of 76 days with frost occur over the year, day length during the vegetation period is about 13 hrs. Flowering and maturing of plants is delayed by one day per ten km from the south-east to the north-west. In the same direction there is a time lag of a fortnight in the beginning of the winter rye harvest (July 19th, Lauenburg, and August 2nd, North Friesland). Mean annual precipitation is 720 mm (525 mm island of Fehmarn, 850 mm North Friesland). With the regional differentiation the degree of humidity varies regionally from 150 to 350 mm. Maximum rainfall occurs in August (regionally differently from 64 to 97 mm), minimum precipitation in March (32 to 53 mm). Relative air humidity is 84 % (76 % in May and June, 91 % in December).

Vegetation: Schleswig-Holstein belongs to the region of atlantic deciduai forests of the Middle European floral region. Typical plant species characterizing the flora are Fagus sil vatica, Tilia cordata, Carpinus betula, Ilex europea, Erica tetralix, and Empetrum nigrum. Besides 938 native plant species there exist 1,087 species which have been brougth to the country, this being an indication of its transitional position between Central Europe and Scandinavia as well as between East and West. With the edaphic conditions changing from the young moraines in the east to the old moraines and sandur deposits in the centre to the marsh lowlands in the west, there are corresponding differences in the vegetational cover. The loamy soils containing marl at low depths carry demanding beech forests, the central "Geest" is covered by oak-birch woods and heath. In the Marshland, forests are nearly totally lacking. Where the sea influences the soils halophytic vegetation prevails.

Surface Formation and Landscape Development in Schleswig-Holstein

(Figure 1)

Three characteristic landscapes exist in Schleswig-Holstein: the **Eastern Hills**, the **"Geest"** and the **Marshland.** Their parent materials are sediments deposited by the action of glaciers, water, and wind: glacial drift sheets (moraines), glaciofluvial deposits (sandur), marine mud, and aeolian sands (dunes). These quaternary sediments cover the underlying tertiary sands and clays with a thickness of up to 425 m. The latter are exposed to the surface at a few points only, cliffs on the islands of Sylt and Fehmarn e.g. Isolated spots of yet older sediments occur near Lieth (Lower Perm clay), Segeberg (Upper Perm gypsum), Lägerdorf (Creteaceous lime), and Helgoland (Mesozoic sand- and limestones). All these rocks have only been elevated since the Jurassic and Creteaceous periods by pressure exerted on the plastic Zechstein (Upper Perm) salts. Salt tectonics has played a role in landscape formation also elsewhere in Schleswig-Holstein. It is one of the causes of petrol and gas deposits in accessable depths. Lime, clay and sand are being industrially exploited as a basis of concrete and cement production. Petrol is being extracted in minor amounts at different locations.

The oldest surface sediments of widespread occurrence in Schleswig-Holstein were deposited during the Saalean Glaciation (until ca. 120,000 b.p.) by glaciers moving southward from Scandinavia to the north of Germany. They consist of boulder marl and boulder sand forming moraines and ice-push ridges and sorted sands deposited by the action of meltwaters. During the consecutive Eemian warm period (from ca. 120,000 to 75,000 b.p.) the ice retreated. Its melting lead to a rising sea level and the North and Baltic Seas were filled with saltwater. Under the influence of a warm oceanic Climate deeply weathered soils formed from the Saalean glacial sediments. The boulder marl became carbonate-free to greater depths and was transformed into boulder loam. With the beginning of the subsequent Weichselian glaciation (ca. 75,000 to 10,200 b.p.) glacial drift was being deposited by glaciers protruding from a more easterly direction, once more, together with transformed material of the earlier glaciation.

Eastern Hills

The Weichselian glaciers covered the eastern part of the country only, the Eastern Hills. This young moraine landscape is characterized by rather conspicious surface forms, moraines and ice-push ridges (Hüttener Berge, Duvenstedter Berge, Westensee region, ridges around the Lübeck Basin), and numerous lakes which formed in depressions excavated by ice lobes, meltwater channels, and after the thawing of isolated ice masses, and which form a lake district in Eastern Holstein. The Großer Plöner See (3,038 hectares) is the largest, and lake Schalsee near Ratzeburg is the deepest (85 m) lake of Northern Germany. Its bottom reaches 50 m b.s.l. and is thus the deepest point in the land surface of the FRG. Fjords deeply penetrating into the country subdivide the Eastern Hills into several smaller landscapes. They were formed by ice lobes and subglacial tunnels. The sea filled these valleys during the Littorina transgression when the ice melted. The fjords are excellent natural harbours (water depth generally greater than 10 m), and old settlements and ports are located at their ends (Flensburg, Schleswig (Haithabu), Eckernförde and Kiel). Near the former margin of the ice in the west, long periods of glacier stagnation lead to a long-lasting flushing of the landscape by meltwaters and the moraines are rather sandy and stony there, conseauently. Further east the landscape is more level, the marl is more uniform and compact, a flatly undulating landscape of subglacial moraines dominates, typically expressed on the island of Fehmarn.

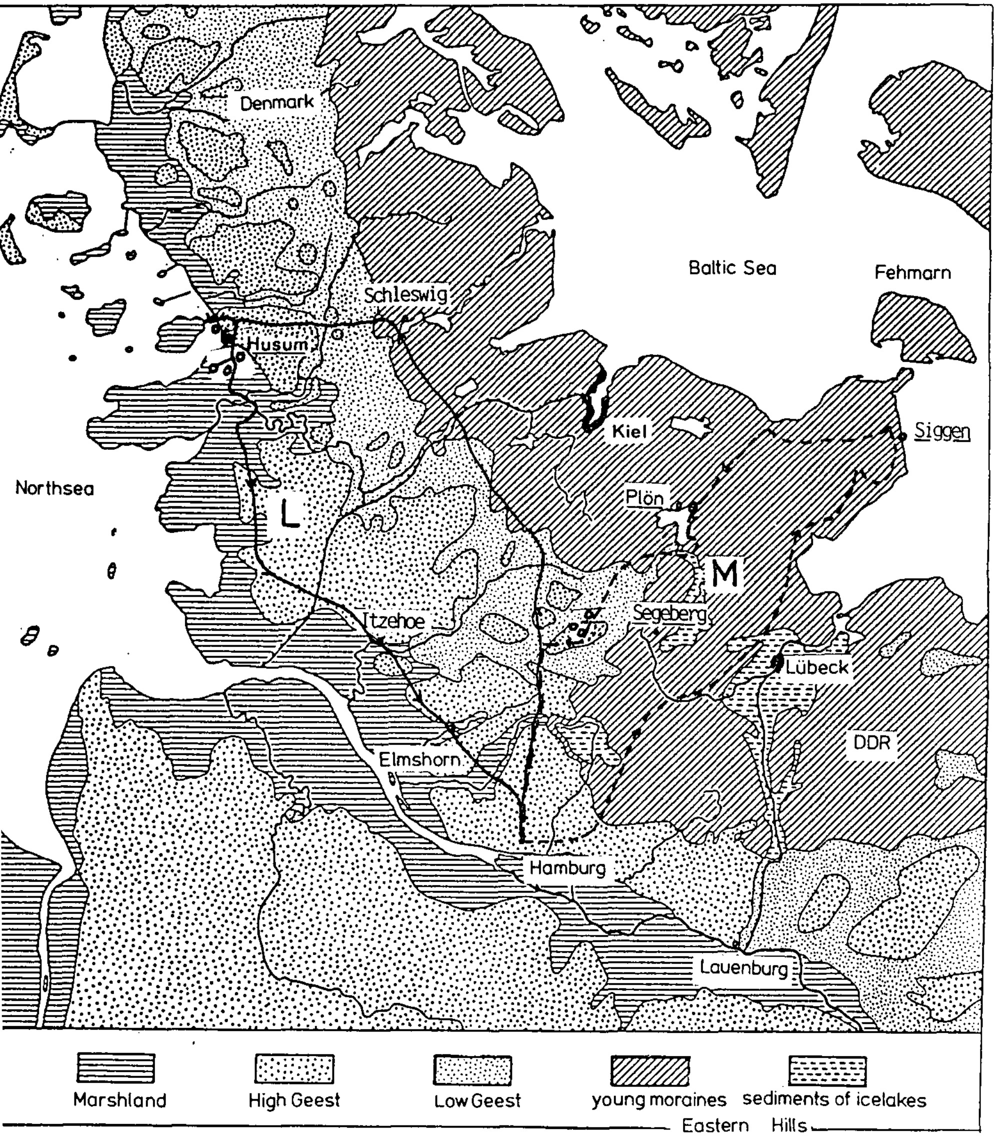

Figure 1: Landscapes of Schleswig-Holstein and excursion routes

Geest

During the Weichselian glaciation the deposits of the former Saalean glaciation were periglacial regions. The old moraines were eroded by great streams of meltwater and vast sand deposits were laid down there. Periglacial processes like solifluction, cryoturbation, and wind erosion levelled the once strong relief under a sub-arctic climate.

Today, old moraines, sandur plains (glaciofluvial sand deposits) and aeolian sand deposits constitute the middle ridge of Schleswig-Holstein, a landscape called "Geest".

The sandur plains (Low Geest) lie next to the Eastern Hills. They often consist of vast outwash fans at the openings of channels and former subglacial tunnels of that landscape. The largest areas of the Low Geest are encountered west of the line Flensburg-Rendsburg and in the Neumünster Basin. This landscape unit is lacking in the south since there the glacier meltwaters drained to the Elbe Valley in the south, where the small outwash fan of Büchen was formed.

Some of the old moraines of the Saalean glaciation project through the sandur deposits; it is in these places where villages and towns were built predominantly. To the west the moraines form the continuous "High Geest" which in some places meets the Marsh lowlands, lying still further west, with steep cliffs. The Geest has hardly any lakes: depressions have partly been filled by landslides during the Weichselian periglacial period or have been filled by organic sediments with the formation of fens and bogs. These were widespread once, they have however largely been drained and cultivated since.

Marshland

To the west of the "Geest" lies the marshland, a belt of varying bredth. During the Weichselian Glaciation, when huge amounts of water were bound in the ice of glaciers, the sea level was up to 130 m lower than today. In vast regions lying today in the Wadden Sea or the North Sea, a tundra landscape formed. With the advent of a warmer climate during the Boreal Period, thin woods of birch and pine spread and, in the lower parts, swamps covered with reed and fen woods formed. A rise in sea- and groundwater level, together with land subsidence, caused further swamp- and bog formation. Finally, with the onset of the Atlantic Period (5500 b.C.) vast areas were covered by the sea (Flandrian Transgression), and swamps and bogs (today layers of "Lower Peat"), as well as sandur plains and old moraines, were buried under marine sediments. Regional differences in sedimentation were caused by the morphology of the Pleistocene land surface.

In the south, where it falls to more than 20 m below today's sea level, the sea reached the western margin of the "Geest", covering the landscapes of Eiderstedt and Dithmarschen; thick mostly fine sandy sediments were laid down there. Thus very stable high lying marshland was formed, which was populated already 2000 years ago. In North Friesia the land surface was much higher (1 - 10 m below today's sea level), less inclined, and also protected against the sea by Pleistocene elevations (around the islands of Sylt and Amrum) so that the sea protruded less far, and only a thin sheet of marine sediments was deposited west of a belt of moors next to the "Geest" margin. During the Sub-Boreal (2400 - 600 b.C.), the rise in sea level stopped (cessation of the Flandrian Transgression) and swamps and bogs formed on the Holocene sediments (Upper Peat).

Another transgression (Dunkirk Transgression) with the onset of the Sub-Atlantic Period has changed especially the North Friesian landscape. On the seaward side marine sediments were deposited, forming the high lying Old Marshland. To the east lay vast lowlands ("Slietland"), where bogs continued to grow. Until a thousand years ago the coastline of North Friesia lay much farther westward than today. The Old Marshland was inhabited by people who protected themselves against floods by building earthern hills ("Warft", "Wurt") and flat dykes. The Upper Peat was cut to obtain fuel and salt. Peat-cutting and, with it, land subsidence, lowered the surface. Thus in the 12th, 13th, and 14th centuries great floods were able to destroy the high western marshland and penetrate into the lowlands further east.

The storm tide of 1362 (Marcellus Flood, "Grote Mandränke") had most catastrophic consequences, it destroyed numerous settlements and villages. The whole of the North Friesian marshland was transformed into intertidal flats, the Wadden Sea. Sand and mud covered the medieval cultured land. Next to the "Geest" new marshland formed, and since the beginning of the 14th century vast areas have been reclaimed. But ever since the marshland has been haunted by great storms tides. Above all, during the Great Flood of 1634 wide stretches of land were lost. Even in recent times (1962, 1976) storm tides made the dykes breach and destroyed land at many points of the coast. In order to protect the marshland and to reclaim land, the mouth of River Eider has been dammed (1971), and the Meldorf- (1978) and Nordstrand- (1986) Bights have been enclosed by dykes.

Development of Climate, Vegetation, and Culture

After the melting of the Weichselian glaciers, 20,000 (Lauenburg) to 13,000 (Fehmarn) years ago, subarctic climatic conditions prevailed in the landscape freed of the ice and a tundra devoid of trees formed. Later birch and pine were the first trees to occur. Man was a hunter of rendeer then, later also other animals were hunted, which provided food and material for clothing, tents, tools, and weapons. Three stages of early man's culture can be distinguished, which are named after three archeological sites near Hamburg, where remaines of the rendeer hunters were excavated: Hamburg Culture I (Meiendorf) and II (Poggenwisch; both late paleolitic), and Ahrensburg Culture (beginning mesolithic).

With the postglacial period (starting ca. 10,000 years ago) the climate became warmer and forests of birch and pine formed. With a further rise in temperature during the Boreal period (warm and dry) more demanding plants as regards temperature spread: hazel, oak, elm, lime, and, in moist places, alder.

The water masses deriving from the molten glaciers led to a marked transgression of the North- and Baltic Seas during the Atlantic period (5,500 to 2,400 b.C.). The Baltic Sea reached its present-day extension by about 2.500 b.C. The climate of northwest Germany (mild, moist) was then determined by the proximity of the sea. Mean annual temperature was probably higher by 3-4^{o} C than today. Oak mixed forests prevailed and heath started to spread on sandy reaches of the Geest, a tendency which was later favoured by neolithic man clearing forests. Low stretches were covered by alder woods which later were overgrown by bogs. Excavations near the Baltic coast (Kiel Bight, Ellerbek culture) reveal the cultural development of man. During late mesolitic times fire-proof pottery and sharpened stone axes were in use. Neolithic man starts to settle, besides being a hunter, he already is a farmer. Crops are wheat, barley, and millet; the first domestic animals (dog, cattle, sheep, and pig) are being bred.

During the subsequent Subboreal period beech appeared besides oak on the carbonate-rich soils of the moraines in the east. Man uses bronze to construct tools and weapons (Bronze Age). In agriculture the wooden plough is used and besides the traditional crops, oats are grown.

With the beginning of the Subatlantic period a change in the climatic conditions set in, which led to the rather cool and moist climate of today. The young moraines of the east were covered with beech forests, while the "Geest" was covered by oak forests and heath. On top of the older bog peat (black peat), which had formed during the Subboreal, younger white peat formed. By now, also in the north-west of Germany the production of iron from bog iron ore came into use (Iron Age) and the iron ploughshare was invented. With this toll even the heavy soils in the Eastern Hills could be ploughed. Seagoing ships with bolted planks were constructed (Nydam boat). Farming and trade expanded. Rye was invented as a new crop and spread fast because of its frost hardiness.

Since the Middle Ages the natural landscape was gradually transformed into a man-made landscape. Forests were cleared and heaths spread as a consequence on the sandy soils of the "Geest" - until 150 years ago half of this landscape was covered by heath. Naturally growing trees were replaced by fast-growing conifers, and the woods transformed into forests of spruce and pine. Peat was taken from the bogs to be used as fuel and litter, the areas later used as grassland. By the end of the 18th century hedgerows were planted on the borders of the fields, they provide excellent protection against wind erosion. These earthen walls planted with bushes and trees are a characteristic feature of Schleswig-Holstein's landscape.

Due to economic constraints during the past 30 years, agricultural areas have been merged, increasing the sizes of individual fields. Along with this a great proportion of the hedges has been sacrified. Nature restitution is now being enforced in several regions of Schleswig-Holstein with the installation of reservates. Hedgerows play an important role in habitat interlocking.

Soils (Figure 2)

Soils of the Eastern Hills

Here the landscape is built predominantly of sediments of the last glaciation. The processes of Ca-carbonate dissolution (the carbonate-free zone is 0.8 to 2 m deep), braunification, loamification, and clay migration have acted on the boulder marls of the undulating ground moraines to form **Parabraunerden** (Luvisols). Their sandy-loamy eluvial horizons are 40 to 60 cm thick. They, and the underlying argillic horizons, are strongly acidified today when covered by forest (pH-values of 3.5 to 4.5). The depth of calcite dissolution and clay migration is greater in the west than in the east, reflecting 1. the direction of the retreat of the glaciers (the west being up to 7,000 years longer free of ice), 2. the substrate conditions (less Ca-carbonate, sandier texture in the west), and 3. differences in precipitation (higher in the west). Clay-illuvial horizons and compacted marl (due to once strong pressure of the overlying ice) constitute drain-age barriers. Stagnating rainwater causes air deficiency, and especially downslope and in flat hollows **Pseudogleye** (Stagno-Gleyic Luvisols) with iron and manganese concretions in the topsoil and mottled subsoil developed. Moraines with stronger relief, especially end moraines, are sandier. Here, as well as on high-lying sandur deposits, deeply carbonate-free acid **Braunerden** (Cambisols) and Bänderparabraunerden (sandy Luvisols with thin clay bands) have formed, some of which

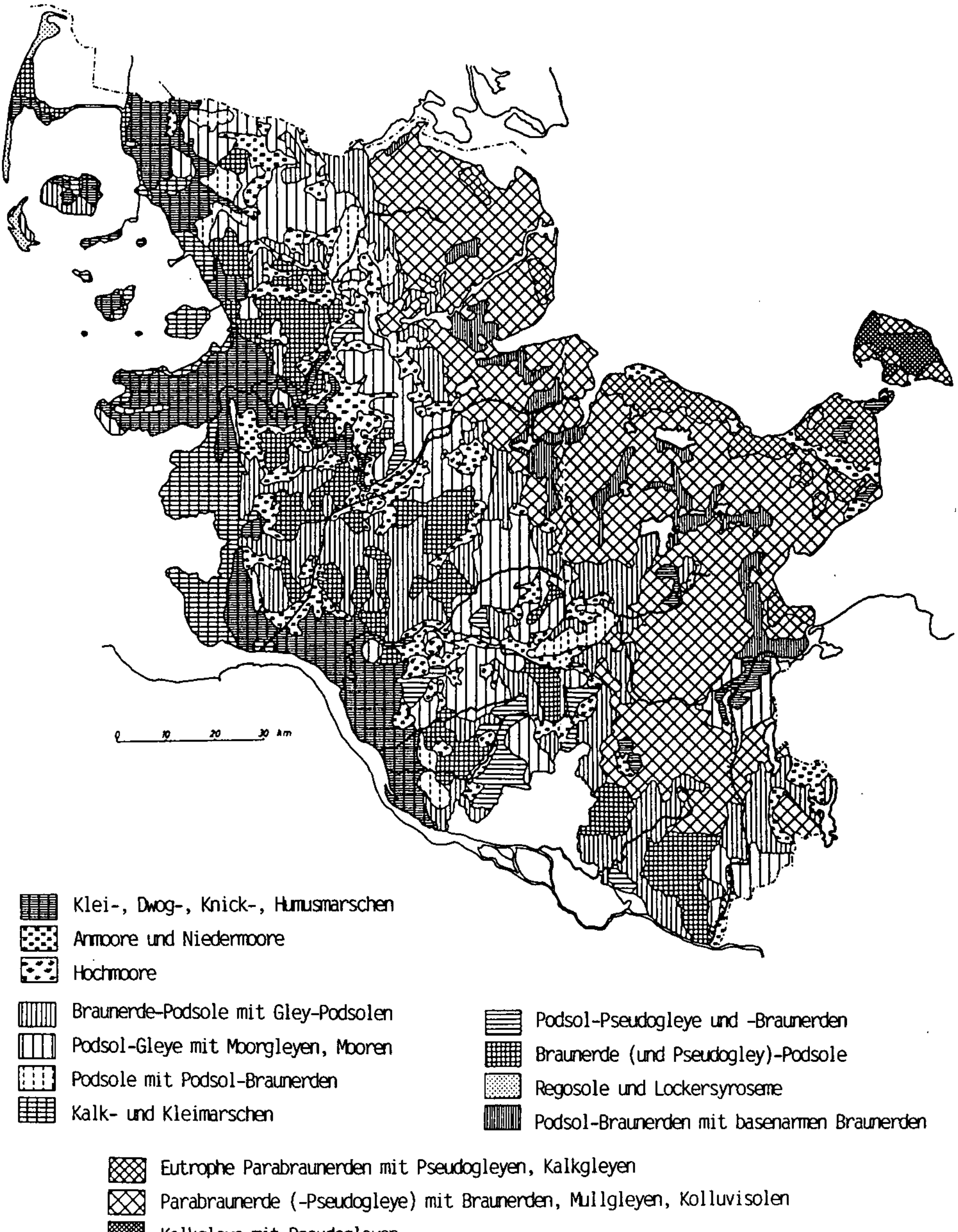

Figure 2: Soils in Schleswig-Holstein (after H.E. Stremme by Schlichting 1960, legend changed)

are moderately podzolized, especially in places with medieval litter removal from the forests.

The mostly sandy valleys are covered by groundwater-influenced soils, **Gleye** with medium to high base content, **Anmoore** (Humic Gleysols), and **Niedermoore** (Histosols), depending on the groundwater level. Especially in the east these groundwater soils are rich in Ca-carbonate (meadow chalk in the Oldenburger Graben). Further to the west (earlier ice-free) also acid **Gleyic Podzols** occur and bogs have formed on top of the fens (Lübeck Basin, Duvenseer Moor). Patchy occurring clay deposits in basins carry clay- and nutrient-rich, wet soils, Gleysols and gleylike soils with high humus contents. Most of the soils are now enriched with nutrients due to their agricultural use. The loamy Luvisols that dominate in the Eastern Hills besides sandy Cambisols have considerable nutrient reserves and useable field capacities. Together with the favourable mild climate, they are sites with very high agricultural yields. Where periodic water stagnation occurs, amelioration is necessary.

Soils of the Low Geest

In the region of the Low Geest, which partly lies below sea level, sandy soils poor in nutrients and with high groundwater tables prevail. The dominating sandur deposits of the Weichselian glaciation are extremely poor in clays (less than 2 %), carbonate-free and base-depleted to great depths. Carbonate- and base depletion presumably commenced in the late Weichselian and was enhanced by then deeper groundwater levels. With the rise in sea level during the Flandrian transgression drainage became poorer and strongly podzolized soils were formed (**Gley-Podsole** (Gleyic Podzols) and **Podsol-Gleye** (Podzolic Gleysols), depending on the nearness of the groundwater). The humus-enriched and often indurated (ortstein) subsoil of the Gley-Podsole still contains some iron as a rule, in the Podzol-Gleys, however, the whole profile is depleted of iron oxides and, with it, of heavy metals such as Mn, Cu, Zn, and Co. The iron leached by seepage water and dislocated in the landscape was partly accumulated in the oxidizing horizons of gleys elsewhere, especially near creeks. At places, the accumulation of iron oxides has led to the formation of **bog iron ore**, which once was used for iron foundry. Wide hollows of the podzol-gley landscape carry moors; first acid, nutrient deficient fens formed, which later mostly developed into acid and extremely nutrient deficient bogs.

Some Saalean moraines project through the sandur plain. With their elevated clay contents (as compared to the sands) more or less podzolized acid **Braunerden** (Cambisols) have developed. Also dry Podsole (Podzols) occur where the boulder sands are covered by Weichselian airborne (practically clay-free) sands, and where, after the clearing of the forests, heath vegetation has prevailed over centuries.

Especially because of the dominance of waterlogged soils, the Low Geest was not attractive to settlement. Only the above mentioned moraine islands were cultivated early, the manuring with heath litter over centuries led to the formation of **Plaggenesch** (Fimic Anthrosols) with thick topsoil layers enriched with organic matter. Today, after artifacial drainage, the soils of the Low Geest are in agricultural use: Histosols and podzolic Gleysols as grassland, gleyic Podzols, especially after deep-ploughing, as arable land. Due to their low nutrient contents the soils require heavy fertilization, also with micro-elements besides macro-elements. Fertilizers should only be applied during the vegetation period and in small amounts at a time to avoid groundwater contamination. The sandy gleyic Podzols need additional irrigation during dry summers, even with groundwater tables as high as 80 - 100 cm, because of the low water-holding capacity of the soils.

Soils of the High Geest

Also on the Saalean moraines of the High Geest **Luvisols** have developed. Since already during the Eemian interglacial soil forming processes have been going on, they are free of Ca-carbonate to depths of several meters today, strongly acidified and often podzolic. The clay depletion of the topsoil reaches often a meter deep, partly a consequence of clay translocation, but also due to sedimentation of airborne sands during the Weichselian glaciation. These sands have been mixed with the underlying material by cryoturbation. Many of the soils on the moraines contain frost wedges filled with sand to several meters deep. Often they form nets of 5 to 10 m grid size. They are formed when periglacial conditions prevailed in this landscape during the last glaciation. The sandy cracks have drier soils with somewhat poorer vegetation, and they can thus be recognized in aerial photographs. Where the loamy subsoil is nearer to the surface gley like soils have developed on level terrain, a tendency enhanced by a precipitation which is higher by 100 to 200 mm per year as compared to the Eastern Hills. Thicker covers of aeolian sand carry **Podzols** also here, depressions have **podzolic Gleysols** or **Histosols.**

Soils of the Marshland

The properties of the marshland soils derive from both geogenic and pedogenic processes. Their development starts seaward of the dykes, where sediments are being deposited. Depending on the flow velocity of the water, in Schleswig-Holstein they contain 3 - 60 % clay, 0.5 - 10 % organic matter, and 3 - 8 % total carbonates (0.5 - 2 % dolomite therein). A specific fauna and flora of the Wadden Sea settles, and the surface is slowly elevated above the level of the dayly tides: Salzmarsch (Gleyo-Salic Fluvisol, Halaquent) forms. It is only flooded by storm tides. The marshland soil profile is thus characteristically layered: layers of fine sand, silt and clay interchange, and - corrosponding to the history of the landscape (cf. chapter "Geology") - peat layers and fossile topsoil horizons occur. The soil forming processes of the young marshland outside the dykes and in freshly enclosed polders ("Koog") are: intensive redox processes, especially sulphide formation and -oxidation, structure formation, salt leaching and starting carbonate leaching. They lead to the formation of the fertile Kalkmarsch (Gleyo-Calcaric Fluvisol, Calcareous Fluvaquent) and are summarized under the term maturation. Subsequent degradation consists of the processes of carbonate leaching, clay migration and acidification. In Schleswig-Holstein it takes around 200 to 400 years of "Koog" development to complete carbonate leaching of the topsoil. Kleimarsch (no or little compaction, carbonate-free 40 cm, Gleyo-Eutric Fluvisol, Fluvaquent) is formed. Marshland soils which are carbonate free (40 cm), clay-rich, and compacted are called Knickmarsch (Fluvi-Dystric Gleysols, Epiaquic Haplaquepts or Haplaqualfs). The "Knick"-horizon consists of clay-rich sediments covered by sandier material deposited during storm tides, it is often additionally compacted by clay illuviation.

In cases, where marine sediments were deposited on former land surfaces, "Dwogmarsch" (carbonate-free 40 cm, Fluvi-Dystric Gleysols) formed: Humic "Dwogs" containing fossile Ah-horizons, and Iron "Dwogs" containing fossile iron-rich Go-horizons. Marshland soils over fen peat (sediment cover 40 cm) are called Moormarsch or Peat-Marsch. When much organic material (from old bogs or old Ah-horizons) was contained in the marine sediments, organic matter-rich Marshland soils derived: Humusmarsch (Fluvi-Humic Gleysols, humaqueptic Fluvaquents). In sedimentary environments of the latter three types the formation of "Maibolt" (Jarosite, $KFe_3(OH)_6(SO_4)_2$) was enhanced with long development under direct influence of the sea: here very acid (pH down to 2) Marshland soils formed.

Agriculture in Schleswig-Holstein

Agriculture and nutritional industries are important in Schleswig-Holstein's economy. Around 25 % of the working population are imployed in this sector. Agriculture's contribution to the gross national product is more than double the federal average here. More than half of the population live in places of less than 15000 inhabitants. In rural regions, agriculture is the supporting economic branch. The subdivision into the landscapes of Eastern Hills, "Geest", and Marshland has strong impacts on the patterns of agricultural production. Cropland on Marshland Soils and on Cambisols and Luvisols in the Eastern Hills is dominated by cereal and rape production. The permanent grassland of the marshland supports intensive cattle production. Efficient dairy production has developed in the "Geest", with its light soils and widespread peatsoil lowlands.

Agricultural economic structure is relatively healthy in Schleswig-Holstein. On 25000 of the total 31000 farms, agriculture alone supports the farms; animal production (especially dairy cattle) dominates.

1. Farm sizes

The total number of farms was 30993 at the end of 1984. Compared to 1960 and 1980 it declined by 43 % and 6.3 %, respectively. Mean farm size increased by 1.9 ha (1984 vs. 1980) to 35.2 ha. This is double the federal figure of 15.3. More than 15000 farms are larger than 30 ha, they cover almost 80 % of the agricultural area of Schleswig-Holstein.

No. of farms and %-coverage by size classes

Size classes	1960	1970	1980	1984
No. of farms	54,163	43,172	33,012	30,933
Percent area by size classes				
up to 10 ha	36.2	29.1	26.5	27.5
10 - 20 ha	24.3	18.4	11.9	11.0
20 - 30 ha	18.1	21.1	15.6	13.3
30 - 40 ha	9.4	13.7	15.1	13.9
40 - 50 ha	5.3	7.6	11.3	11.3
50 - 100 ha	5.7	8.5	16.4	19.1
more than 100 ha	1.0	1.6	3.2	3.9
mean farm size	21.0	25.9	33.3	35.2
mean size of farms greater than 30 ha	53.2	53.3	57.8	60.6

Land use in Schleswig-Holstein

	1960	1970	1980	1984
Total productive area	1569	1570	1327	1316
Agricultural area	1187	1153	1101	1091
%-ages of:				
Arable land	57.4	44.9	56.7	55.0
Horticulture, fruit-growing, nurseries	3.6	2.7	0.9	0.8
Permanent grassland	39.0	41.4	42.4	44.2
Forests (% of total production area)	8.6	8.5	10.5	10.6

2. Developments of culture and yields of principal crops

Cereals and rape are the dominant crops in Schleswig-Holstein. Winterwheat areas have approximately doubled between 1960 and 1984, those of winter barley and rape have increased 4-fold and 6-fold, respectively. Winter barley has replaced rye and spring cereals on sandy sites. Cereal yields have approximately doubled in this period. In favourable years, peak yields of 10 metric tons per hectare of wheat were harvested. Also for other crops, the yields have increased considerably.

Culture area of selected crops (1000 ha)

	1960	1970	1980	1982	1984
Winter wheat	74.4	81.1	161.2	136.4	149.7
Spring wheat	14.0	12.0	5.5	8.3	2.3
Rye	112.5	72.9	67.6	51.5	52.2
Winter barley	31.7	58.9	108.5	121.3	129.9
Spring barley	43.3	55.9	27.5	33.2	13.3
Oat	61.4	103.9	41.7	38.4	22.9
Cereals (total)	408.2	409.7	413.6	390.5	370.9
Winter rape	14.2	46.2	73.7	84.4	90.4
Potatoes	42.1	14.0	5.3	5.0	5.1
Sugar beet	13.7	15.0	18.7	19.4	18.8
Common beet	29.0	25.9	13.3	8.2	7.2
Green maize	0.3	5.3	39.8	46.2	49.6
Fodder crops (total)	121.3	100.6	88.7	96.0	96.4

Average yields of selected crops (dt/ha)

	1960	1970	1980	1982	1984	1985
Winter wheat	38.2	46.0	54.8	73.1	73.5	74.7
Spring wheat	33.9	39.8	41.4	51.2	49.8	51.8
Rye	26.9	25.4	38.9	45.3	43.4	42.8
Winter barley	36.2	34.8	58.0	65.3	62.5	56.9
Spring barley	32.0	26.6	36.5	42.8	40.0	45.9
Oat	31.2	31.5	40.0	50.5	49.7	51.3
Cereals (total)	31.4	32.9	50.1	61.8	62.5	-
Winter rape	24.1	22.3	29.4	31.8	25.4	34.2
Potatoes	411	599	548	864	713	-
Sugar beet	238	295	268	285	368	390
Common beet	357	376	386	458	442	442
Green maize (shoots)	365	434	393	431	380	-

3. Fertilization

Since 1979/80 the use of commercial fertilizers has been decreasing somewhat. The nutrient supply by farmyard manure (solid, semi-liquid, and liquid), soil nutrient balance, and crop demand are being increasingly considered.

Use of fertilizers (kg/ha) in Schleswig-Holstein

	N	P	K	CaO
1960/61	55	25	60	37
1970/71	106	35	73	56
1979/80	169	41	92	143
1981/82	162	27	68	141
1983/84	163	29	78	167

Mean nutrient addition in 1981/82 in Schleswig-Holstein

	N	P	K
Farmyard manure	53	26	95
Commercial fertilizer	162	28	68
Sum	215	54	163
Fertilizer recommendation	198	41	152

Fertilizer recommendations (calculated from soil analyses, average yields, and cropping patterns) show that a decrease of commercial fertilizer use is possible. The chamber of agriculture consults on fertilization (nitrate service).

4. Animal stocks in Schleswig-Holstein (in 1000)

	1960	1970	1980	1984
Horses	46	18	35	33
Cattle (total)	1219	1407	1552	1627
Dairy cattle	460	493	520	545
Pigs	1414	1774	1808	1768
Sheep	105	97	123	157

5. Forestry

Woods and forests cover 8.9 % of the area of Schleswig-Holstein, and 10.6 % of its productive area. Main tree species are Oak (11 %), beech (23 %), spruce (+ fir and Douglas fir) (37 %), pine (+ larch) (19 %), and miscellaneous deciduous trees of minor importance (10 %). 465000 m^3 of timber were cut in 1984. The forests are mostly rather young: 35 % less than 20 years, and only 3 % over 100 years. To cut down an overproduction, afforestation of agricultural areas is planned for the future.

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Hamburg, Germany, August 1986

Typical Soils and Landscapes in Holstein

by H.-P. Blume (Ed.), J. Lamp, E. Schnug and D. Wiese
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Contents

Preface

During Excursion **M** typical landscapes and soils of East- and Middle Holstein are demonstrated.

In **East-Holstein** the **Siggen** estate, located near the Baltic cliff coast, serves as an example for genesis, dynamics and use of loamy Luvisols and Pseudogleys of the younger moraine landscape.

Near **Plön** development and eutrophication of a lake are demonstrated.
On the **Geest** in Middle Holstein, locations in and beside the **Segeberger Forest**, serve as examples for genesis, dynamics and use of sandy Dystric Cambisols and Ferric Podzols of the elder moraine and sandur landscape.

Many coworkers of the Institute of Plant Nutrition and Soil Science in Kiel have participated by the preparation of the excursion, investigations of soils profiles, interpretation, drawings and typing of the results. Without their help the preparation of the excursion would have been impossible. We have to thank administrator Walch (Siggen farm), director Schwarz (Segeberger forest) and farmer Schmidt (Heidmühlen for their cooperation and help.

The excursion has been substantially sponsored by the Government of Schleswig-Holstein.

Kiel, May 1986

Hans-Peter Blume und Jürgen Lamp

Route description

Hamburg; ride in eastern direction to Autobahn to Lübeck; after lowland of Weichselian sandurs, hilly moraine landscape of Weichselian boulder sand and -marl. Podzolic Cambisols under cropland. After

Ahrensburg, gently rolling moraine landscape with loamy Luvisols (partly ± gleyic) under cropland beside gleyic and marshy hollows covered with grassland or forest. Form

Reinfeld: Valley of River Trave and Lübeck Basin, an ice-barred lake during the Ice Age, where clay and, finally, sands were deposited nutrient-rich Gleysols and Stagnogleys formed on the former, nutrient-poor Podzols on the latter.

Lübeck, most important medieval "Hanse" town on the Baltic Sea, today with industries (shipyards, metal processing) and university (medicine), 220 00 inhabitants.

Travemünde, largest Baltic seaport of the Federal Republic. Hilly moraine landscape with loamy Luvisols and sandy Cambisols, both under cropland, and gleyic and marshy hollows under grassland. The fields are bordered by hedgerows ("Knick", rows of shrubs and trees planted on mounds in the 18th century, today protected).

Lehnsahn, ride through rolling moraine landscape with loamy wet gleyic Luvisols. Crossing of the Oldenburg Valey, a wide glacial meltwater channel once dividing Oldenburg from the mainland as a sound. It was cut off from the sea by beach ridges and moors formed in it. In this century it was protected by dikes, drained, and is today under intense agricultural use. (Further east: Lübeck Bight with modern seaside resorts, Timmendorfer Strand, Scharbeutz, Haffkrug).

Siggen - Gently rolling ground moraine landscape, soils 1 - 3, modern farm (cropping, no livestock). - Passage to

Oldenburg, today a small town (10 000 inhabitants), built near the site of an old Slavic castle (Starigard) of the 8^{th} century. After the Cristianisation of the area by the German emperor Otto I in the 10^{th} century, estates of the nobility formed. Even today 1/3 of the area is covered by farm units of more than 100 ha. - Crossing of the Oldenburg Valley and passage through increasingly hilly moraine landscape to the

Kossau Valley, a glacial meltwater channel with the meanders of the Kossau, fishpons (trout raising) on its banks. The Kossau is one of the last creeks with a natural bed.

Plön, resort in the centre of the "Holsteinische Schweiz", an idyllic landscape rich in lakes and forests. The former residence of the counts of Schleswig-Holstein Sonderburg is today a boarding school. Max-Planck-Institute of Limnology. Crossing of Lake Großer Plöner See (see special description) to

Bosau, fishermen's village and resort, with a small church built of boulder stones (12th century). - Passage through a meltwater channel bordered by hilly moraines. At

Trensfeld the valley widenes to form the Bornhöved sandur fan: the "Low Geest" is reached. Here Podzol-Gleysols and moors on glacio-fluvial sands dominate. The soils are mostly drained today, lower parts are covered by grassland, higher parts by cropland (rye and fodder maize). -

Segeberger Forst, partly on acid Cambisols on Saalean moraines, partly on Podzols on Weichselian glacio-fluvial sands, soil profiles 4 - 6. - Ride back on

Autobahn passing flat undulating old moraine landscapes and valley of fluvial sands to

Hamburg.

Mitteilgn. Dtsch. Bodenkundl. Gesellsch. 51, 18 - 31 (1986)

Soils, Natural and Economical Resources of Siggen-Farm

by H.-P. Blume, J. Lamp and E. Schnug, University of Kiel
with C.-G. Schimming and M. Zingk, Kiel

Topography, climate, geology and soils

The Siggen farmyard is situated 16 km east of the district town Oldenburg next to the shore of the Baltic Sea. The mean annual precipitation is only 560 mm. Relative continentality is also shown by the range of monthly air temperatures (see table 1).

As part of Eastern Hill landscape of Holstein the farmland was formed during the Weichselian glaciation and shares typical soils of the region as already described. In fig. 2 some Cambisols and mainly Luvisols occur on hilltops; Pseudogleys on mid slopes, Gleysols and calcarious Histosols in depressions (see also sequence in tab.4). Slopes, often between 3 and 10 %, favour water erosion which formed decapitated soils during eight hundred years of cultivation. Plough layers already enriched with marl from the underlying parent material are encountered on some hilltops of the Farm area. Colluvisols or colluviated soils often occur at hillfoots, and in levelled small depressions at upper slopes (colluvial coverages and depths to marl under forest and ploughland evaluated from borings see fig.1). In some depressions anthropogenic soils from drainage channel clearing are mapped. In the south-west stratified silty Gleysols on fen peats derive from a drained lake bottom.

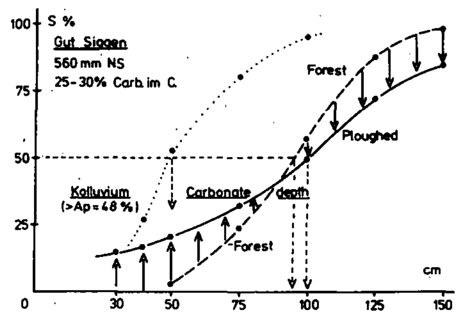


Fig. 1: Distribution of colluvial coverages and depth to marl observed by borings

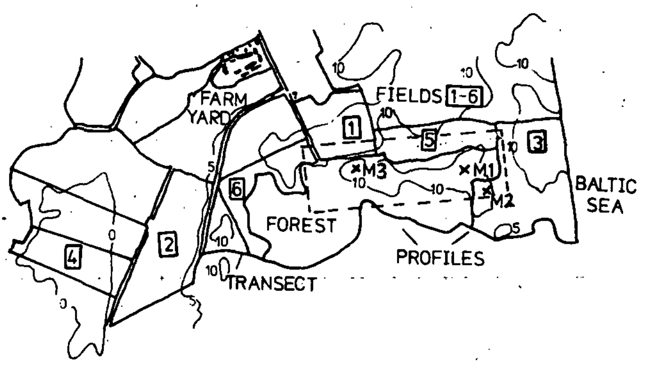
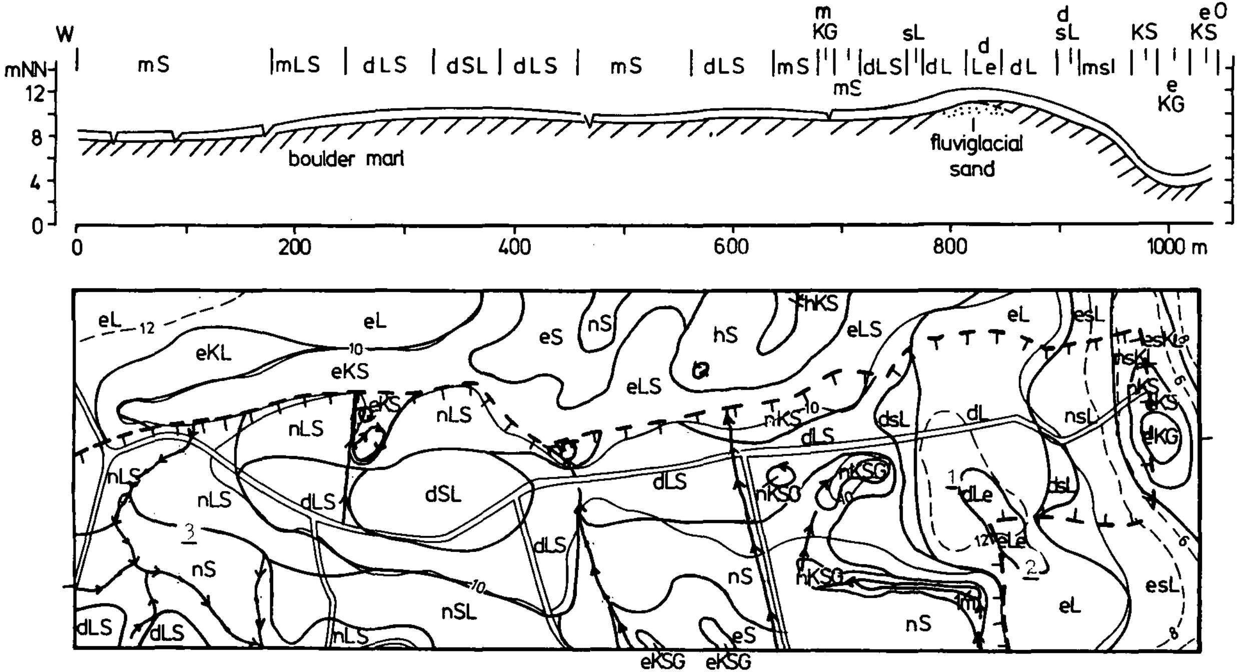


Fig. 2: Locality, fields, transect and soil map section of Siggen farmyard

Tab. 1: Mean rainfall and air temperature in Dahmeshöved (9 Km south of Siggen)

J	F	M	A	M	J	J	A	S	O	N	D	year	
37	35	33	36	43	50	69	40	54	49	40	40	569	mm
0.3	0.1	2.5	6.8	11.2	15.2	17.1	16.5	14.0	9.5	5.3	2.4	8.4	C



G : Gley , K : Kolluvium , L : Parabraunerde , Le : eroded L , S : Pseudogley , s : pseudovergleyt

d : dystroph (<4)ˣ n, m : mesotroph (4-6)ˣ e : eutroph (6-7)ˣ k : w.carbonates ˣpH ($CaCl_2$) of epipedon

—— : forest →→ : ditch

Fig. 3 : Section through, and soil map of a moraine landscape, Siggen, East Holstein

Siggen 1

Location: 12.3 m a.s.l., small ridge, groundwater 4 to 6 m below the soil surface (see Figure 3)
Parent material: Boulder marl above fluvioglacial sand
Vegetation: Forest with beech and oak
Soil type: Typische Parabraunerde (Orthic Luvisol, Typic Hapludalf)

profile description:

L/Of	(01)	5 - 3 cm	brown beech and oak leaves together with branch pieces; only few frass pattern
Of	(02)	3 - 2 cm	older leaves and broken branches, strongly reduced to small pieces, together with small crumbs of earthworms and arthropods
Oh	(03)	2 - 0 cm	very dark grey (10YR3/1), fine crumb, many roots, gradual boundary
Ah	(Ah)	0 - 14 cm	dark greyish brown (10YR4/2), loamy sand, crumb, many roots, clear boundary
Alv	(E)	- 47 cm	brown (10YR4/3), sandy loam, coarse blocky, common roots, diffuse boundary
Bvt	(Bt)	- 91 cm	yellowish brown (10YR5/5), blocky to prismatic, clay skins, sandy clay loam, few roots, diffuse boundary
BtC	(BC)	-117 cm	yellowish brown (10YR5/4), prismatic, clay skins, sandy clay loam, very few roots, clear boundary
Ccv	(Ck)	-135 cm	yellowish brown (10YR5/4), weak prismatic, whitish powder of carbonates on peds, diffuse boundary
Cv	(C)	-182 cm	pale brown (10YR6/3), coherent, sandy loam, abrupt boundary
IIC	(2C)	-200 cm	pale yellow (2.5YR7/4), structureless, gravelly medium sand

Table 2 : **Total contents of metals**

No.	hor.	Fe	Mn	Cd	Cu	Pb	Zn	Ti	K	Mg	P
		--mg/g---		--mg/kg--		-------		--mg/g-------			
1	**Parabraunerde under forest**										
11	Ak	16.6	0.69	0.41	20	28	49	3.3	18.3	3.3	0.52
12	Alv	27.9	0.43	0.19	22	37	54	3.5	21.1	5.5	0.32
13	Bvt	30.4	0.43	0.24	30	42	58	3.6	21.6	6.7	0.35
14	BtC	27.0	0.49	0.26	23	32	52	3.2	20.6	6.8	0.48
15	Ccv	23.5	0.43	0.22	20	31	47	2.9	17.9	6.2	0.51
3	**Pseudogley under forest**										
31	OAh	14.9	0.45	0.40	5.0	37	47				
32	SwAh	14.5	0.24								
33	Sw	20.2	0.38	0.12	4.5	25	41				
34	BtSd	29.7	0.27	0.15	13	28	55				
35	Skd	29.5	0.59	0.12	19	28	53				
36	CSd	22.5	0.46	0.10	12	30	52				
37	CSd	20.9	0.41	0.12	12	28	48				

1 Parabraunerde under forest

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	fS: mS	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11	Ah	0-14	2.8	4.8	16.4	25.7	46.9	17.3	11.9	8.2	37.4	15.7	1.5	1000
12	Alv	-47	3.0	4.8	13.9	22.5	41.2	14.6	10.4	9.0	34.0	24.7	1.6	710
13	Bvt	-91	3.1	4.7	13.8	21.0	39.5	14.0	8.8	9.3	31.7	28.8	1.5	2.7
14	BtC	-117	2.3	4.4	13.8	24.0	42.2	12.2	9.6	9.3	31.1	26.7	1.7	
15	Ccv	-135	2.6	3.9	15.3	22.8	42.0	14.8	10.7	9.8	35.3	23.1	1.5	1.3
16	Cv	-182	2.6	4.4	14.0	24.2	42.6	15.2	11.7	8.7	35.6	21.6	1.7	1.3
17	IIC	-200	25.0	29.3	49.8	14.3	93.4	1.3	0.8	0.8	2.9	3.7	0.29	1100

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o: Fe_d	Mn_d mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
11	Ah	1.10	57.4	41.0	35.4	32.2	9.5	4.5	3.7	6.16	2.85	0.46	0.61	11
12	Alv	1.62	36.5	32.5	31.1	29.5	17.5	4.7	3.8	9.50	2.22	0.23	0.32	11
13	Bvt	1.67	37.0	32.3	31.0	30.0	18.4	5.2	4.3	10.4	1.85	0.18	0.32	28
14	BtC	1.71	35.5	33.5	32.5	32.0	19.9	8.0	7.3	8.8	1.11	0.13	0.33	21
15	Ccv	1.74	34.3	31.7	30.1	29.0	19.0	8.1	7.4	6.44	0.89	0.14	0.27	2.5
16	Cv	1.74	34.3	31.7	30.1	29.0	19.0							
17	IIC	1.69	36.4	32.9	7.3	5.8	2.6							

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	car-bon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg with NH_4Cl: Ca	K	Mg	Na	H	Al	V_p %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
11	Ah	2.11	1.91	11	0	172	83	14.1	3.5	4.8	0.7	19	42	13
12	Alv	0.56	0.62	11	0	149	123	16.5	3.8	5.5	1.3	5	91	18
13	Bvt	0.29	0.37	8	0	158	121	77.0	2.8	17.2	2.1	3	20	63
14	BtC	0.20	0.31	6	6.7	166	166	142	2.7	16.2	1.9	1.8	0	98
15	Ccv	0.16	0.19	9	16.1	148	148	132	2.4	11.5	1.8	0	0	100
16	Cv				18.0									

Interpretation

Parent material is a dense (compacted by strong ice pressure) 1.8 m thick sheet of dark grey boulder marl over fluvio-glacial sand. It consisted of about 40 % quartz, 10 % feldspars, 10 % mica, 2 % heavy minerals such as amphibols magnetite, and garnet, 18 % clay minerals (mainly illite and smectite), 20 % carbonates, and, probably, 2 o/oo metal sulphides. The boulder marl is relatively homogeneous: The depth functions of the quotient fine sand/medium sand and the size distribution of grains between 0.6 µm and 1 cm (not affected by clay migration) are rather similar (Fig. 4).

The boulder marl was sedimented about 13 000 years ago (Steffan, pers. comm.) in the Late Glacial Period. Until the end of the Late Tundra Period (ca. 10 500 years ago) this soils was subject to permafrost. No major traces of cryoturbation and solifluction are observed, however. Since the texture of top- and subsoil are rather similar, addition of eolian sand can practically be excluded.

The sulphides have been completely oxidized (sulphide containing boulder marl deeper than 3 or 4 m in the surroundings), favoured by the underlying permeable sand. The soil is carbonate-free down to 90 cm and carbonate-depleted down to 120 cm, this means that 350 kg per m2 of $CaCO_3$ have been leached (Tab. 4). The soil is strongly acidified and base-depleted. Silicate weathering occurs especially in the topsoil. About 35 kg/m2 of clay has formed, mostly by mica transformation. No greater changes of clay mineral composition have occurred. Clay migration (lessivage) lead to clay depletion in the topsoil and accumulation in the subsoil. In spite of the material's density no hydromorphism by stagnation water occurs, surplus water is removed by overland flow and drainage into the underlying sand.

Table 3 : **Clay minerals (in %) by x-ray analysis of the <0.1, 0.1-0.5, and 0.5-5 µm fraction** (s:smectite, x interstratified, i illite and mica, v vermiculite, k kaolinite, c chlorite, q quartz)

	< 0.5 µm Ø					0.5 - 5 µm Ø				
hor.	s	x	i	c	k	i	v	x	k	q
1 Parabraunerde under forest										
Ah	55		32	5	8	10	5		5	30
Alv	40	15	35	4	6	15	10		5	30
Bvt	53	6	33	4	4	20	10		5	25
Ccv	51	6	34	4	5	20	10		5	25
3 Pseudogley under forest										
SwAh	50		20	15	15	10	2	5	5	40
Sw	26	29	30	7	8	10	5		5	40
BtSd	55	6	32	5	2	20	10		10	35
CSd	44	6	39	6	5	25	10		10	30

The soil is deeply rootable, well aerated and fresh. The topsoil is nutrient-depleted. Medium to high nutrient reserves make it a very productive forest site, agriculture with high yields would also be possible here.

In spit of its strong acidification the soil is biologically active. The litter is decomposed almost completely within year. A combined litter and organic matter analysis of 25 years ago showed a decrease in lignin and cellulose with soil depth, and an increase in humic cid and especially fulvic acid (Fig. 6). Protein decreased absolutely, but increased relatively, probably resulting from higher proportions of N-rich root debris and protein-rich biomass of soil organisms.

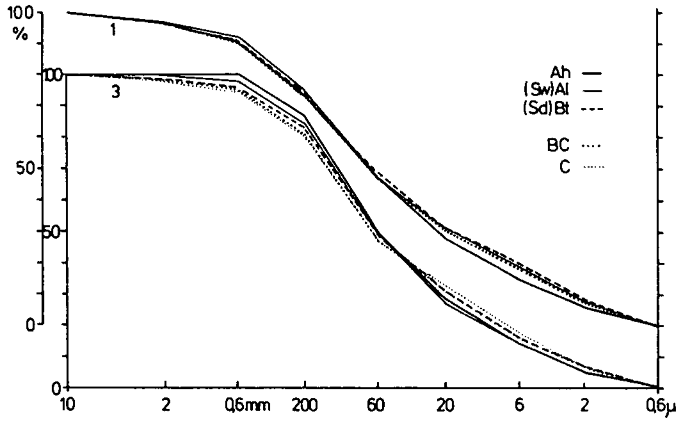


Fig. 4.: Texture distribution (cumulative) of the fraction 0.6 µm - 1 cm of a Luvisol (1) and a Gley-like soil (3) under forest

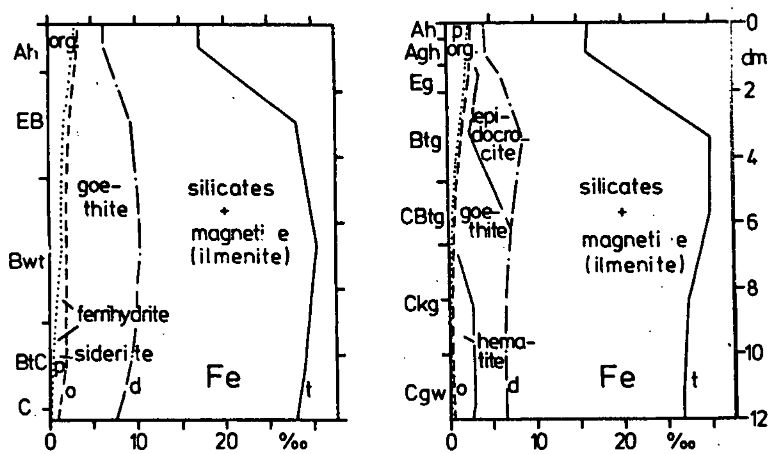


Fig. 5: Fe-fractions of a Luvisol (left) and a gley-like soil (right) from boulder marl (Siggen 1 and 3)

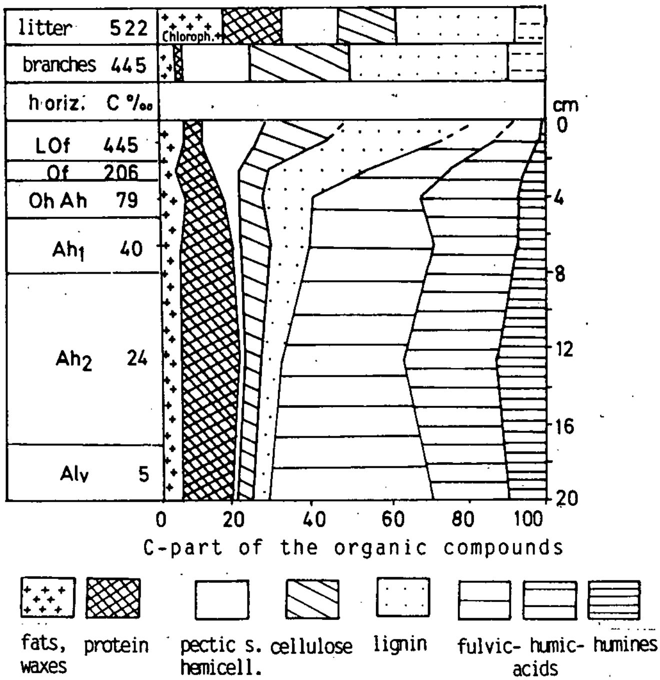


Fig. 6 : Composition of litter and soil organic matter of a Luvisol on boulder marl under oak-beech forest.

Because of the limit selectivity of the methods employed only a possible composition is shown, further it was assumed that humic substances do not contain amino acids. Extractive fractionation: soluble in alcohol/bezene: fats, waxes and resins; 0.05 n H_2SO_4 - soluble red. sugars: pectin, hemicellulose (+ sugar and starch); 72 % H_2SO_4 -soluble red. sugars: cellulose; - amino-N x 6.25 = protein; methoxyl x 6.7 = lignin; differentiation of humic substances with NaOH and H_2SO_4.

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Profile balances

Quantitative changes in the soil constituents since the beginning of soil development ca. 13 000 years ago were balanced. The present-day element concentrations were analysed for each horizon. Considering bulk densities and thickness of the horizons, the amount in the whole solum was calculated (Tab. 1.3). The original amounts in the parent material were derived from the fractions of fine-sand quartz (resistant to weathering and translocation) and Ti (much resistant to translocation), and their relative contents in the unchanged boulder marl.

Since the beginning of soil development, both profiles have lost relative high amounts of P (Tab. 4): an average of 0.3 kg per hectare and year over the last 13 000 years. Metals on the other hand were not leached to a great extent. This does not hold, however, for the relatively mobile Cd, which has leached to some extent from the Luvisol, and partly accumulated in the neighbouring Gley-like soil. The present-day Cd immissions are less than 0.2 mg/m^2 a and have not influenced the balance greatly yet.

Table 4 : **Recent and former amounts of heavy metals, organic matter, carbonates and clay in the solum of a Parabraunerde (1) and a Pseudogley (3)** (in g per square meter and 120 cm depth, percentage of gains and losses)

		Fe	Mn	Cd	Cu	Pb	Zn	C_{org} [1)]	$CaCO_3$	clay	P
1 Parabraunerde	[1)] bis 50 cm										
re-	vegetation	3	2	0.005	0.03	0.2	0.6	10000			
cent	O-horizon	89	6	0.004	0.09	0.3	0.4	850			
recent	A+B-hor.	53300	910	0.45	47	69	105	7200	56000	498000	760
former		55200	970	0.52	48	71	111	0	410000	464000	1200
difference		1900	60	-0.07	-1	-2	-6	+7200	-354000	+34000	-440
% diff.		-3	-7	-14	-2	-3	-5	+100	-86	+7	-37
3 Parabraunerde-Pseudogley											
recent		45700	780	0.27	24	56	100	6200	186000	456000	580
former		45400	880	0.26	26	60	105	0	465000	429000	890
difference		+300	-100	+0.01	-2	-4	-5	+6200	-279000	+27000	-310
% diff.		+1	-11	+3	-9	-7	-5	+100	-60	+6	-42

Blume, H.-P.: Schwermetallverbreitung und -bilanzen typischer Waldböden aus nordischem Geschiebemergel (Heavy-metal distribution and -balances of typical forest soil on northern boulder marl). Z. Pflanzenern. Bodenkunde 144: 156-163 (1981)

Siggen 2

Location: 11.5 m a.s.l., upper (1^o) slope of a ridge, groundwater 3 to 5 m below the soil surface (see Figure 3)
Parent material: Boulder marl above fluvioglacial sand
Use: Arable land
Soil type: Typische Parabraunerde, leicht erodiert (Orthic Luvisol, Typic Hapludalf)

profile discription:

Ap	(Ap)	0 - 24 cm	dark brown (8YR3/2), crumb to coarse subangular, sandy loam, abrupt boundary
Bvt	(Bt)	- 70 cm	strong brown (8YR4/4), dark brown tubules, small very dark brown nodules, clay skins, coarse prismatic, sandy clay loam, diffuse boundary,
BtC	(BtC)	- 86 cm	strong brown (8YR4/4), clay skins, some small very dark brown nodules, coarse prismatic, sandy clay loam, gradual boundary,
Ccv	(Ckw)	-140 cm	dark yellowish brown (10YR4/6), small very dark brown nodules, coarse prismatic, whitish powder of carbonates on peds, clear boundary,
IIC	(2C)	-200 cm	light yellowish brown (2.5Y6/4), structureless, gravelly coarse sand/fine sand/gravelly medium sand
IIIC	(3C)	-220 cm	brown (10YR5/3), coherent, silty fine sand.

Interpretation

Parent material and soil formation are very similar to that of the Luvisol under forest. Liming and fertilization have increased the pH and exchangeable basic cations, and P content in the topsoil. Organic matter content is lower, C/N ratio smaler, obviously NH4 fixation in clay mineral interlayers has occurred.

2 Parabraunerde under arable land

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	fS: mS	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
21	Ap	0-24	3.4	4.8	16.0	22.7	43.5	13.5	11.1	7.5	32.1	24.4	1.4	412
22	Bvt1	-46	3.5	3.7	14.0	22.0	39.7	9.7	17.3	3.8	30.8	29.5	1.6	23
23	Bvt2	-70	6.1	4.4	13.8	21.7	39.9	9.4	12.0	8.7	30.1	30.0	1.6	20
24	BtC	-86	4.6	3.2	12.6	24.5	40.3	11.6	11.9	8.6	32.0	27.7	1.9	
25	Ccv	-140	4.3	6.0	17.8	23.4	47.2	7.1	10.1	10.2	27.5	25.3	1.3	72
26	IIC	-200	25	29.3	49.8	14.3	93.4	0.3	1.6	1.0	2.9	3.7	.29	
27	IIIC	-220		2.7	10.2	61.3	74.3	19.6	1.7	0.6	21.9	3.9	6.0	226

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o: Fe_d	Mn_d mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
21	Ap	1.51	41	37	29	24	15	7.6	7.0	7.2	2.4	.34	434	156
22	Bvt1	1.71	36	34	32	28	20	7.2	6.4	9.4	1.4	.15	285	3.4
23	Bvt2	1.74	34	34	32	29	19	7.1	6.2	9.1	0.9	.10	345	4.1
24	BtC	1.75	33	33	31	27	18	8.4	7.6	7.2	1.4	.19	290	2.2
25	Ccv	1.76	33	33	29	25	17	8.4	7.6	5.3	0.8	.14	114	10
26	IIC							8.4	7.6	2.1	0.3	.13	204	8.2
27	IIIC									1.8	0.2	.11	40	4.8

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	car-bon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg with NH_4Cl: Ca	K	Mg	Na	H	Al	V_p %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
21	Ap	.88	1.2	7	0.1	139		116	9.3	13	0.6	0		100
22	Bvt1	.27	.48	6	0	168		116	4.5	14	0.8	33		80
23	Bvt2	.24	.47	5	0	180		125	2.6	16	1.2	35		81
24	BtC		.35		7.8	154		139	2.2	9.2	0.9	38		98
25	Ccv		.24		18.9	134		126	1.9	5.4	0.6	0		100
26	IIC		.09		13.5	36		35	0.1	1.2	0.1	0		100
27	IIIC		.04		6.7	36		34	0.2	1.2	0.1	0		100

Siggen 3

Location: 8.5 m a.s.l., flat foot slope, groundwater 2 m below soil surface (see Figure 3)
Parent material: Boulder marl
Vegetation: Forest with beech, oak, ash
Soil type: Parabraunerde-Pseudogley (Stagno-gleyic Luvisol, Typic Umbraqualf)

profile description:

OAh	(OAh)	0 - 4 cm	very dark brown (10YR2/2), fine crumb, many roots, silty loamy sand, gradual boundary
SwAh	(Agh)	- 12 cm	very dark greyish brown (10YR3/2), light brownish gray spots, fine crumb (to platy), many roots, silty loamy sand, gradual boundary
Sw	(Eg)	- 21 cm	olive yellow (2.5Y6/6)/reddish yellow (7.5YR6/7), mottled, dark greyish brown tubules (10YR4/2), fine crumb to subangular, small brown nodules, common roots, silty loamy sand, gradual boundary
BtSd	(Btg)	- 48 cm	light brownish grey (10YR6/2)/reddish yellow (6YR6/6) mottled, very pale brown surfaces of peds, small dark brown nodules, prismatic, few roots, sandy clay loam, diffuse boundary,
Skd	(Btcg)	- 66 cm	light brownish grey (2.5YR6/3)/reddish yellow (7.5YR6/7) mottled, pale olive (5Y6/4) surfaces of peds, many dark brown nodules, very few roots, coarse prismatic, sandy clay loam, gradual boundary,
CcSd	(Bkg)	-100 cm	light brownish grey (2.5Y6/3)/reddish yellow (8YR6/7) mottled, white powder of carbonates on surface of peds, small dark brown nodules, coarse prismatic to coherent, sandy loam, diffuse boundary,
CSd	(Cg)	-200 cm	greyish brown (10YR5/2.5), partly pale olive (5Y6/4)/ yellowish red (8YR6/7) mottled, coherent (to platy), sandy loam.

Interpretation

The parent material of this Gley-like soil is comparable to that of the Luvisol lying some 4 m higher, it has a somewhat higher fine sand content and slightly lower medium and coarse sand contents. It is also rather homogeneous over the profile (see texture curves in Fig. 4) . The soil receives lateral groundwater since it is situated on a slope. Carbonate has leached from the top 60 cm corrosponding to a loss of 380 kg $CaCO_3$ per m^2. The topsoil is strongly acidified and base-depleted. Around 25 kg/m^2 of clay minerals have formed. Clay migration lead to a depletion of clays (and Fe-oxides) in the topsoil with corrosponding enrichment in the subsoil. This is reflected in the smectite distribution. Illite content has decreased in the subsoil where Al-chlorite has formed. The position near the hillfoot and the poor drainage characteristics of the boulder marl cause stagnation of excess water. Fe- and Mn-oxides dissolve by reduction mainly near the aggregate surfaces and are being transported into the centres of the aggregates. There, mainly in carbonate-free horizons, lepidocrocite forms (Fig. 5).

The soil's rootability is good (top) to medium (bottom), it is moist, aeration is good (top) to poor (bottom). Nutrient reserves and availability are good below 50 cm depth. The topsoil is impoverished by carbonate and base (nutrient) leaching and clay migration.

3 Parabraunerde-Pseudogley under forest

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	fS: mS	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
31	OAh	0- 4	0	0	12.4	33.3	45.7	19.2	13.0	8.6	40.8	13.5	2.7	
32	SwAh	-12	0	0	12.3	32.5	44.8	20.1	13.7	8.3	42.1	13.1	2.6	44
33	Sw	-21	1.5	0	12.4	32.9	45.3	19.9	12.0	8.7	40.6	14.1	2.7	40
34	BtSd	-48	1.2	1.3	9.7	25.8	36.8	13.2	11.2	7.4	31.8	31.4	2.7	
35	Skd	-66	1.4	2.6	11.0	26.9	40.5	11.9	11.8	7.6	31.3	28.2	2.5	0.2
36	CcSd	-100	2.3	2.5	12.4	27.2	42.1	12.4	12.8	8.5	33.7	24.2	2.2	
37	CSd1	-120	2.3	2.5	10.8	28.4	41.7	11.9	13.8	8.6	34.3	24.0	2.6	2.7
38	CSd2	-155	2.4	2.4	11.1	28.9	42.4	11.8	13.4	8.6	33.8	23.4	2.6	
39	CSd3	-200	2.4	2.5	11.0	29.0	42.5	12.1	13.5	8.4	34.0	23.5	2.6	

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o: Fe_d	Mn_d mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
31	OAh	0.75	54.6	51.8	43.9	41.0	14.3	4.6	3.8	4.1	2.6	.65	268	16
32	SwAh	1.17	53.9	42.4	37.6	35.3	16.2	4.4	3.6	4.7	2.8	.60	104	4.1
33	Sw	1.52	42.0	33.0	31.3	29.5	18.0	4.3	3.5	6.2	2.8	.45	167	4.5
34	BtSd	1.55	42.5	37.5	35.5	34.9	21.5	4.3	3.5	8.6	1.5	.18	127	4.5
35	Skd	1.64	38.1	34.0	31.7	31.2	22.0	7.2	6.3	7.4	0.8	.11	310	60
36	CcSd	1.77	33.2	30.0	27.8	27.5	16.5	8.0	7.3	5.4	0.3	.06	138	86
37	CSd1	1.75	34.0	34.0	32.5	30.5	22.3	8.2	7.5	5.6	0.4	.07	122	

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg with NH_4Cl: Ca	K	Mg	Na	H	Al	V_p %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
31	OAh	4.3	2.7	16	0	175	81	46	2.4	10	1.3	6	15	34
32	SwAh	2.1	1.4	15	0	141	98	43	1.3	11	1.4	1	40	40
33	Sw	1.1	.80	14	0	159	119	55	2.6	19	2.4	2	38	52
34	BtSd	.36	.34	11	0	206	167	92	2.6	28	3.0	2	41	61
35	Skd	.18	.28	6	.67	159	154	123	3.0	22	2.3	1	3.0	97
36	CcSd				18.1	152	152	130	3.1	17	2.4	0	0	100
37	CSd1				22.4									

Economical resources and farm management

Immovable Properties: The Evershof-farm comprises an area of 633 ha with 485 ha tilled land, 90 ha forest, 23 ha natural pasture being leased off and a total of 34 ha diversive areas. There exists a manorhouse, a living and office house for the steward, two sheds for storage and repair of machines. Two big stables and one old dairy house are rather unused now due to the conversion of a mixed dairy to a management without cows 15 years ago.
Labour: The farmwork is statistically done by 1.5 labourer/100 ha. Field work is carried out by 4 persons and repair by a locksmith. Besides the manager two temporary assistance are employed for 60 days a year.
Plant production: Oilseed rape, winter wheat and winter barley grow on 92 % of the fields, the share of sugar beets is to 8 % only.
Fertilizer: Basic fertilization is carried out in autumn (40 kg/ha P, 130 kg/ha K). The costs for fertilizer amount to 380-430 DM/ha, pestizides total to 280 DM/ha. The nutrient balance for several crops is shown in table 5.

Table 5: Nutrient balances of the Siggen farm in 1985

kg/ha	Cereal			Oilseed rape			Sugar beet		
	N	P	K	N	P	K	N	P	K
Supply by:									
mineral fertilizer	+200	+50	+170	+200	+50	+160	+120	+50	+160
Removal:									
grain or root +	-200	-35	- 80	-110	-20	-100	- 90	-30	-130
difference	0	+15	+ 90	+ 90	+30	+ 60	+ 30	+20	+ 30

(**yields** (dt/ha) in 1985: rape 35, wheat 85, barley 75, sugar beets 450)

Nutritional status of soils and plants

The nutritional status of **soils**, partly derived from natural conditions and partly from fertilizer inputs, is demonstrated by soil and plant analyses of six fields represented in tables 6 and 7. The pH-value sometimes exceeds the advisable limit of 6.5 due to recent liming and eroded calcareous hilltops. With the exception of field 4 the status of available nutrients in the soils is optimal or luxurious for K.
S-supply of **plants** seems to be sufficient for growth; possibly a critical factor in future (low S-immission). There exist no problems concerning the K-supply of cereals. Mg(exch.)-concentrations in soils are sufficient (50ppm Mg) in contrast to Mg-concentrations in cereals, which are too low (rape excepted). Cl-, Fe-, Mn- and Zn-supply are a non-limiting for plant growth in contrast to B-supply of rape.

Table 6: Results of soil analysis of six Siggen fields in 1985 (average of 6 plots at each field; see fig.2)

Field	pH-value	ppm P	ppm K	ppm Mg	ppm Fe	ppm Mn	ppm Zn	ppm Cu
1	6.8	148	286	52	66	11.5	1.6	2.0
2	7.4	100	226	52	77	5.2	1.6	1.2
3	6.9	158	211	75	65	11.3	1.0	1.6
4	7.2	36	74	54	89	6.3	3.1	1.6
5	6.9	178	200	71	71	9.4	1.2	1.8
6	7.0	190	266	64	63	8.1	1.5	1.5
Optimum	6.5	100	120	50	50	10	1.5	0.5

Methods: pH: CaCl2; P and K: Double-Lactat Acc. Egner-Riehm; Mg: Exchangeable acc. Schachtschabel; Fe, Mn, Cu: DTPA-extract acc. Lindsay and Norvell

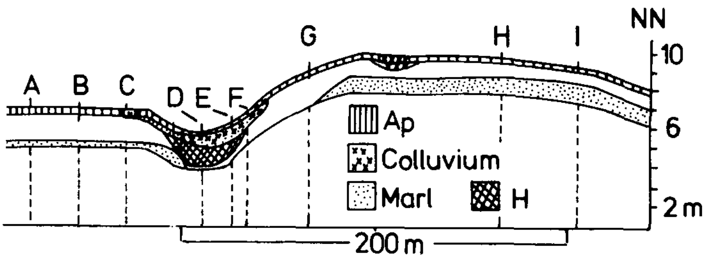
Table 7: Results of plant analysis of crops grown on Siggen 1985
(average of 6 plots at each field; see fig.2)

Field	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	Cl	B	Si
	‰						ppm				%	ppm	%
1	32	3.2	2.2	33	3.8	0.6	72	31	16	6.9	2.2	2.9	7.7
2	37	2.5	1.9	27	4.0	0.6	51	31	17	4.8	1.9	3.5	13.2
3	48	4.7	4.0	23	18.8	1.9	147	51	40	9.9	1.3	14.8	0.3
4	28	2.0	1.6	22	3.8	0.5	44	73	15	4.2	2.1	2.5	20.2
5	41	5.0	3.5	22	19.4	1.6	114	50	43	11.6	0.6	15.6	0.1
6	35	2.6	1.8	26	3.7	0.6	55	27	15	5.1	1.7	2.8	11.3
Approximate critical value													
Cereals	30	3.0	4.0	25	3.0	1.5	50	30	23	3.5	-	3.0	-
Rape	40	3.0	6.5	25	10.0	1.5	50	30	23	3.5	-	28.0	-

Sampling:
Cereals (Fields 1,2,4,6): whole plant tops at shooting stage
Oilseed rape (field 3,5): younger differenciated leaves at shooting stage

Tables 6, 7 and fig. 2 present average values of 6 plots from each field, but a noticable variability within fields of nutritional parameters often indicated by the relief is demonstrated in figure 7. Following the catena at many places fertilizing could be reduced.

Figure 7: Nutrient status of soils (0 - 30 cm) and punctual yield at a catena of Siggen soils



	A	B	C	D	E	F	G	H	I
pH-CaCl2	7.0	6.9	7.7	7.0	7.1	7.3	7.3	7.4	6.8
" 60-90cm	7.5	7.6	7.5	7.1	7.2	7.3	7.8	7.3	7.4
P (ppm)	204	150	205	228	229	275	270	360	245
K (ppm)	350	222	154	229	275	270	360	245	400
Mn (ppm)	7.2	7.9	5.1	14.6	10.5	10.7	13.1	6.4	8.0
yield(t/ha)	9.0	11.7	8.7	0.9	10.3	11.7	10.9	10.5	10.5

(methods and optimal values: see tab. 6)

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Lake Großer Plöner See

by W. Hofmann und U. Münster, MPI Plön

Covering an area of 3000 hectares, this is the largest lake in Schleswig-Holstein. Its basin is very heterogeneously composed of a number of throughs and ridges: Its eastern part consists of a row of five deep throughs with maximal depths of more than 30 m, the southernmost of these contains the lakes's greatest depth of 60 m. The lakes's surface lies 21 m above see level. According to WEGEMANN (1922), an area of 725 hectares of the lake bottom lies below sea level. In the western part depth seldom exceeds 20 m. A line of small islands and flat water divide eastern and western parts. The Schwentine river, originating in the south-east (Bungsberg) and flowing to the Kiel Fjord passes the lake.

Characteristics of Lake Großer Plöner See

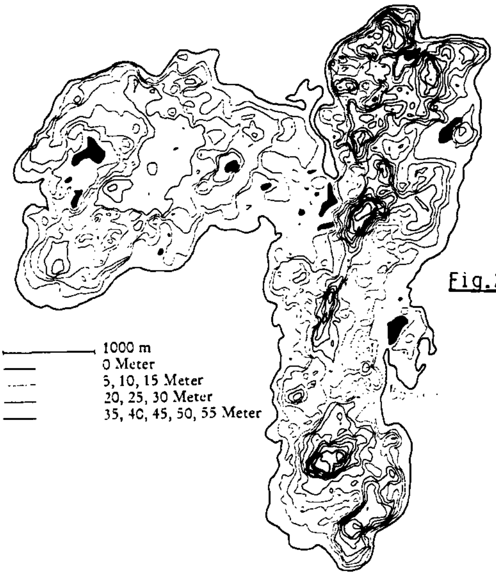
surface area	2997 ha	length of shoreline	42.5 km
maximum depth	60 m	watershed area	29300 ha
mean depth	12.5 m	retention time	18 yr
volume	0.373 km^3	primary production	209 g C/m^2 yr

The deep eastern part of the lake basin was formed by a glacier lobe, which also formed the moraines south-east and south-west of the lake. North of the lake, a ridge of moraines of a later glacier protrusion is found. At the end of the Weichselian glaciation, the lake was included in a much larger melt-water lake, the surface of which was about 15 m higher than today. This lake drained to the south, its outlet was near the southern end of the present-day lake. During the Alleröd period an outlet towards the Baltic was formed and the lake's surface was lowered to 27 m above sea level. Thawing of buried ice during commencing Holocene resulted in today's lake morphology (GRIPP 1953).

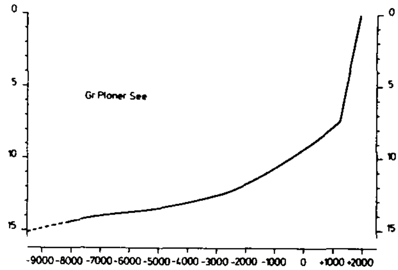
The fishes of greatest economic importance are eel (Anguilla anguilla), white-fish (Coregonus albula), and haddock (Esox lucius).

Lake Großer Plöner See is a eutrophic lake with high concentrations of plant nutrients, high algal production, oxygen depletion of the deep water during summer stagnation, and with a sediment rich in organic material (Gyttja, mud) (THIENEMANN 1920, OHLE 1953). As in many other lakes of the river Schwentine, signs of excessive nutrient contents are recorded which lie above the levels normally encountered in eutrophic lakes. They are: No nutrient depletion during summer, long-lasting blooms of blue-green algae, mass development of filamentous algae near the shore, deterioration of the reed banks. On the other hand there are also signs showing that the nutrient load is limited: There still occur vast stands of submerged macrophytes and a large population of whitefish.

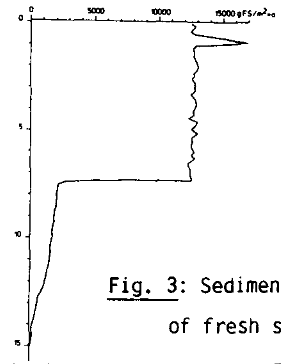
The lake does not receive sewage form the town of Plön. A central sewage treatment plant collects the wastewater of Plön and other villages situated on the eastern and western side of the lake (Ascheberg, Dersau, Bosau). The sewage is treated in a three-step process which includes the elimination of Phosphorus. The plant thus meets the high standards required for a lake district. Today's nutrient load partially derives from the past (unsufficient sewage treatment) and nutrient input with the river Schwentine.



<u>Fig.1:</u> Computed isobaths



<u>Fig.2:</u> Historic accumulation of sediments



<u>Fig. 3</u>: Sedimentation of fresh substances

The history of the lake is well documented in its sediments. A 15 m long sediment core taken in 41 m water depth revealed a continuous profile from the Late Dryas period to the present. The most striking process is the eutrophication of the lake with a corrosponding sudden increase in the sedimentation rate from 0.2 - 1.5 mm/yr up to 9.9 mm/yr during the Sub-Atlantic period. This is accompanied by a change in the benthic fauna. Insect species characterizing oligotrophic lakes were substituted by such that are characteristic of eutrophic lakes. In the plankton simmilar changes could be observed (AVERDIECK 1978, OHLE 1979, HOFMANN 1984).

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Characteristic soils of the Segeberg Forest area

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Topography, Geology, and Climate of the Segeberg Forest

With a total area of 5140 hectares, the Segeberg Forest is the second largest forest in Schleswig-Holstein. It is situated 40 km north of Hamburg and 10 km west of Segeberg on a flat residual plateau of sandy moraines and boulder sand of the late Saalean glaciation (Warthe-stage). The carbonates once contained in this material have been leached down to depths of 15 - 20 m, starting with the Eem-period. Soils have been strongly eroded since. The height of the plateau is between 40 and 50 m a.s.l., it is encompassed by Weichselian sandur plains (about 30 m a.s.l.). Erosion gullies are found on its margain. The location of the area and of selected profiles is shown in Fig. 1.

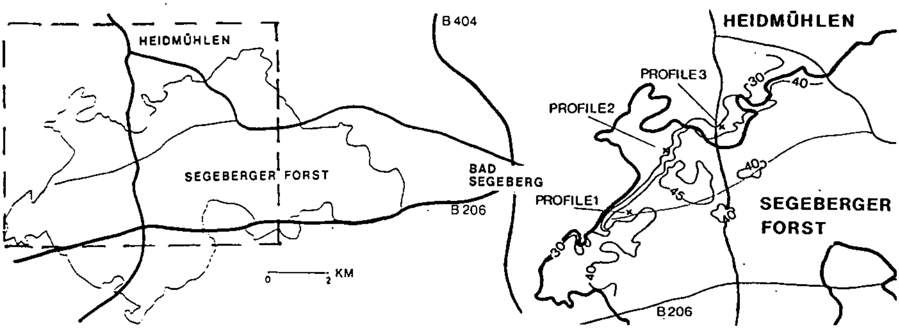

Fig. 1: Location of the Segeberg Forest area and of selected profiles

The mean annual temperature is 8.1^{o}C and precipitation 750 mm (monthly averages see Table 1). Potential and actual evapotranspirations are about 600 mm/a and 500 mm/a (SCHULZ 1977), respectively.

Table 1: Mean monthly rain fall and air temperatures of Segeberg

	J	F	M	A	M	J	J	A	S	O	N	D	Year	
Rain	60	47	51	50	51	59	85	85	64	70	56	68	747	mm
Temp.	-0.2	0.4	2.7	6.4	11.4	14.8	16.6	15.6	12.7	8.2	3.8	1.2	8.1	^{o}C

Vegetation, Soil Types and Acidification

With rising temperatures, the tundra without trees of the late Ice Age was invaded by birch and, later, pine and hazel forests. During the Atlantic period oak mixed forests dominated on the sandurs and moraines; during the Sub-Atlantic beech and hornbeam forests established on the richer soils of the moraines. Great demand for wood (glass industry, smelters, tanneries) and the disturbance of forest rejuvenation by the fattening of pigs with acorns and beechnuts. This is reflected in the distribution of forests in 1803 near the site of profile Segeberg 2. Beech is only found on the sloping margin of the plateau, the rest of the area is covered by heath and clearcuts. The area was reforested during the 19th century, mostly with pine and spruce(Fig.2a/b).

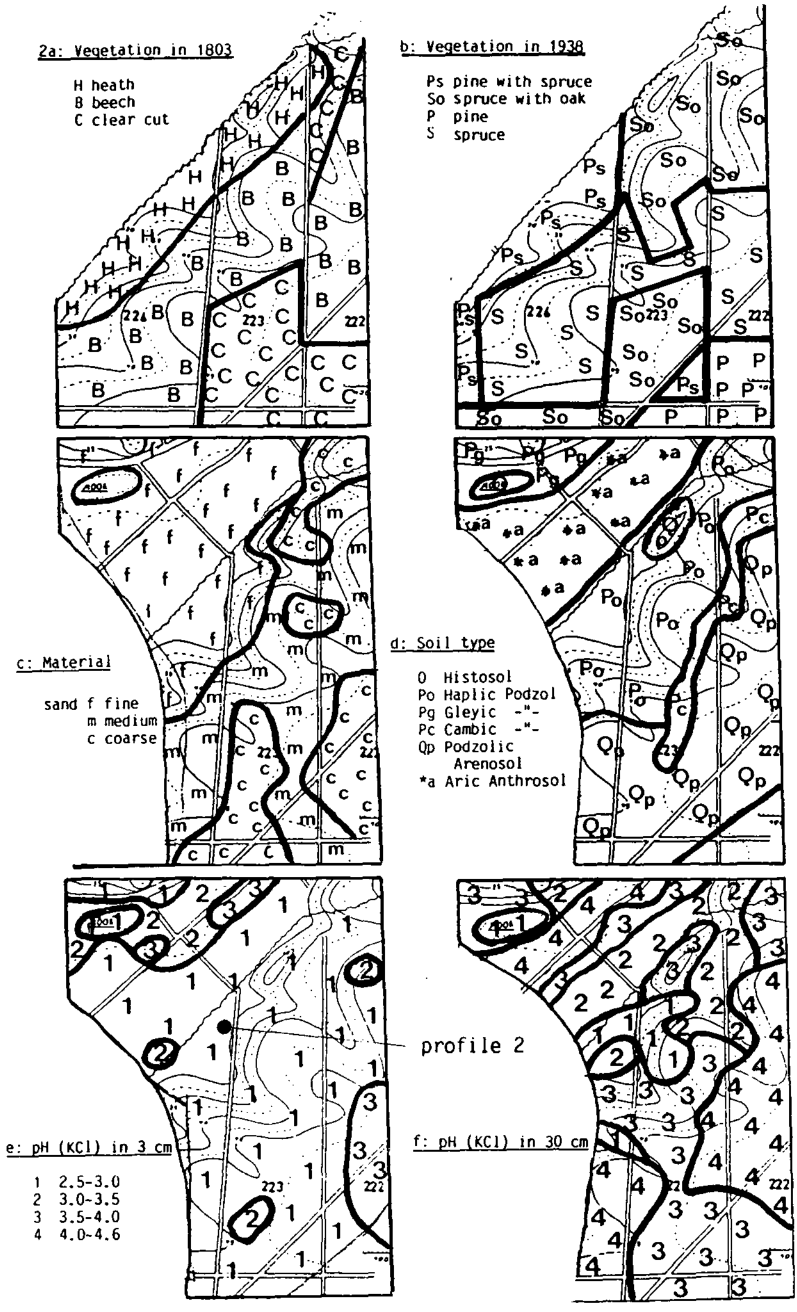

Fig. 2: Vegetation, parent material, soil type and pH-value near profile 2

The long-lasting cover of heath promoted soil acidification. On fine (pre-eluviated) sands, well developed Podzols are found, while Podzolic Arenosols to Brunic Podzols dominate on the coarse (boulder) sands (cf. Figs. 2a,c,d,f). The pH-values of the B-horizons (30 cm) reflect the influence of soil, vegetation and relief (lateral water influence). The A-horizons (3 cm depth) are strongly acidified except in the depressions (Fig. 2e).

Profile Segeberg 1

Location:	Segeberger Forest, section 218, plateau, level, 42 m a.s.l., groundwater > 2 m below soil surface
Parent material:	Saalian moraines (Warthe-stage), deeply weathered
Vegetation:	oak (Quercus robur), few pine (Pinus sylvestris)
Soil type:	Podsolierte Braunerde (Cambi-Podzolic Arenosol, Spodic Udipsamment)

Profile description

Sign.[1]	(cm)	[1] german (and FAO)
Ohf (O)	5- 0	Very dark grey to dark brown (10YR3/1-3) leaf remains partly decomposed, loose, common roots
Aeh (Ah)	- 10	black (10YR2.5/1), medium sand, very few gravel, fine crumb, common roots
AhBv (AB)	- 30	dark yellowish brown (10YR3/4), medium sand with few gravel, fine crumb to singular, friable, some roots
Bv (Bw)	- 50	strong brown (7YR4/6), medium sand with few gravel, singular, very friable, some roots
CBbv (CB)	- 95	yellowish brown (10YR5/7), coarse to medium sand with few gravel, singular, friable, thin clay/iron pans, few roots
BvC (BC1)	-140	yellow brown (10YR5-6/4-6), gravelly coarse sand above medium sand, friable, few iron/manganese concretions, few roots
BsC (BC2)	-170	brown (7YR 5/4), gravelly coarse sand above medium sand layer, singular, friable, some iron/manganese mottles and concretions
Cv (C)	-200	yellow brown (10YR 6/6), medium sand with few gravels, singular, friable, very few roots

Interpretation

The soil has developed from coarse to medium sandy Saalean moraine material which has been weathered pedogenetically and been remoulded geogenetically during the Eem and Weichselian period. This coarse parent material, although strongly acidified in the topsoil, is only weakly podzolized. This shows the dithionite-soluble iron enrichment in the subsoil. Reasons for the relativly weak podzolation are:

- presence of alkaline minerals (feldspars and others, cf. Tab. 5)
- vegetation history (oak-beech forest in prehistoric and present times, probably few heath during the Middle Age)

The soil is well aerated, available water capacity is low (130 mm). A large fraction of circulating nutrients is bound in the organic layer, nutrient release in the subsoil by weathering is low. Avaible nutrients can be efficiently used by trees of slow growth and dense root systems such as oak. Relevant amounts of nutrients are provided by deposition from air.

Tab. 2: Analytical data of profil 1 (Cambic-Podzolic Arenosol under oak)

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c+m	silt m	silt f	silt Σ	f silt +clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
01	Ohf	5-0												
02	Aeh	10	4	20	54	17.4	91	7.5				2.0	664	
03	AhBv	30	6	22	52	17.1	91	7.2				1.6	-	
04	Bv	50	34	26	55	12.2	92	5.5				2.2	505	
05	CBv1	70	12	37	53	6.0	96	2.0				1.9	-	
06	CBbv	95	12	31	59	7.2	97	1.0				1.6	-	
07	CBv2	110	54	48	41	7.2	96	1.8				1.8	-	
08	BvC	140	2	26	70	3.8	99	.3				.6	2500	
09	BsC	170	62	41	42	12.5	95	3.8				1.3	-	
10	Cv	200	6	21	74	3.9	99	.2				.6	-	

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	Fe_p mg/g	C_p %	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21			24	25	26	27	28
01	Ohf							1.24	2.39	4.1	1.5	.37	69	-
02	Aeh	1.26	50	50	21.3	9.3	4.5	2.30	1.04	5.6	2.5	.44	103	1.5
03	AhBv	1.31	50	47	18.8	8.0	3.9	1.97	1.07	6.6	2.5	.38	120	4.9
04	Bv	1.35	49	43	16.2	6.6	3.2	.42	.33	4.7	.87	.19	74	.0
05	CBv1							.12	-	3.3	.32	.10	86	.0
06	CBbv	1.44	46	32	4.1	3.0	2.5	.09	-	3.1	.34	.10	138	.0
07	CBv2							.05	-	2.6	.53	.21	155	4.9
08	BvC	1.67	37	35	12.3	7.7	3.2	.04	-	1.6	.28	.18	70	.4
09	BsC	1.60	40	32	4.1	3.0	2.5	.03	-	9.0	.84	.09	388	2.6
10	Cv	1.67	36	35	12.3	7.7	3.2	-	-	1.3	.23	.18	97	1.6

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	pH H_2O	pH $CaCl_2$	CEC p	exchang. cations in meq/kg: Ca	K	Mg	Na	H+Al	Al	V %
1	2	29	30	31	22	23	34	35	36	37	38	39	40	41
01	Ohf	27.5	12.7	22	4.0	3.0	790	69.4	8.3	19.4	3.6	682		14
02	Aeh	2.5	1.1	23	3.9	3.1	143	1.2	.20	.45	.62	141		2
03	AhBv	2.0	.85	24	4.4	3.9	93	.77	.21	.34	.60	91		2
04	Bv	.50	.30	17	4.8	4.4	38	.36	.00	.11	.29	37		2
05	CBv1	.14	.11	13	4.9	4.4	26	.31	.05	.09	.30	25		3
06	CBbv	.10	.09	11	4.9	4.3	18	.28	.04	.03	.32	17		4
07	CBv2	.06	.05	12	5.2	4.4	16	.20	.06	.03	.17	16		3
08	BvC	.02	.01	20	5.1	4.4	9.7	.29	.06	.17	.18	9		7
09	BsC	.06	.06	10	5.1	4.3	27	.71	.09	.61	.23	25		6
10	Cv	.05	.02	25	5.3	4.4	6.5	.24	.04	.08	.16	6		8

Profile Segeberg 2

Location:	Segeberger Forest, section 224, hillfoot to level, slope 1-2 % N/NW, 29 m a.s.l, groundwater 2 - 4 m below soil surface
Parent material:	Weichselian glacial sandurs
Vegetation:	spruce (Picea abies), pine (Pinus sylvestris)
Soil type:	Eisen-Humus-Podsol (Haplic Podzol, Typic Haplorthod)

Profile description

Sign.[1]	(cm)	
Ofh (O)	13- 0	dark grey to dark brown (5YR2.5/2 - 2YR2.5/0) needle remains partly decomposed, friable to firm, common roots
Aeh (Ah)	- 10	black (5YR2.5/1), bleached medium sand, very friable, fine crumb, common roots
Ahe (E)	- 20	very dark to dark grey (10YR3-4/1-2), strongly bleached medium sand, fine crumb to singular, very friable, very few roots
Bh (Bh)	- 25	black (5YR2.5/1), medium sand, fine granular to coherent, friable to firm, organs (humus pellets), common horizontal growing roots
Bhs (Bhs)	- 30	dark reddish brown (2.5YR2.5/4), medium sand, sequans and organs, fine granular to coherent, firm, few roots
CBvs (CB)	- 70	yellish brown (10YR5/6), medium sand, singular, friable, fine humus layer in 50 - 60 cm, humus pellets (10YR4/6), root tongues to 120 cm, few roots
SCv (Cgw)	-160	brownish yellow (10YR6/6), medium sand, singular, few iron mottles (5YR4/8), manganese concretions in root-tubes, friable, gravel layer at the bottom with some iron mottles (5YR5/8)
IIGC (2Cg)	-190	yellowish brown (10YR5/6), gravelly loamy fine to medium sand, firm, singular to fine polyeder, few iron mottles
GC (3Cg)	-220	dark yellowish brown (10 YR4/6), medium sand with gravel, singular, friable, few iron mottles

Interpretation

Parent material of the soil is sandur material from the Weichselian glaciation and possibly some in the Middle Age eroded medium and fine sand material of Saalian Warthe stage moraines. Strong weathering in the past and present has lowered the contents of basic minerals (cf. Tab. 5: feldspars content less than 10 %) and enhanced podzolation.

Top- and subsoil are well aerated. The underground shows some hydromorphism due to lateral subsurface water flow and high groundwater level during winter. Low water capacity of the sandy parent material is enhanced by illuviation. Root growth of the flat-rooting spruce into the subsoil is physiologically restricted. Exchangeable and plant-avaible nutrients are mainly stored in the thick organic layer, only single roots penetrate the E-horizon spreading laterally on the beginning of the Bh-horizon and get use of nutrient reserves from the subsoil. But only few nutrient reserves of deeper subsoil horizons (cf. Tab. 5) can be exhausted by the the root system of spruce. Centuries of nutrient export and soil exhaustion made this a very poor site.

Tab. 3: Analytical data of profil 2 (Haplic Podzol under spruce)

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m+f	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
04	Aeh	10	1.2	6.4	48	24	79	13.2	4.3		17.5	4.0	215	
05	Ahe	20	.2	6.0	61	27	94	2.0	1.7		3.7	2.0	226	
06	Bh	25	.2	4.2	56	33	94	.0	1.9		1.9	4.5	609	
07	Bhs	30	.0	6.8	55	30	92	3.7	2.2		5.9	2.5		
08	Bvs	70	.0	7.6	69	21	98	1.3	.3		1.6	.6	555	
09	SCv	160	.1	4.2	53	40	97	2.1	.2		2.3	1.0	519	

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	Fe_p mg/g	C_p %	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21			24	25	26	27	28
04	Aeh	.81	68	67	54	40	9.7	.49	1.31	.55	.45	.82	11	16
05	Ahe	1.54	45	38	12.5	6.3	3.1	.07	.30	.06	.04	.67	14	2.3
06	Bh	1.37	47	45	16.6	11.6	4.1	-	3.71	1.8	1.8	1	63	110
07	Bhs							1.32	1.32	9.7	6.3	.65	9.6	37
08	Bvs	1.59	40	39	7.1	2.9	1.9	.18	.12	.64	.19	.30	31	11
09	SCv	1.59	40	38	6.8	3.4	1.7	.13	.10	-	-	-	-	-

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	pH H_2O	pH $CaCl_2$	CEC p	exchang. cations in meq/kg: Ca	K	Mg	Na	H+Al	Al	V %
1	2	29	30	31	22	23	34	35	36	37	38	39	40	41
01	Ol	51	15	34	4.0	3.1	350	84.6	10.6	18.3	5.0	266		24
02	Of	50	17	29	3.8	2.9	1008	93.3	4.6	21.5	3.8	885		12
03	Oh	37	15	25	3.7	2.8	1142	83.0	4.6	17.3	4.6	1032		10
04	Aeh	13	4.6	27	3.7	2.7	298	21.9	3.0	5.3	1.5	266		11
05	Ahe	1.6	.51	36	4.0	3.1	17	2.4	.72	.51	.72	13		25
06	Bh	7.6	2.8	27	3.7	3.1	289	6.9	.18	1.0	1.5	279		3
07	Bhs	2.5	.94	27	4.4	4.0	143	1.1	.03	.25	.49	141		1
08	Bvs	.24	.16	15	4.8	4.5	267	.36	.02	.08	.27	26		3
09	SCv	.08	.05	16	5.0	4.7	14	.40	.04	.11	.33	13		6

Profile Segeberg 3

Location:	2 km south of Heidmühlen, near road to B-206, hillfoot to level, slope 1-2 % W, 31 m a.s.l., groundwater 3 - 4 m below soil surface
Parent material:	Weichselian glacial sandurs
Vegetation:	maize (1983,1984,1985), winter rye (1985/86)
Soil type:	Eisen-Humus-Podsol (Haplic Podzol, Typic Haplorthod)

Profile description

Sign.[1]	(cm)	
Ap (Ap)	0- 32	black (N2), medium sand, very few gravel, fine crumb, friable, common roots
Ahe (E)	- 38	very dark grey (10YR3/1) to grey (10YR5/1), medium sand, friable, fine crumb, few roots
Bh (Bh)	- 41	black (N2), medium sand, firm and hard consistence, granular, organs (humus pellets), few roots
Bhs (Bhs)	- 47	very dark grey (7YR2.5/2), medium sand, granular to coherent, firm, sequans and organs (iron/humus pellets), very few roots
Bvs (Bws)	- 64	yellowish brown (10YR5/6), medium sand, firm, fine granular to coherent with organs/argillans, very few roots
BvC (BC)	-127	light yellowish brown (1oYR6/4), medium sand, firm, fine granular to singular with some organic pans
IIGBv (2Bgw)	-160	brownish yellow (10YR6/6), layers of medium to fine and silty sand, firm to friable, singular, some iron mottles
IIIGCv (Bgw)	-200	light grey (2Y7/2), fine medium sand, friable, singular, few iron mottles

Interpretation

The Haplic Podzol under cultivation is very similar to that under forest (profile 2) with respect to geomorphologocal position and parent material (medium to fine sand of outwash fan).
The E-Horizon under the ploughed horizon of this site with a long history of agriculture use shows that podzolation is not only a process typical for the industrial age. Illuvation is reflected by the dithionit-soluble iron content of the subsoil. Liming stopped acidification in the whole profile but a 5 year break of lime application let pH drop in the topsoil. Water and air characteristics are similar to the Haplic Podzol under forest. The illuvial horizon increases water storage and reduces nutrient leaching compared to a Arenosol in the same field.

Tab. 4: Analytical data of profil 3 (Haplic Podzol under cultivation)

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m+f	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
01	Ap	32	.3	3.7	51	33	88	4.4	4.7		9.1	3.6	308	
02	Ahe	38	.1	2.1	50	40	92	3.6	2.6		6.2	1.6	204	
03	Bh	41	.1	2.9	51	38	92	2.7	2.2		4.9	3.3	344	
04	Bhs	47	.4	3.5	54	36	94	2.2	2.8		4.9	1.5	744	
05	Bsv	64	.3	1.9	49	44	95	2.9	1.1		3.9	1.4	812	
06	Bv	127	.1	1.8	53	41	96	2.3	.6		3.0	1.2	685	
07	IIGBv	160	.1	1.8	40	40	82	13.2	3.3		16.5	1.7	29	
08	IIIGC	200	.1	3.0	63	31	97	1.5	.3		1.8	.9	608	

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	Fe_p mg/g	C_p %	Fe_d mg/g	Fe_o mg/g	Fe_o: Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21			24	25	26	27	28
01	Ap	1.40	46	46	27.6	18.5	9.1	1.01	1.06	2.7	1.8	.68	113	115
02	Ahe	1.52	42	41	18.4	9.1	7.0	.28	.47	.48	.35	.73	5.1	46
03	Bh	1.25	51	51	30.3	20.5	14.6	.72	2.96	1.2	1.2	1	12	83
04	Bhs	1.36	48	45	13.7	7.5	7.0	1.16	.97	5.1	4.6	.90	4.0	22
05	Bsv	1.44	45	45	11.3	5.6	4.8	.08	.18	.90	.72	.79	28	5.2
06	Bv	1.54	42	41	12.0	4.9	1.9	.05	-	.24	.10	.42	39	6.8
07	IIGBv	1.74	38	38	5.9	2.0	1.5	.08	-	.44	.13	.30	56	4.9
08	IIIGC	1.64	34	34	20.3	4.1	1.4	.05	-	.36	.07	.19	57	5.8

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	pH H_2O	pH $CaCl_2$	CEC p	exchang. cations in meq/kg: Ca	K	Mg	Na	H+Al	Al	V %
1	2	29	30	31	22	23	34	35	36	37	38	39	40	41
01	Ap	3.1	1.5	19	5.5	4.6	139	45.6	1.7	2.8	1.1	88		37
02	Ahe	1.1	.46	25	5.8	4.8	69	23.9	.36	1.8	.88	42		39
03	Bh	4.0	1.5	26	5.7	4.8	226	69.4	1.1	5.9	1.1	149		34
04	Bhs	1.4	.54	27	5.7	5.0	80	10.7	.65	1.4	.41	67		25
05	Bsv	.22	.15	15	5.8	5.1	18	2.7	.18	.26	.27	15		19
06	Bv	.09	.05	18	5.8	5.1	14	1.1	.08	.11	.14	13		10
07	IIGBv	.07	.07	10	5.8	5.1	13	1.0	.23	.11	.15	12		11
08	IIIGC	.04	.03	13	5.7	5.0	19	.52	.04	.05	.08	18		4

Tab.5: Texture parameter, reserve nutrients and mineral composition(2-.06mm) of a Cambi-Podzolic Arenosol and a Haplic Podzol (Segeberg 1 and 2) (after RAHTKENS, KALK and HILLER, unpublished)

Sign.	depth(cm)	Median	Sort. coeff.	Quartz	Feldspars	Ca	Mg	K	P
				(% of sand)		(‰, boiling HCl)			
CAMBI-PODZOLIC ARENOSOL									
Ohf	5 - 0	--	--	--	--	2.29	.86	1.87	.32
Aeh	- 10	.32	1.8	80	16	.34	.30	1.34	.22
AhBv	- 30	.36	1.8	80	17	.58	.58	1.57	.18
Bv	- 50	.66	3.7	75	18	.71	.89	2.37	.13
CBv	- 70	.56	1.8	75	19	.14	.89	2.00	.09
BvC	- 95	.47	1.7	76	9	.12	.80	2.11	.09
HAPLIC PODZOL									
Ofh	11 - 0	--	--	--	--	1.20	.34	1.30	.18
Aeh	0 - 10	.21	1.5	95	4	1.09	.18	.54	.09
Ahe	- 25	.21	1.4	96	4	.05	.07	.44	.07
Bh	- 29	.21	1.4	90	9	.11	.08	.62	.46
Bhs	- 52	.23	1.4	88	10	.12	.18	.90	.58
CBv	- 95	.18	1.5	89	9	.20	.38	1.00	.20

Summary comparison of profiles

The strong degradition of the soils concerning acidification and podzolisation have two main factors of genesis and regional differentiation: Parent material and vegetation/cultivation.
The Cambi-Podzolic Arenosol (P1) developed from coarser, less sorted moraines of medium sand with higher amounts of feldspars and reserve nutrients. The Haplic Podzol (P2) derived from finer, sorted outwash sands with less amounts of feldspars and reserve nutrients (cf. Table 5).
Degradation was also enhanced by anthropogen removal of the natural vegetation and the spreading of heath in the area of profile 2 (cf. Fig. 2a). Nutrients that leached into greater depth cannot be taken up by the flat rooting calluna, the same applies to spruce, which was planted here later. This vegetation produces very poor litter , which slowly decomposes yielding a number of organic ligands, enhancing the podzolation process.
The organic cover and the illuvated horizons Bh/Bhs are important nutrient and water reservoirs in this poor substrate. The Podzoles (both under forest and cultivation) therefore have higher storage and buffer capacities for both, rainfall and chemical substances, than the acid Arenosols.

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Marshland Soils of Nordfriesland

by G.W. Brümmer* and H. Finnern**

The marshland region of Nordfriesland has mainly been formed after the great storm tide of 1362 (Grote Mandränke). Numerous villages and settlements of this area were destroyed then, and the existing marshland was transformed into tidal flats stretching to the "Geest" in the east. The medieval cultured land was covered by sand and mud. New marshland formed, starting at the Geest margin, progressively to the west. 1468 the Südermarsch (profile 4, south of Husum next to the Geest) and 1563/65 the Obbenskoog (profile 3, south-east of Husum) were diked.

Another great storm tide in 1634 strongly reshaped the landscape of Nordfriesland. 9000 people drowned in this region then. Wide areas of marshland, expecially in the region of todays North Frisian Islands, were destroyed (Old Nordstrand). After 1634 until today, new land has been reclaimed. The Finkhaushalligkoog (profile 2) was diked in 1935/36, another Wadden area there in 1966/67. The dam connecting the island of Nordstrand with the mainland was built in 1935 (profile 1). Since that time, on both sides of the dam new wadden flats and Salzmarsch soils have formed supported by reclaimation measures. North of the dam these areas are being diked now.

The types of marshland soils of the excursion area are shown on the enclosed soil map. Fig. 1 shows a schematic cross-section through this region.

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Those ditches and **wadden** flats not yet covered by higher plants (south of the Nordstrander Damm, profile 1a) are subject to the processes of sedimentation and reduction (especially of sulphate with the accumulation of sulphide). The elevated areas between the ditches, covered by halophytes (profiles 1b, c) are already aerated and oxidized in the uppermost horizons, also structure formation starts.

The more elevated **Salzmarsch** areas north of the dam (profile 1d, 1.2 m a.s.l.) are only flooded during storm tides. The processes of aeration and oxidation of reduced compounds of sulphur, iron, and manganese, drainage, structure formation, and the commencing leaching of salt and carbonates are the predominant soil-forming processes, summarized as **maturation.**

In the Finkhaushalligkoog (diked 1935/36, profile 2, 1.3 m a.s.l.) the processes of maturation have completed. After drainage, salt leaching, structure formation, and Ca-saturation of the exchange complex, **Kalkmarsch** soils have formed. These are among the most fertile soils of Schleswig-Holstein. In good years, peak yields of more than 100 dt of wheat are reached. Ongoing carbonate leaching enhances processes of **degradation** (silicate weathering, clay migration, structure deterioration, compaction, acidification).

Kleimarsch soils in the Obbenskoog (diked 1563/65, profile 3) are already carbonate-free down to 50 cm. The top horizons were subject to silicate weathering and 'browning'. Drainage of this area by pumping stations is necessary, since it lies deeper (0.9 m a.s.l.) than the seaward Kalkmarsch area (1.2 to 1.5 m a.s.l.). Bad drainage was the reason for land use as permanent grassland until recently.

The Kleimarsch and especially the **Knickmarsch** soils of the Südermarsch (diked 1468, profile 4, $\pm$ 9 m a.s.l.) are also mainly used as grassland due to bad drainage. Improvement of drainage has recently led to a more favourable water regime. The profile is composed of a sheet of clay-rich sediments overlying fen peat of several meters thickness. Soil physical properties of Knickmarsch soils drive from their high clay content, especially of the "Knick"-horizon. Its higher clay content is due mainly to sedimentation, partly secondary clay illuviation has taken place. This horizons constitutes a drainage barrier, it causes unfavourable air and water regimes. The soils are difficult to plough, another reason for the predominance of grassland.

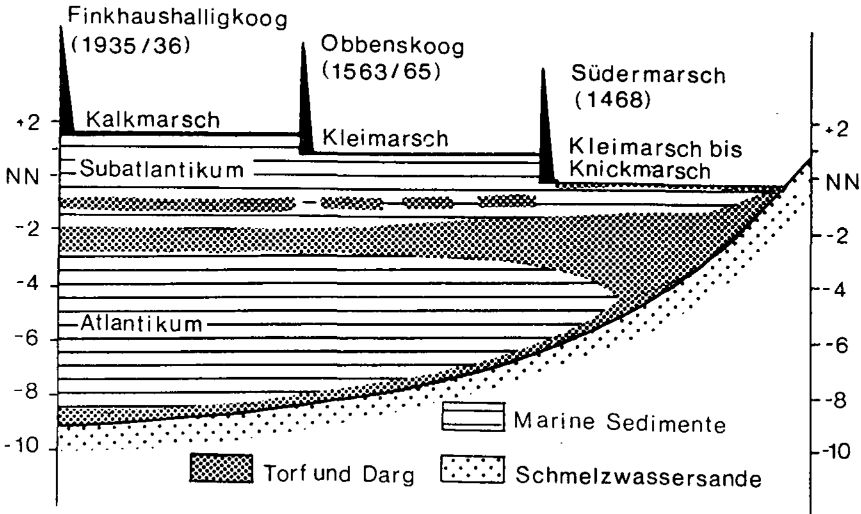

Fig. L1: Schematic cross section of the excursion area (after data of S. Bressau)

Excursion L, route description

Start at Hamburg, following the Autobahn to the north, which passes through the "Geest" landscape. It is composed of wide flat sandur plains - outwash sand deposits of the Weichselian (Low Geest) - and Saalean "old" moraines (High Geest). The low-lying sandurs (partly below sea level) are covered by gleyic Podzols and podzolic Gleysols, predominant land use is pastures. In the old moraine landscape podzolic Luvisols and acid Cambisols have developed on sediments richer in clay, sandy sediments (boulder sand, aeolian sand) are covered by (dry) Podzols here.

Ca. 30 km north of Hamburg **Bad Brahmstedt** is passed (9000 inhabitants, watering place with moor baths), 20 km further north the industrial town of **Neumünster** (founded 1100, 75000 inhabitants).

North of Neumünster, the Autobahn follows the border between "Geest" and the Weichselian terminal moraines of the **"Eastern Hills"**.

Near Rendsburg crossing of the **Kiel Canal** which connects Baltic Sea (at Kiel) and North Sea (at Brunsbüttel on the mouth of River Elbe). It was built during 1777 - 1784 and 1887-1895; ca. 60000 passages per year.

Rendsburg (40000 inhabitants) founded 1199 as a fortified city with castle where an old trackway crossed the River Eider. Today still an important traffic center.

North of the Kiel Canal the Hüttener Berge (to the east) are passed, terminal moraines of the Weichselian. At Schuby (west of Schleswig) the Autobahn is left, passage through the Geest to the marshland of the North Sea coast.

Schleswig (32000 inhabitants), on the Schlei Fjord, founded after the destruction of Haithabu, a wiking settlement, in the 12th century.

Near **Schuby**, a small former village, transition of "Eastern Hills" and "Geest".

Passage through the "Geest" with river lowlands (River Trave), sandur plains, and flat old moraines. The latter mostly with old farmer villages

(Silberstedt, Treia, Oster- and Wester-Olerstedt, Schwesing with church in roman style of ca. 1200).

Husum (24000 inhabitants), founded on the Geest's margin in 1252. Today cultural centre of Nordfriesland, many distinguished buildings of the 14th - 17th centuries. Famous persons from Husum: J. Brüggemann (woodcarver, 1640), C. Dankwerth and J. Mejer (cartographers, Dankwerth's Atlas of 1650), Th. Storm (poet, 1817-1888).

Stop 1: Wadden flats and Salzmarsch on the Nordstrander Damm (north-west of Husum). The dam connects the island of Nordstrand with the mainland, constructed 1935. Diking of the Nordstrand Bight: 1986/87.

Stop 2: Kalkmarsch of the Finkhaushalligkoog (south west of Husum), diked 1935/36.

Stop 3: Kleimarsch of the Obbenskoog (south west of Husum), diked 1563/65.

Stop 4: Knickmarsch of the Südermarsch (south of Husum), diked 1468.

Passage back along the Geest's margin against the marshland, through fens and Moormarsch of the lowland of River Eider. Crossing of the Eider at Friedrichstadt (5000 inhabitants, founded 1621, settlers from the Netherlands).

Old beach ridges and cheniers of the former constructive coastline are passed (Lundener Nehrung), partly covered by dunes (= Donn cf. St. Michaelisdonn, Norderdonn etc.), also sandurs (Saalean, near Heide) and flat moraines (near Meldorf).
The town of **Heide** (= heath) was founded at the end of the 15th century on the border of the marshland in a heath landscape of the Dithmarscher Geest. It has a great market square and is now the centre of Dithmarschen.

Meldorf (8000 inhabitants) former centre of Dithmarschen, situated on a flat old moraine. First parish in Schleswig-Holstein in the 8th century.

After the crossing of the **Kiel Canal**, **Itzehoe** (35000 inhabitants) is passed, one of the oldest towns in Schleswig-Holstein, founded in 810 by Charlesmagne on the Geest/marshland border. In Lägersdorf nearby createaceous chalk and Tertiary clays provide the basis of cement industry.

Back to Hamburg through moor lowlands, sandur and old moraines of the Geest.

Chemical Methods of Soil Analysis

Carbonates:	a) Gas volumetric determination of total CO_2 after HCl treatment. b) Destruction of calcite by stirring a ground soil sample with Na_2EDTA (pH 4.5) for 30 min. and determination of dolomite-CO_2. c) Total CO_2 minus dolomite-CO_2 gives calcite-CO_2.
Salts:	Electrical conductivity of saturation extract in mS. Sum of Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, NO_3^- and SO_4^{2-} in saturation extract in g/l. For some samples only chloride determination in 1:5 soil:water extract and calculation of NaCl in g/kg soil.
Redox potential:	Measurement in fresh soil material with or without additions of de-aerated destilled water.
FeII %:	Extraction of the fresh soil sample with 0.5 m HCl (1:5) by vigorous stirring for 5 min., colorimetric determination (o-phenanthroline) of the extracted Fe^{2+} and Fe^{3+}. $\text{FeII \%} = \frac{\text{FeII} \cdot 100}{\text{FeII} + \text{FeIII}}$
S^{2-}:	Monosulphides and instable Polysulphides; determined as H_2S after HCl dissolution.
Fe_d, Mn_d =	dithionite-citrate-bicarbonate extractable Fe and Mn.
Fe_o, Al_o =	oxalate extractable Fe and Al.
CECp =	potential CEC, determined by Sr^{2+} adsorption at pH 8.1.

Nordfriesland 1a, b, c: Schlick (1a), initial stages of Salzmarsch (1b,c)

No	hor.	depth cm	text. in % humus/carb. free soil: sand f	silt c	silt m	silt f		clay	carbonates %: calc.	dol.		EC mS	NaCl g/l	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1a	Gr	1-5	0.1	16.0	39.7	16.6	72.3	27.6	5.7	1.5	7.2		52.0	0.6
1b	AhGro	2-6	0.2	17.3	38.2	15.9	71.4	28.4	4.6	1.4	6.0	85.5	42.0	0.2
1c	AhGo	2-6	0.1	21.3	28.4	22.4	72.1	27.8	3.2	1.5	4.7	41.7	24.7	0.5

No	bulk dens g/cm^3	GPV %	water content at pF(%) 1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	redox E_h mV	FeII %	S^{2-} mg/kg	Fe_d mg/g	Fe_o mg/g	$\frac{Fe_o}{Fe_d}$	Mn_d mg/kg
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1a	0.40	83.3	57.4	51.9	15.4	7.3	7.3	-120	100	2380	12.5	11.9	0.95	673
1b	0.63	75.2	68.4	66.1	44.9	7.4	7.4	+200	20	-	13.1	12.0	0.92	859
1c	0.94	62.7	59.7	57.2	38.6	7.5	7.5	+300	7	-	12.0	11.4	0.95	591

No	Corg %	N_t mg/g	C/N	S_t mg/kg	P lact mg/kg	CEC P	sol. + exch. cations meq/kg: Ca	Mg	K	Na	H+Al	Ca/Mg	V %	Al mg/g
1	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1a	3.5	3.4	10.3	8220	65	349	200	250	53	869	0	0.8	100	0.6
1b	3.1	3.1	10.0	3760	52	289	175	177	45	720	0	1.0	100	0.6
1c	3.3	3.2	10.2	3510	55	296	137	91	26	345	0	1.5	100	0.5

Marsh Soils of Northfrisia

Nordfriesland 1 d, Salzmarsch

Location:	Salt marsh area north of Nordstrander Damm (1935), northwest of Husum.
Parent material:	Marine sediments
Vegetation:	Salt marsh vegetation, mainly Pucinellia maritima.
Soil type:	Typische Salzmarsch (Gleyo-Saltic Fluvisol, Halaquent).
Site qualities:	Storm floods and salt content of the soils limit agricultural use, sheep grazing.

Profile description: Typische Salzmarsch

zAhl (Azhl)	0- 5 cm:	very dark grayish brown (2.5 Y 3/2), few thin storm flood layers, silt loam, crumb to fine subangular, many roots.
zAh2 (Azh2)	5- 28 cm:	dark grayish brown (2.5 Y 4/2), thin storm flood layers, silt loam, crumb to fine subangular, some mottles/concr., some roots.
zAGo (Ahzg)	28- 50 cm:	dark grayish brown (2.5 Y 4/2), some storm flood layers, silt loam, crumb to subangular, few mottles/concr.
zGol (Czgl)	50- 63 cm:	gray to light brown gray matrix (2.5 Y 5/0-6/2), medium to high content of mottles/concr. of strong brown (7.5 YR 5/6) to reddish yellow (7.5 YR 6/8) colour, silt loam, subangular to angular.
zGo2 (Czg2)	63- 75 cm:	gray matrix (2.5 Y 5/0), high amount of mottles/concr., very dark brown Mn-conretions (10 YR 2/2), silt loam, subangular to angular.
zGro (Czrg)	75- 90 cm:	gray matrix (N5), iron oxide accumulation in crevices of reddish yellow (7.5 YR 6/8) to yellowish red (5 YR 4/6) colour, silt loam.
zGrl (Czrl)	90-110 cm:	dark greenish gray (5 GY 4/1), very few sulphides, silty clay loam, structureless.
zGr2 (Czr2)	110-130 cm:	black (2.5 Y/2.0), many sulphides, silt loam, structureless.

Nordfriesland 1d: Salzmarsch

No	hor.	depth cm	text.in % humus/carb. free soil sand f	silt c	m	f		clay	carbonates % calc.	dol.		EC mS	NaCl g/l	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.1	zAh1	0- 5	12.6	40.0	16.7	10.5	67.2	20.2	3.0	1.3	4.3	25.2	7.5	-
1.2	zAh2	- 28	11.7	37.8	18.1	11.9	67.7	20.6	1.8	1.3	3.1	28.1	8.4	0.4
1.3	zAhGo	- 50	2.9	32.3	27.7	13.9	73.9	23.2	1.6	1.3	2.9	37.5	11.0	0.4
1.4	zGo1	- 63	21.3	38.7	15.2	8.1	62.0	16.7	2.1	1.3	3.4	31.2	7.8	-
1.5	zGo2	- 75	18.2	33.8	19.6	10.4	63.8	18.0	2.1	1.5	3.6	35.9	10.3	-
1.6	zGro	- 90	3.4	24.1	32.7	15.5	72.3	24.3	2.2	1.3	3.5	46.2	18.9	0.4
1.7	zGr1	-110	3.7	24.1	22.8	14.5	61.4	34.9	3.6	1.5	5.1	53.3	21.5	-
1.8	zGr2	-130	9.0	28.5	24.8	12.5	65.8	25.2	5.6	1.3	6.9	68.4	27.0	-

No	bulk dens g/cm^3	GPV %	water content at pF(%) 1.8	2.5	4.2	pH H_2O	$CaCl_2$	redox E_h mV	FeII %	S^{2-} mg/kg	Fe_d mg/g	Fe_o	$\frac{Fe_o}{Fe_d}$	Mn_d mg/kg
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1.1	-	-				7.7	7.5	+370	5	-	10.7	7.2	0.67	618
1.2	1.14	57.3	49.0	46.0	38.1	7.7	7.6	+410	4	-	11.4	7.2	0.63	848
1.3	1.00	61.1	53.5	50.3	38.6	7.6	7.4	+410	4	-	13.4	8.7	0.65	981
1.4	-	-	-	-	-	7.7	7.6	+415	4	-	9.7	5.6	0.58	740
1.5	-	-	-	-	-	7.8	7.7	+370	3	-	10.6	6.4	0.60	2011
1.6	0.92	65.4	59.8	57.1	45.7	7.7	7.6	+125	53	-	33.0	27.6	0.84	483
1.7	0.80	71.1	64.8	63.6	32.8	7.6	7.6	+ 10	99	182	6.8	3.0	0.44	107
1.8	-	-	-	-	-	7.6	7.5	-130	100	2280	9.6	6.7	0.70	340

No	Corg %	N_t mg/g	C/N	S_t mg/kg	P lact	CEC P	sol. + exch. cations meq/kg Ca	Mg	K	Na	H+Al	Ca/ Mg	V %	Al mg/g
1	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1.1	2.7	2.9	9.3	3190	55	195	99	67	14	142	0	1.5	100	0.5
1.2	2.2	2.2	10.0	2580	44	194	101	71	14	156	0	1.4	100	0.5
1.3	2.1	2.2	9.5	1760	33	243	108	90	20	243	0	1.2	100	0.6
1.4	0.9	1.2	7.5	1040	26		64	43	11	140	0	1.5	100	0.4
1.5	0.9	1.2	7.5	1140	33	159	88	52	15	172	0	1.7	100	0.4
1.6	2.1	1.9	11.1	1420	76	214	97	82	28	321	0	1.2	100	0.5
1.7	1.9	1.6	11.9	1960	33	336	163	111	32	466	0	1.5	100	0.5
1.8	2.4	2.0	12.0	5350	11	192	111	55	23	192	0	2.0	100	0.5

Marsh Soils of Northfrisia

Nordfriesland 2, Kalkmarsch, Finkhaushalligkoog, diked 1935/36

Location:	Finkhaushalligkoog (507 ha), southwest of Husum, close to the north sea coast, 1.3 m a.s.l., groundwater 1.00 - 1.50 m below surface.
Parent material:	Marine sediments.
Vegetation:	Pasture, sheep grazing (H. Assmussen).
Soil type:	Typische Kalkmarsch (Gleyo-Calcaric Fluvisol, calcareous Fluvaquent).
Site qualities:	Deep root zone, good supply of nutrients, very fertile soil.

Profile description: Typische Kalkmarsch

Ah	(Ah)	0- 5 cm:	dark grayish brown (2.5 Y 4/2), silt loam, crumb, many roots.
Ap	(Ap)	5- 20 cm:	grayish brown (2.5 Y 4-5/2), silt loam, crumb to fine subangular, roots, few mottles/concr.
GoAh	(Agh)	20- 31 cm:	grayish brown (2.5 Y 4-5/2), silt loam, crumb to fine angular, roots, few mottles/concr.
(Ah)Go1	(AhCg1)	31- 46 cm:	light brownish gray (2.5 Y 6/2) fine sand layers and grayish brown (2.5 Y 4-5/2) silt layers, medium to high content of mottles/concr. (7.5 YR 4/4-5/8), silt loam, fine angular.
Go2	(Cg2)	46- 71 cm:	storm flood layers of fine sand (2.5 Y 6/2) and silty clay (2.5 Y 5/2), high amount of mottles/concr. (7.5 YR 4/4-5/8), silt loam, fine angular.
SwGo3	(Cg3)	71- 73 cm:	light olive gray (5 Y 6/2) layer of fine sand and silt, sandy silt, single-grain.
SwGo3	(Cg3)	73- 91 cm:	layers of fine sand (5 Y 6/2) and silty clay (5 Y 5/1), some parts with very high amount of mottles/concr., silt loam, fine angular to single-grain.
SdGo3	(Cg3)	91- 95 cm:	layer of higher clay content (5 Y 5/1-2), silt loam, structureless, few mottles/concr.
Go4	(Cg4)	95-102 cm:	layer of higher silt content (5 Y 6/1), few mottles/concr., sandy silt, single-grain.
Go5	(Cg5)	102-119 cm:	grayish brown matrix (2.5 Y 5/2), medium content of mottles/concr. (7.5 YR 5/6-8), diffuse iron oxide accumulations, sandy silt, single-grain to fine angular.
Gro	(Crg)	119-140 cm:	olive gray to olive (5 Y 5/2-3), loamy silt, single-grain to fine angular, medium amount of mottles/concr. (7.5 YR 4/4-5/6), sulphides around decaying roots.
G(o)r	(C(g)r)	140-155 cm:	gray (N5), few sulphides, iron oxides accumulations in creavices, loamy silt, structureless.
Gr	(Cr)	, :	dark gray (N4), few sulphides, loamy silt, structureless.

Nordfriesland 2: Kalkmarsch

No	hor.	depth cm	text. in % humus/carb. free soil: sand f	silt c	silt m	silt f	silt Σ	clay	carbonates %: calc.	dol.	Σ	salts mS	salts g/l	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2.1	Ah	0- 5	13.9	55.5	11.0	6.9	73.4	12.7	0.6	1.2	1.8	1.33	0.43	-
2.2	Ap	- 20	10.3	54.2	9.5	4.6	68.3	21.4	1.0	1.2	2.2	3.05	1.74	13
2.3	GoAh	- 31	13.0	53.2	11.7	7.0	71.9	15.1	0.9	1.5	2.4	2.49	1.34	-
2.4	(Ah)Go1	- 46	10.9	51.5	11.6	4.2	67.3	21.8	1.6	1.5	3.1	1.26	0.61	24
2.5	Go2	- 71	9.0	54.3	10.3	5.5	70.1	20.9	2.6	1.5	4.1	1.63	0.73	46
2.6	SwGo3	- 73	37.6	50.2	2.7	2.1	55.0	7.4	2.1	1.2	3.3	1.71	0.72	-
2.7	SwGo3	- 91	19.7	47.0	12.9	2.3	62.2	18.1	3.0	1.5	4.5	2.61	1.33	34
2.8	SdGo3	- 95	12.3	50.5	9.3	4.4	64.2	23.5	2.9	1.6	4.5	4.07	2.00	26
2.9	Go4	-102	32.4	52.0	3.7	2.6	58.3	9.3	3.1	1.5	4.6	3.70	1.80	-
2.10	Go5	-119	22.8	63.3	3.7	3.7	70.7	6.5	2.8	1.4	4.2	5.19	2.83	-
2.11	Gro	-140	34.2	47.1	5.1	2.8	55.0	10.8	2.7	1.3	4.0	8.63	5.34	-
2.12	G(o)r	-155	28.8	51.0	6.5	2.6	60.1	11.1	3.3	1.4	4.7	11.54	7.26	-
2.13	Gr	-175	31.3	49.9	5.5	3.2	58.6	10.1	3.4	1.4	4.8	10.44	6.10	-

No	bulk dens g/cm³	GPV %	water content at pF(%) 1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	redox E_h mV	FeII %	S^{2-} mg/kg	Fe_d mg/g	Fe_o mg/g	$\frac{Fe_o}{Fe_d}$	Mn_d mg/kg
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29
2.1	-	-	-	-	-	6.8	6.7	+410	14	-	5.0	3.0	0.60	237
2.2	1.45	46.2	37.3	33.7	21.5	6.9	6.8	+470	18	-	4.8	3.0	0.63	240
2.3	-	-	-	-	-	7.0	6.8	+440	11	-	4.7	3.3	0.70	197
2.4	1.44	47.4	36.7	32.9	18.5	7.3	7.2	+470	12	-	5.1	3.5	0.69	91
2.5	1.34	52.1	39.3	35.5	26.0	7.8	7.4	+450	11	-	6.5	4.7	0.72	164
2.6	-	-	-	-	-	8.0	7.6	+400	13	-	2.7	1.6	0.59	52
2.7	1.40	48.5	39.2	35.5	13.8	8.0	7.5	+450	11	-	5.3	3.8	0.72	120
2.8	1.33	52.2	46.3	43.1	16.7	8.0	7.5	+430	19	-	3.2	1.2	0.38	82
2.9	-	-	-	-	-	8.1	7.7	+385	26	-	1.8	0.7	0.39	53
2.10	1.56	44.7	40.2	36.7	6.6	8.1	7.8	+490	18	-	2.2	1.5	0.68	74
2.11	-	-	-	-	-	7.8	7.8	+295	39	-	3.2	2.2	0.69	66
2.12	-	-	-	-	-	7.9	7.8	+153	94	4	3.0	2.3	0.77	87
2.13	-	-	-	-	-	7.9	7.7	+ 54	99	105	1.7	1.1	0.65	87

No	Corg %	N_t mg/g	C/N	S_t mg/kg	P lact mg/kg	CEC P	sol. + exch. cations meq/kg Ca	Mg	K	Na	H+Al	Ca/Mg	V %	Al_o mg/g
1	30	31	32	33	34	35	36	37	38	39	40	41	42	43
2.1	3.0	2.6	11.5	480	120	201	133	18	13	2	35	7.4	83	0.2
2.2	1.7	1.7	10.0	446	109	191	153	14	10	1	13	10.9	93	0.2
2.3	1.5	1.4	10.7	345	98	157	120	15	9	2	11	8.0	93	0.2
2.4	0.9	0.9	10.0	317	50	111	88	13	9	1	0	6.8	100	0.2
2.5	0.7	0.7	10.0	312	33	121	90	18	10	3	0	5.0	100	0.2
2.6	0.4	0.3	-	275	17	45	25	11	4	5	0	2.3	100	0.1
2.7	0.6	0.6	-	312	31	98	61	21	10	6	0	2.9	100	0.1
2.8	0.7	0.8	-	328	26	91	47	19	8	17	0	2.5	100	0.2
2.9	0.5	0.4	-	373	13	47	20	11	6	10	0	1.8	100	0.1
2.10	0.5	0.3	-	379	11	32	10	7	4	11	0	1.4	100	0.1
2.11	0.6	0.5	-	1680	9	63	23	10	6	24	0	2.3	100	0.1
2.12	0.6	0.6	-	1420	9	55	11	9	8	27	0	1.2	100	0.1
2.13	1.0	0.5	-	2670	13	70	70	15	11	50	0	4.7	100	0.1

Finkhaushalligkoog, Kreis Nordfriesland (Schleswig-Holstein)

Diked 1935/36, area: 507 ha, soil fertility indices lS 1 Al 67/67, sL 1 Al 82/79, L 2 Al 86/84, 1.2 - 1.5 m a.s.l., depth to groundwater 1.00 to 1.30 m. Topsoil contains carbonate. Mean annual temperature: 7.9^{0} C, mean annual precipitation: 800 mm.

Farm Harro Asmussen (1985)

1. Size:

total	: 85 ha	43 freehold
arable land	: 83.5 ha	42 ha leased (leasing rate 900 DM/ha)
farmyard	: 1.5 ha	soil fertility index: 42 - 76

2. Cultures:

		Ø yield
winter wheat	: 48.5 ha	75 - 85 dt/ha
winter rape	: 17 ha	35 - 40 dt/ha
winter barley	: 18 ha	70 - 75 dt/ha

3. Live stock: 700 pigs

4. Machinery:
   - 2 tractors, 125 and 49 PS
   - 1 seed drill combination
   - 1 strwa baler
   - 1 sprayer
   - 1 combine harester (360 cm/100 PS)
   - 1 fertilizer distributor
   - 1 turnover plough, 4 share
   - 1 coulter harrow (3 m)

5. Labour: farmer, mutual help of neighbourss

6. Fertilization: Soils contain carbonate, pH 7 - 7.6

Fertilizer amounts by crops: kg/ha

	N	P_2O_5	K_2O
winter wheat	180 - 210	105	105
winter rape	200	120	185
winter barley	150	105	105

25 ha wheat: 40 m^3 semi-liquid manure from pigs + 120 kg N

7. Costs of plant protection: 540 DM/ha (1985)

8. Fertilizer costs : 650 DM/ha (1985)

Marsh Soils of Northfrisia

Nordfriesland 3, Kleimarsch, Obbenskoog, diked 1563/65

Location:	Obbenskoog (460 ha), southwest of Husum, +0.9 m a.s.l., groundwater 100-120 m below surface.
Parent material:	Marine sediments.
Vegetation:	Pasture (Andresen).
Soil type:	Typische (Nasse) Kleimarsch (Gleyo-Eutric Fluvisol, Fluvaquent or Fluventic Haplaquept).
Site qualities:	Imperfectly drained waterlogged in periods of heavy rainfall.

Profile description: Typische (Nasse) Kleimarsch

Ah	(Ah)	0- 7 cm:	dark brown to dark grayish brown (10 YR 3/3-4/2), silt loam, crumb to fine angular, many roots.
GoAh	(Agh)	7- 12 cm:	dark grayish brown (10 YR 4/2), silt loam, crumb to fine angular, mottles/concr., many roots.
GoAh	(Agh)	12- 25 cm:	grayish brown to brown (10 YR 4/2-3), silt loam, fine subangular to fine angular, few mottles/concr., roots.
(Ah)Go	(AhBg)	25- 40 cm:	grayish brown (2.5 Y 4-5/2), silt loam, crumb to angular, few mottles/concr., argillans?, roots.
Gol	(Bgl)	40- 54 cm:	grayish brown (2.5 Y 5/2), silt loam, crumb to angular, few mottles/concr., roots.
Go2	(Cgl)	54- 67 cm:	light olive brown (2.5 Y 5/4), some spots with reducing conditions (5 Y 5/2), some mottles/concr. (7.5 YR 5/6), calcareous, silt loam, subangular to angular, some roots.
Go3	(Cg2)	67- 82 cm:	olive gray matrix (5 Y 5/2-6/2), many mottles/concr. (7.5 YR 4/6), silty sand, subangular to angular, calcareous, layers of shells.
Go4	(Cg3)	82-101 cm:	olive gray matrix (5 Y 5/2-6/2), many mottles/concr. (7.5 YR 4/6), silt loam, subangular to angular, calcareous.
HGro	(Crg)	101-120 cm:	dark gray (5 Y 4/1) humus rich material, silty clay, structureless, in some parts iron oxide accumulations (7.5 YR 3/4).

Nordfriesland 3: Kleimarsch

No	hor.	depth cm	text.in % humus/carb. free sand f	silt c	m	f		soil clay	carbonates % calc.	dol.		salts mS	g/l	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3.1	Ah	0- 7	24.3	41.1	9.5	4.2	54.8	20.9	-	-	-	1.03	0.35	-
3.2	GoAh	- 12	30.2	37.5	9.3	3.3	50.1	19.7	-	-	-	0.83	0.35	-
3.3	GoAh	- 25	27.6	38.1	9.7	6.4	54.2	18.2	-	-	-	0.54	0.28	0.3
3.4	(Ah)Go	- 40	20.6	43.2	10.0	5.7	58.9	20.5	-	-	-	-	0.35	0.4
3.5	Go1	- 54	23.0	41.6	11.2	4.3	57.1	19.9	-	-	-	0.72	0.23	-
3.6	Go2	- 67	33.1	37.3	9.0	2.5	48.8	18.1	-	-	3.3	0.87	0.31	0.5
3.7	Go3	- 82	59.8	25.1	4.8	1.7	31.6	8.6	-	-	2.2	0.83	0.30	-
3.8	Go4	-101	29.2	43.5	8.2	3.9	55.6	15.2	-	-	2.2	1.52	0.65	0.3
3.9	Gro	-120	0.9	12.4	6.6	22.8	41.8	57.3	-	-	-	20.42	11.03	

No	bulk dens g/cm^3	GPV %	water content at pF(%) 1.8	2.5	4.2	pH H_2O	$CaCl_2$	redox E_h mV	FeII %	S^{2-} mg/kg	Fe_d	Fe_o mg/g	$\frac{Fe_o}{Fe_d}$	Mn_d mg/kg
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29
3.1	-	-	-	-	-	5.1	5.0	+600	7	-	4.6	3.6	0.78	330
3.2	-	-	-	-	-	5.2	5.0	+600	7	-	5.0	4.1	0.82	404
3.3	1.57	41.9	36.8	33.4	18.7	5.5	5.3	+630	8	-	4.6	2.7	0.59	317
3.4	1.62	40.8	35.4	32.1	17.2	6.0	5.7	+610	6	-	4.6	2.4	0.52	234
3.5	-	-	-	-	-	6.9	6.6	+545	5	-	4.6	2.3	0.50	224
3.6	1.58	42.7	34.6	31.0	14.4	7.7	7.5	+550	5	-	4.1	2.5	0.61	148
3.7	1.56	44.6	36.4	31.2	7.5	7.9	7.6	+530	5	-	3.4	2.1	0.62	130
3.8	1.49	46.4	41.7	37.7	14.4	8.0	7.6	+485	7	-	4.5	2.8	0.62	169
3.9	-	-	-	-	-	7.0	6.7	+345	20	-	16.2	8.7	0.54	220

No	Corg %	N_t mg/g	C/N	S_t mg/kg	P lact	CEC P	sol. + exch. cations meq/kg Ca	Mg	K	Na	H+Al	Ca/ Mg	V %	Al_o mg/g
1	30	31	32	33	34	35	36	37	38	39	40	41	42	43
3.1	3.9	3.6	10.8	559	98	212	102	28	7	3	72	3.6	66	0.3
3.2	3.3	2.4	13.7	498	55	170	87	25	5	2	51	3.5	70	0.2
3.3	1.2	1.5	8.1	412	13	140	89	26	3	3	19	3.4	86	0.3
3.4	0.8	1.2	-	348	9	128	85	27	4	2	10	3.1	92	0.3
3.5	0.6	0.9	-	348	20	126	88	32	4	2	0	2.8	100	0.3
3.6	0.5	0.5	-	306	17	108	83	20	4	1	0	4.2	100	0.2
3.7	0.4	0.4	-	306	15	64	50	11	2	1	0	4.5	100	0.1
3.8	0.3	0.4	-	328	17	91	60	21	5	5	0	2.9	100	0.1
3.9	3.3	4.6	7.2	6020	20	524	183	163	16	171	-	1.1	-	0.2

Marsh Soils of Northfrisia

Nordfriesland 4, Knickmarsch, Südermarsch, diked 1468

Location:	Südermarsch (3070 ha), south of Husum, situated close to the geest-landscape, ± 0 m a.s.l., groundwater 0.90 m below surface.
Parent material:	Marine sediments.
Vegetation:	Pasture.
Soil type:	Nasse Knickmarsch (Fluvi-Dystric Gleysol, Epiaqnic Haplaquept).
Site qualities:	Imperfectly drained, subsurface horizons of very low permeability, waterlogged in rainy periods.

Profile description: Nasse Knickmarsch

Ah	(Ah)	0- 10 cm:	very dark grayish brown (10 YR 3/2), silty clay loam, crumb to fine angular, few mottles/concr., many roots.
GoAh	(Agh)	10- 17 cm:	very dark grayish brown (10 YR 3/2), silty clay, crumb to fine angular, few mottles/concr., many roots.
SwGo1	(Bg1)	17- 27 cm:	dark gray (5 Y 4/1) to dark grayish brown (10 YR 4/2), silty clay loam, angular, some mottles/concr. (7.5 YR 4/4), roots.
SwGo2	(Bg2)	27- 46 cm:	gray (5 Y 5/1-2) to dark grayish brown (10 YR 4/2), silty clay loam, angular to prismatic, many mottles/concr. (7.5 YR 5/6).
SqGro	(Crg)	46- 72 cm:	gray (5 Y 5/1) to olive gray (5 Y 5/2), silty clay, prismatic, some mottles/concr., Phragmites rhizomes.
Gro	(Crg)	72- 82 cm:	gray (N5) to greenish gray (5 GY 5/1), silty clay, angular to prismatic, some mottles/concr., Phragmites rhizomes.
HGr	(Cr)	82- 92 cm:	gray (N4), silty clay, structureless, humus rich material.
nH	(H)	92-130 cm:	very dark brown (10 YR 2/2), Phragmites peat.

Nordfriesland 4: Knickmarsch

No	hor.	depth cm	text.in % of humus and carb. free soil: sand c+m	sand f		silt c	silt m	silt f		clay	carb. %	salts EC mS	salts g/l	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4.1	Ah	0- 10	-	9.3	9.3	16.7	20.9	14.3	51.9	38.8	-	3.40	2.00	-
4.2	GoAh	- 17	2.9	6.0	8.9	16.9	18.4	12.5	47.8	43.3	.	3.24	1.59	0.8
4.3	SwGo1	- 27	7.0	14.1	21.1	23.2	14.8	7.1	45.1	33.8	-	2.71	1.13	3.4
4.4	SwGo2	- 46	5.6	16.0	21.6	26.4	14.6	6.5	47.5	30.9	-	1.91	0.63	0.1
4.5	SqGro	- 72	-	2.5	2.5	16.2	21.7	8.3	46.2	51.3	-	1.39	0.63	0.2
4.6	Gro	- 82	-	1.9	1.9	13.8	23.0	10.0	46.8	51.3	-	1.59	0.51	0.2
4.7	HGr	- 92	-	1.3	1.3	10.7	17.6	12.0	40.3	58.4	-	3.75	2.12	-
4.8	nH	-130	-	-	-	-	-	-	-	-	-	-	-	-

No	bulk dens g/cm^3	GPV %	water content at pF(%) 1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	redox E_h mV	redox FeII %	S^{2-} mg/kg	Fe_d mg/g	Fe_o mg/g	$\frac{Fe_o}{Fe_d}$	Mn_d mg/kg
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29
4.1	-	-	-	-	-	4.8	4.4	+555	11	-	14.0	11.5	0.82	693
4.2	0.94	59.5	54.1	51.0	30.1	4.7	4.2	+585	12	-	12.3	10.2	0.83	630
4.3	1.09	57.8	49.2	46.7	30.4	5.0	4.4	+450	11	-	11.7	9.6	0.82	746
4.4	1.37	48.4	43.1	41.7	18.0	5.2	4.5	+545	13	-	10.6	8.1	0.76	392
4.5	1.30	53.3	52.8	51.5	25.1	6.9	6.0	+445	14	-	9.5	5.4	0.57	743
4.6	1.10	61.1	56.9	55.1	37.1	6.9	6.3	+375	13	-	12.3	7.8	0.63	258
4.7	-	-	-	-	-	6.6	6.2	+360	60	-	3.5	2.3	0.66	97
4.8	-	-	-	-	-	5.7	5.5	+350	47	-	5.0	2.5	0.50	219

No	Corg %	N_t mg/g	C/N	S_t mg/kg	P lact mg/kg	CEC P	sol. + exch. cations meq/kg Ca	Mg	K	Na	H+Al	Ca/ Mg	V %	Al mg/g
1	30	31	32	33	34	35	36	37	38	39	40	41	42	43
4.1	11.3	7.5	15.1	2750	37	590	170	30	14	5	371	5.7	37	1.0
4.2	8.5	6.9	12.3	2110	15	520	136	17	9	2	356	8.0	32	0.9
4.3	3.8	4.2	9.0	580	33	320	97	20	8	3	192	4.9	40	0.6
4.4	2.0	2.2	9.1	330	28	240	83	18	6	1	132	4.6	45	0.6
4.5	0.9	1.1	8.2	315	31	320	161	65	13	3	78	2.5	76	0.7
4.6	1.3	1.5	8.7	355	31	360	177	70	13	5	95	2.5	74	0.6
4.7	4.0	3.1	12.9	1730	9	400	220	67	15	6	92	3.3	77	0.6
4.8	37.0	21.5	17.2	12900	4	1190	640	110	6	21	413	5.8	65	0.8

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Field Tour K

Hamburg - Hahnheide - Sachsenwald

B. Hintze, M. Lüderitz, H.W. Scharpenseel

Programme:

- Soils developed in Weichselian and Saalian moraines
- Soils in various glacial and eolian deposits
- Soil formation of Eemian age

PLEISTOCENE .GEOLOGY OF NORTH-WEST GERMANY (by. J. Ehlers)

During the Quaternary the North German Lowland was partly or completely covered by inland ice in the course of at least three glaciations. Investigations in the Netherlands and in England seem to indicate that these known glaciations were possibly preceded by another one, but so far no evidence has been found in North Germany.

The oldest known glaciation occurred during the Elsterian. The ice advanced as far south as the Central German Uplands (Fig. 1). In East Germany two different Elsterian ice advances can be distinguished. There the Elsterian was the most extensive glaciation, whereas in the west the Saalian ice went much further.

During the Elsterian - most likely as a consequence of intensive subglacial meltwater erosion - up to over 400 m deep channels were cut into the pre-Quaternary substratum, which were largely re-filled after falling inactive. When the Elsterian ice melted down, vast ice-dammed lakes were formed in front of the glacier, following the courses of the channels. In these lakes silt and clay, the so-called "Lauenburg Clay", were deposited. Around Hamburg the Elsterian deposits are normally covered by younger sediments and only exposed in thrust zones.

During the Holsteinian interglacial the North Sea invaded the former channels, depositing marine sands and silts. The transgression reached as far east as Wittenberge (GDR). Outside of the marine areas peat and gyttja were deposited in depressions, but those deposits are not widely distributed. Fossil soils of the Holsteinian so far have been rarely found, most likely because of the lack of good exposures. Felix-Henningsen (1979) mentions an example from the Isle of Sylt.

The Saalian like the later Weichselian glaciation started with a longer non-glaciated period with prevailing cold climate. This cold phase was interrupted by at least two interstadials (Hoogeveen and Bantega), which have been described from the Netherlands.

In the Hamburg region the Saalian sequence starts with often over 10 m thick fine to medium sand, which especially south of the River Elbe form a continuous sand sheet over tens of kilometres. Cross-bedding measurements have shown that these sands were deposited by northwards flowing rivers, most likely in major distance from the ice margin.

The sands were overridden by the ice of the Older Saalian advance. The inland ice again went south to the Central German Uplands, blocking the Rhein at Düsseldorf. In Hamburg region a normally 5 - 10 m thick relatively sandy till was deposited.

When after a period of widespread deglaciation the glaciers of the Middle Saalian advance entered North Germany, mostly over 10 m thick meltwater sands were accumulated in sandur deposits in front of the ice. Even in this relatively coarse outwash material the gravel content goes rarely beyond 10 - 20 %.

These meltwater sands were overridden by the ice of the Middle Saalian advance, which did not cross the Weser - Aller line any more. It deposited a charateristic chalk- and clay-rich till, which in many parts of Hamburg lies close to the present surface. Because of its fresh appearance this till repeatedly was misinterpreted as being Weichselian in age, but stratigraphical investigations (e.g. at Lauenburg) made it clear beyond doubt that this is a Saalian till. Depth of weathering in this till is so small because of its high original carbonate content.

At the end of this ice advance the glaciers melted down back to the Baltic region. This intervall was followed by the third and least extensive Saalian ice advance, the younger Saalian advance. The outermost margin of this glaciation was slightly west of Hamburg, it is not marked by any prominent end moraines. The Younger

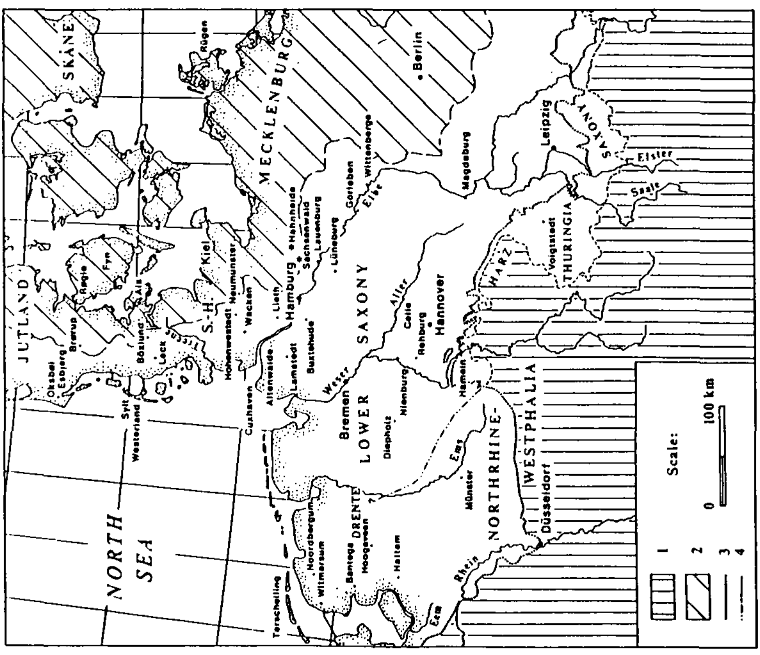
Saalian till thus forms only a thin cover on top of the Middle Saalian deposits in and around Hamburg. Its thickness rarely exceeds 5 m. Where this till lies directly on top of the Middle Saalian till, it is difficult to distinguish from it, when decalcified. It has, however, a completely different clast orientation maximum: This last Saalian ice approached Hamburg from the east.

During the Eemian interglacial the sea could not enter the North German Lowland again; the Eemian coastline largely corresponds to the present North Sea coast. In Hamburg the Eemian is represented by widespread peat and gyttja deposits, which had formed in valleys and closed depressions. In Lower Saxony south of Lüneburg diatomite deposits were formed during the Eemian as well as during the Holsteinian. Fossil soils of the Eemian have been found in a number of localities.

The Weichselian glaciation again started with a long cold phase, during which the glaciers did not advance to North Germany. This period of periglacial climate was interrupted by a number of interstadials (Brörup, Odderade, Keller), which were too cool to allow a renewed afforestation.

The Glaciers of the Weichselian covered northern North Germany only for a short period of time between ca. 0.000 and 13.000 B.P. The Elbe was not crossed by the ice any more; it functioned as the principal marginal streamway of the Weichselian. East of Hamburg the ice remained north of the Sachsenwald area. Like in the Elsterian and in contrast to the Saalian meltwater channels were formed again, but this time at a much smaller scale, only tens of metres deep. Major parts of these channels today are occupied by lakes.

Like in the areas of the older glaciations the outer limit of the Weichselian is not represented by end moraines but has to be reconstructed from sedimentological evidence or minor landform elements. So although the general course of the Weichselian limit is clear today (Fig. 1), in detail there is still much room for discussion.



Extent of the three Quaternary glaciations and places, mentioned in the text : 1 = unglaciated area

2 = area of the Weichselian Glaciation

3 = maximum extent of the Saalian Glaciation

4 = maximum extent of the Elsterian Glaciation

S. - H. = Schleswig Holstein

(after Liedtke, 1981; Ehlers, Meyer & Stephan, 1984)

STRATIGRAPHIC CORRELATION CHART

Estimated age (years BP)	North-West Europe (General division)		Schleswig Holstein and Hamburg (Stages)	Main glacial deposits	Pedogenesis
	Holocene				distinct
10.000	late Pleistocene	Weichselian: Upper	Weichselian: some Interstadials	often rather silty tills (chalk content variable)	very slight (spodic horizon)
		Middle			
61.000 65.000		Weichselian	Brörup Interstadial		slight- temperate (Spodosols)
		Early	Glacial		
110/ 115.000		Eemian	Eemian Interglacial	peats, muds	distinct
125.000		Saalian: Younger	Fuhlsbüttel, Warthe II: Stadial	upper : more clayey, reddish lower : more sandy tills	--------
			Borgfelde/Mildstedt Interstadial	glacifluvial sands	very slight (spod. hor.)
150.000		Middle	Niendorf, Warthe I: Stadial	upper : more clayey, chalk-rich tills lower : sandy base (tills)	--------
200.000		Saalian	Treene/Wandsbek Interglacial or -stadial		slight or moderate (controvers)
		Older	Drenthe: Stadial	commonly sandy, low-chalk tills (upper part often reddish)	---------
285.000	mid.	Holsteinian	Holstein Interglacial	marine dep.(Holstein sea)	---------
300.000		Elsterian			

Topography / Geomorphology

Two different landscapes are essential for the excursion area:
- state forest'Hahnheide' near Trittau, a preserverd area, which extends some 25 square kilometre (on topographical map 1:25.000, card no. 2328 - 'Trittau')
- private forest 'Sachsenwald' near Aumühle, with some 60 square kilometre the most extensive uninterrupted forest in Schleswig Holstein, S and SW of 'Hahnheide' (on topographic map 1.25.000, card no. 2428 - 'Schwarzenbek')

The excursion route is restricted to central parts of 'Hahnheide' (S and SE of 'Hahnheide hill') and northern 'Sachsenwald'. The Hahnheide upland (adapted from high heath) is limited by the Bille valley to the NE, E and S, by the Mühlenau-dale to the W and to the north by road Linau-Grönwohld. The western/northwestern boundary of Sachsenwald is also the river Bille, the approximate northern and eastern limits are highway A24 to Berlin and state road B404 to Schwarzenbek.

Both areas show very different morphological features. The average altitude of Hahnheide forest is between 40 and 60 m above standard sea level, while the central high itself strikes between 60 and 100 m. It declines steeper to the east , than to the west. Sachsenwald forest, in comparism, has an average altitude about 30 - 45 m (highest parts even reach 50 m). The highest spot elevation of the whole region is 'Hahnheide hill' (Todtmann's nunatakka), with 99,1 m above sea level, while some parts of Bille valley are lowest (with 25 m).

Hahnheide's relief demonstrates unsteadyness and vicaceousness as a result of its polygenetic origin (close entanglement of different facial ranges). Hills and ridges, dominantly striking N-S and NNW-SSE, are intercalated by plateaus and nearly even'peneplains' , that where secondary articulated by erosional flutes, periglacial dales, closed depressions and some kind of small knolls and domes.

Some hollows and depressions are due to former dead ice; they became moorland during the Holocene. A broad glacifluvial washout traverses the Hahnheide region from NE to SW.

On the contrary Sachsenwald forest has a slightly rolling, very smoothy landscape view (called 'old drift landscape'). This relative plainness attributed to long during erosional processes. Meltwater erosion notched the Bille valley into the 'old' Saalian ground moraine plateau and consequently built up a natural boundary between Hahnheide and Sachsenwald during Weichselian times.

Geology and history of the landscape

Former borings indicated, that the Tertiary surface is located up to over 20 m above the sealevel in the region westerly Hahnheide forest and plunged to the east and northeast. This Tertiary ridge strikes from NW-Trittau to Ahrensburg and is completely covered by younger glacial sediments. We can assume, that this morphological situation was appropriate for accumulation and thrusting of Quaternary deposits.
Mainly allochthonous outliers of clay, aged Eocene and Miocene, namely occuring at Dwerkathen, Trittau, Schwarzenbeck and "Wildpark"/Pulverborn (Sachsenwald), which were partly worked by brickyards in former days, are the oldest surface (regional) strata (of the region). The advancing inland ice eroded, "bulldozed" (displaced) and pushed them into the present position during the Saalian stadials. A greyish lodgement till, which is oftenly rich in clay and chalk represents the oldest boulder clay (resp. marl) here. Its deposited at the Middle Saalian

Niendorf advance. Extensive zones south of the Hahnheide (including the Sachsenwald area) were established during this advance as a ground moraine plain, which was subsequently abraded by the river Bille in some parts. It seems to be clear, that the master pattern of the Bille valley proceeded in the course of the Niendorf event by glacial erosion. (general valley strike corresponds with measured ice flow direction).
Just so the nucleus of the "Hahnheide high" developed during this time or even earlier. Such older nuclei of lodgement till under the topset are presumed in the Trittau-Ahrensburg area too (Illies, 1952).
The typic glacial sedimentary cycle consists of till - meltwater sands (finer over coarser) - till ... and so on. Those expected glazifluvial sands between the Middle and the Upper Saalian (called "Fuhlsbüttel") till are proved only in few borings at Hahnheide, but may be outcrop more extensive. They represent "Nachschüttsande" (attached to the Niendorf advance) or "Vorschüttsande" (attached to Fuhlsbüttel advance).
The Hahnheide got its main morphological face within these Upper Saalian Fuhlsbüttel glaciation. The ice namely reached as far as the Harburg region (Ehlers, 1978). The deposited lodgement till is more or less sandy, coloured reddish (7,5 YR) and forms the surface of a rather high and hilly old drift landscape in the Hahnheide region nowadays. A very narrow change of hills and drainless depressions (hollows) is prominent. In many cases thrusting and pushing on the existent relief (see above) took place during the sedimentation. Little supfantes of Niendorf till are indications for this thesis.

Further south (map Schwarzenbeck) the Fuhlsbüttel till takes part in the ground moraine peneplain. Long axis measurements (on boulders) in a gravel pit near Neukasseburg (Nr. 9) show a NE-SW ice flow direction for the Fuhlsbüttel glaciation. Deepseated areas in this landscape were partly covered by "Nachschüttsanden" during deglaciation (flow direction mostly ENE-WSW), especially north, east and south of the Hahnheide region. A broad meltwater channel (washout), which strikes from NE to SW through the Hahnheide high, also constituted at these times.

The following Eemian interglacial was a period of intense weathering and pedogenetic processes. The overlying marls altered and decalcified from 2 up to 5 m (sometimes more in through areas), sandy and sandy-skeletal deposits much deeper. Moorlands often established in hollows and dead-ice holes.

During the last (Weichselian-/Würm-) glaciation, the ice margin lies in the excursion area. The extreme glaciation limit, which represents no synchronus line and is marked by terminal moraines, crosses the region from NW (Wilstedt/ upper Alster valley) to SE and - at least - E (Sachsenwald near Möhnsen). The run of this so called "young moraine" is affected by the mentioned "old moraine" nuclei in the basement. The top wall in the outcrop Neukasseburg (Nr. 9) seems to be a Weichselian till and has a long clast orientation ENE-WSW (local ice movement).

In this region the Weichselian age is usually represented by diverse meltwater sands or sandy respectively sandy-skeletal moraine facies. Highest parts of the Hahnheide (Hahnheide Hill and surrounding area) are built up by a Weichselian push end moraine, which was thrusted on the sharp Eemian relief from northern and eastern directions. Latest Saalian "Nachschüttsande" (s.a.) are the parent material. Deep and intense weathering and decalcification of the Eemian till surface, which pitched under these sediments of the Hahnheide Hill, give evidence to the theory of a intra-Weichselian thrust. Former investigators interpreted the Hahnheide as a late Saalian end moraine ridge, whereat the top regions (Hahnheide Hill) acted as a Nunatakka (Todtmann, 1954).

A thin and strongless Weichselian iceflow has overridden the Hahnheide district partly and left behind a rare and fragmentary sheet of more or less gravelly moraine sands (here ablation and terminal moraines). The pre-Weichselian surface was not essentially varied by these last ice actions.

Also the Bille valley got its definite face during Weichselian times. The border of glaciation lies near Witzhave at the maximum phase. The meltwater eroded the Bille bed with its meandering streams. "Vorschüttsande" and (more important!) Weichselian "Nachschüttsande" buried extensive areas of the old ground moraine plains (made up by middle and younger Saalian boulder clays), namely S and SW of the Hahnheide. Subglacial meltwater streams abraded a broad channel ("tunnel") valley westerly Trittau, which is nowaday filled up from Großensee and Lütjensee. Dead ice bodies, which melted down in early Holocene times, preserved their relief up to the present time.

The whole region was affected by meltwater erosion one more time during the Weichselien deglaciation. Many shallow and small grooves are evident. The following periglacial cold phase mainly created drying valleys and aeolian deposits like the sand dunes leewards Hahnheide Hill (but older dunes, created in former periglacial climates, can be also found). Ice wedge casts, cryoturbation, solifluction (soil flows) and frost cracking of stones are periglacial features too.

Renewed mooring, pedogenesis and the formation of anthropic heathes took place during the Holocene. We can resume, that the considered region is built up very complex. The grating of many different formative elements (of different age and genesis) is obvious. The soils are mostly polygenetic (derived from bipartite or tripartite beddings).

Climate

The climatic character is dominantly altanctic; nevertheless continental influences are abundant (combined by the term 'subatlantic'). Its a humid regime with a mean annual rainfall about 750 mm, distributed nearly equable to the wholeout year (only one significant peak at july, august). About 200 days p.a. have precipitation, 35 days with snowfall by it. The data's for mean annual temperature vary between 7,5 and 8,1 C (critical case: cryic or mesic?). Western winds in general were alternated by drying east winds at springtime.Usually the relative atmospheric moisture is rather high.

Hydrology

The watershed North-Sea - Baltic sea (along Elbe resp. Trave river) is located nearly 5 kilometre northerly Hahnheide, on a line Franzdorf - Sandesneben - SE (northern regions of map 'Trittau').
Artificial ponds are both frequent at Hahnheide and Sachsenwald. Numerous fens, developed in shoal, drainless depressions, become a typical element Sachsenwald's landscape.

The surrounding area, especially W,N and NE of Hahnheide, presented some drainless Weichselian seabeds, which silted up during Holocene times. Moorland residuals of Gölmer moor, Linauer moor and Koberger moor give evidence to that; open water only rested in the deepest hollow spaces, namely Großensee (12-15 m) and the smoother Lütjensee (both W-WNW Hahnheide).

Hahnheide forest belongs to the action radius of the Elbe stream and drains mainly through Bille river, which has its main source at Hoberg moor (eastern margin of Hahnheide forest). The Mühlenau (at Trittau) and the Corbek, which came from Großensee, run into Bille river. The heights of Hahnheide were radial drained by some smaller brooks. These were mainly periglacial dry valleys during Weichselian. Their irrigation originated later on by retroregressive erosion. The Sachsenwald area also drains through Bille river; the most important brook, which crosses the forest E-W, is called 'Schwarze Au'.

Forest history

Vast parts of the interesting region were destroyed and deforrested by the hand of man. Plagioclimax acidic heathes (maximum about 1700) then established on the largely open areas:
- Calluneto-Genistetum-typicum (drained, sandy soils)
- Calluneto-Genistetum-Molinetosum (fresh to moist soils)
- Ericetum tetralicis (wet or aquic soils near ground-water level)

Thus far a wholesale regeneration took place. There are only some relictic occurrences of Calluna (for instance near Hahnheide Hill) nowadays. Within the 18th century renewed afforestation (now manmade) with deciduous trees began on the damaged soils. A summergreen mixed forest, dominated by Fagus and Quercus, and with little quantities of Pinus was primary for some hundred years (up to ~1820) in Sachsenwald and Hahnheide. Only the highest region of the Hahnheide forest with its "poor"and sandy soils were restricted to Pinus.

The genus Picea started its triumphal march in the following decades. Defective "Naturverjüngungen" of Fagus stocks were replaced by Picea (and sometimes Pinus) in the Sachsenwald/Hahnheide forest-ranges. Mere Pinus stocks arised only on grounds, which weren't fit (suitable) for mixed forest growth.

The modern trend to large and mere stands of Picea came to existence during the last decades of th 19th century and continued (partly) even to this day. Still in the seventies Fagus stocks were renounced and substituted by Picea in Sachsenwald. This trend was not so crass in Hahnheide forest, where we could observe a continual increase in the proportion of deciduous trees since the 20tees and 30tees of our century. Today we have - according to the soil properties - mixed forests with Fagus, Quercus and Picea (in different ratios). Coniferous stocks predominate in the central high only (with Picea; in some places also Pinus and Larix). Otherwise in Sachsenwald more than 40 percent of the forest-range are stocked with Picea today, some 30 percent with Fagus (each in solitary stands). For future, mixed forests are favoured here too.
Coniferous trees like Abies grandis, Picea sitchensis and Larix kaempferi are common in Sachsenwald and Hahnheide regions also.

Vegetation

A general view for Hahnheide and Sachsenwald would, very simplified, includes the most important groups of plants (ground vegetation):

<u>Group 1</u>: habitat: verges of ways, edges of forest , more or less eutrophic
soil moisture regime: dry or frequently moist
particle size: very different

According to different soils and substrata the plant communities vary. A common tendency is limited withdrawal of Fagion/Luzulo-Fagion species to the considered periphery zones. Frequent species are:
Anthriscus sylvestris, Ajuga reptans, Galium aparine, Geranium sylvaticum, Geum rivale, Moehringia trinerva, Ranunculus auricomus, Urtica dioica, Rubus idaeus and some elements from the above mentioned associations.

Group 2: habitat: domaines with ground water contact/influence, moorland, brook banks ...
soil moisture regime: permanent wet (mainly stagnant water)
particle size: very different

These zones rarely belong to the commercial forest. Natural successions are common. Stocks of Fraxinus excelsior, Alnus glutinosa, Betula and Pinus. Typical grasses are Molinia coerulea, some Carex species (gracilis, canescens, echinata) and Juncus species. Eriophorum is restricted to moors in Sachsenwald. Abundant herbs are Cardamine amara, Geranium robertianum, Chrysosplenium oppositifolium, Lysimachia vulgaris and nemorum, Mentha aquatica, Ranunculus ficaria, Stellaria alsine, Veronica montana, some species of Galium.

Group 3: habitat: Plateuas, plains and shallow depressions built up of boulder clay or clay
soil moisture regime: frequently moist to dry
acidity: epipedon more or less acid
particle size: lS above sL-stL (lT)/ loamy skeletal

Stocks of Quercus and Fagus; sometimes mixed with Picea, and also pure coniferous stocks (wrong place!) are abundant. Some index species for frequent hydromorphic moisture regime of the genera Carex and Luzula are common: Carex echinata, flacca and sylvatica; Luzula camprestris and pilosa. Other typic grasses are Juncus filiformis, Dechampsia caespitosa, Milium effusum and Holcus lanatus. If the topsoil becomes more acid, acidophyllous species like Dechampsia flexuosa or Agrostis tenuis took place. Frequent herbs are Ajuga reptans, Gleochroma hederaceum, Maianthemum bifolium, Oxalis acetosella and Stellaria holostea. Typicalfern is Pteridium aquilinum. Some bushes like Frangula alnus, Ilex aquifolium and Lonicera perichymenium are also abundant.

Group 4: habitat: Some regions like group 3, but with marl in less than 1 m to the surface
acidity: non acid
soil moisture regime and particle size: see group 3

Humus form and nutrient supply are better, than in group 3. Fastidious plant genera are abundant. Some small domaines in Hahnheide and Sachsenwald belong to this group. Typical herbs are Anemone nemorosa, Galium odoratum Impatiens noli-tangere, Lysimachia nemorum, Lamiustrum galeobdolon, Polygonatum multiflorum/ odoratum, Viola reichenbachiana.

Group 5: habitat: Regions with loamy-skeletal moraine sands
soil acidity: non acid to moderate (medium) acid
soil moisture regime: dry or fresh
particle size: l'S - l˙S

Stocks of conifers (esp. Picea and Larix); but also deciduous trees like Fagus and Quercus. Better conditions for plantal growth, than on pure sands (group 6/7) because the weatherable mineral content (silicates) is relatively high. Common grasses are Agrostis tenuis, Dechampsia flexuosa (seldom) and Molina coerulea (moisty spots). Tympical herbs are Galium herzynicum, sometimes Oxalis acetosella and Mainathemum bifolium.

Group 6: habitat: Regions with sandy deposits; different genesis
soil acidity: moderate or strongly acid
soil moisture regime: dry or fresh (often absoultely dry·
particle size: S, paritculary l'S

Stocks of conifers, mostly Picea and Pinus. The typical grass is Dechampsia flexuosa, sometimes Molinia coerulea (moisty spots) and Carex pilulifera. Common herbs are Trientalis europaea, Galium herzynicum, Rumex acetosella. Bushes and trees (natural succession) are Vaccinium myrtillus, Sorbus ancuraria and Betula, sometimes Calluna vulgaris (residual). Spots with slope water also have Pteridium aquilinum and Frangula alnus.

Group 7: habitat: regions formed by inland dunes/or aeolian sand sheets
soil moisture regime: dry - mostly dry/fresh
particle size: ūfS - fS

Absolutely poor, silicateless substratum (if there is no other upper layer). Only coniferous stocks, few species of herbs, grasses and bushes like Trientalis europaea, Calluna vulgaris, Dechampsia flexuosa, Carex arenaria and Vaccinium myrtillus.

Paleosols

"Height and geomorphology in many regions of the "East-Holsteinian hilly country" must be essentially created during the Warthe Stadial (Middle or Upper Saalian), because their Eemian paleosols are fairly high situated. The Weichselian glaciers invaded this landscape. They passed over (ran over) higher areas in form of a thin icesheet respectively took a roundabout way in the far western and southern zones of glaciation." (adapted after Stephan, 1979/ 81)

This scenario is also applicable for the Hahnheide high. The fossil or relictic Eemian soils on basal till (boulder clay) can be used as stratigraphical index horizons for the pre-Weichselian land surface. Only in a few marginal places this soil was exarated by the Weichselian ice or truncated by its meltwater streams.

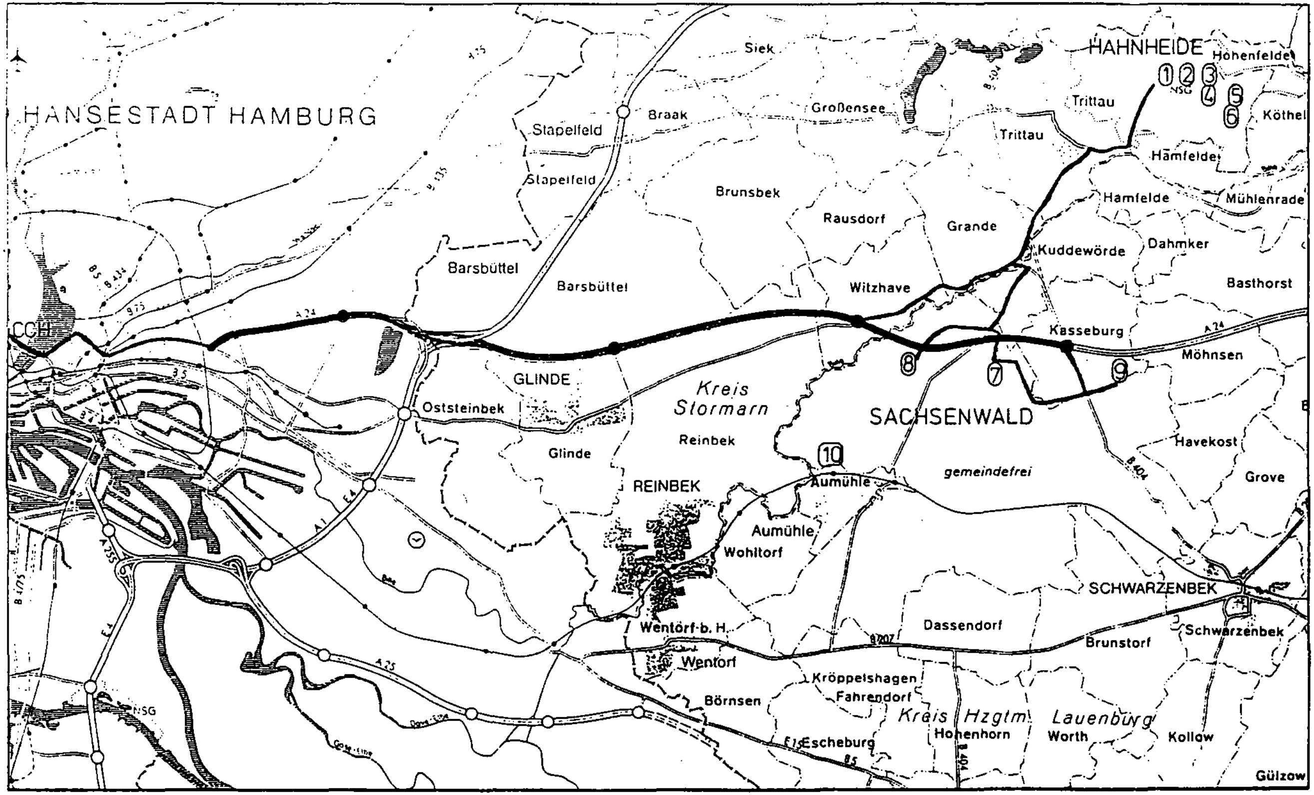
Resting and stable enrichment horizons (here rBt or rBtSd) are already preserved and oftenly buried through later sedimentation. The light eluvial horizons on the other hand were reworked in the forming of a non-stratified surface layer, called "Geschiebedecksand". This process of reworking has been exposed to different cryogene, solifluidal, fluvial, aeolian,pedogene and biogene actions (influences). There are indications for a stratification (here bipartition) in the"Geschiebedecksand" in less altered zones - mainly hollows and depressions - indeed (with a mixed/turbated fAl or fAlSw in the topsoil).

The mainly Eemian weathering and decalcification depth is between 1 and 5 m (partly more). The recent soils become polygenetic through following pedogenetic processes in Holocene times and may be during some Interstadials. Their interpretation, in particular the disconnection of recent, subrecent and fossil characteristics, is fairly complicated.

During the Eemain warmphase a podzolisation of the (above mentioned) Alfisols (Ger. "Parabraunerden") was typical after overstepping the climatic state of climax (means end state of the so called "Hainbuchenzeit"). (Menke 1976; Felix-Henningsen, 1980). This must be supposed for Sachsenwald and Hahnheide soils too, but one cannot verify that, because the topsoils are turbated (s.a.) The end of the Eemian Interstadial was indicated by change to a cool and humid climate. This brought about some influences of groundwater and stagnant water to the soils in addition.

Interstadial soil fragments or residues are very seldom and located punctiform in the Hahnheide region (Sachsenwald isn't studied therefore), especially by reason of post-glacial meltwater erosion and aeolian deflation.

ROUTE MAP



HANSESTADT HAMBURG
CCH
HAHNHEIDE
Hohenfelde
NSG
Köthel
Trittau
Siek
Großensee
Braak
Stapelfeld
Hamfelde
Mühlenrade
Brunsbek
Rausdorf
Grande
Kuddewörde
Dahmker
Barsbüttel
Witzhave
Basthorst
Kasseburg
Möhnsen
GLINDE
Oststeinbek
Kreis Stormarn
SACHSENWALD
Glinde
Reinbek
Havekost
REINBEK
Aumühle
gemeindefrei
Grove
Wohltorf
SCHWARZENBEK
Schwarzenbek
Dassendorf
Brunstorf
Wentorf-b. H.
Wentorf
Kröppelshagen
Fahrendorf
Börnsen
Kreis Hzgtm. Lauenburg
Escheburg
Hohenhorn
Worth
Kollow
Gülzow
1
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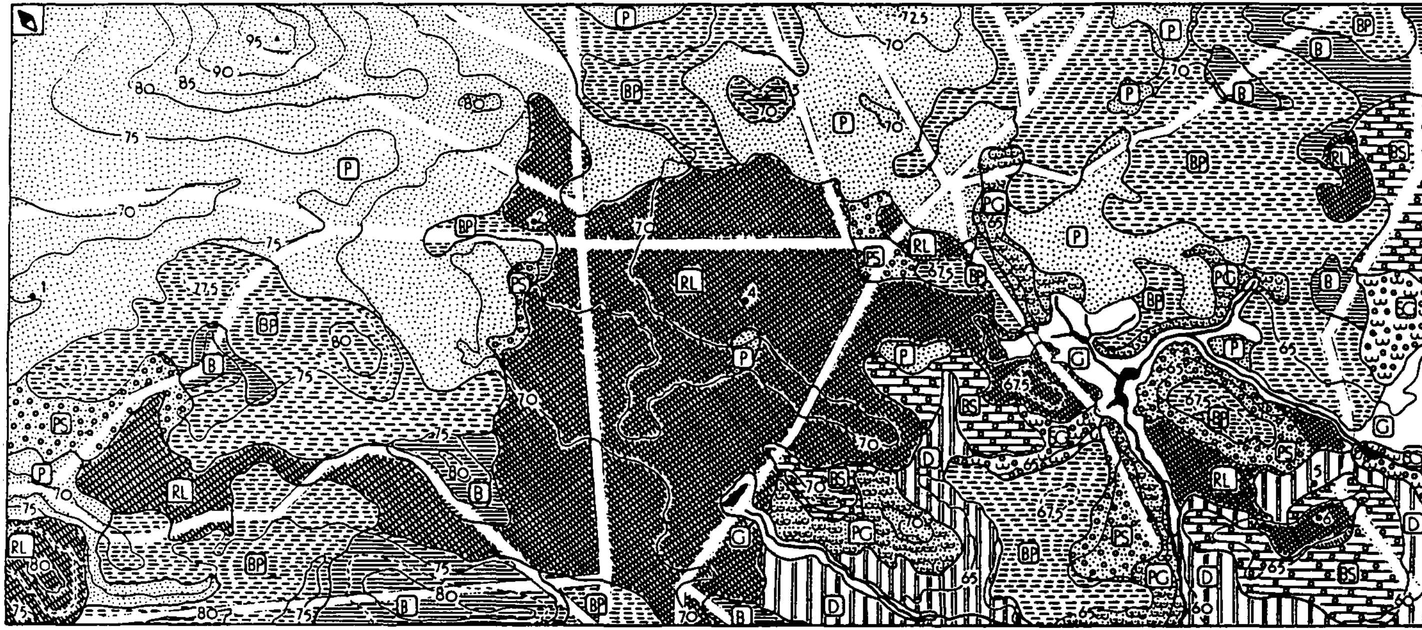
-73-

Bodenkarte Hahnheide



- diverse Podsole (insb. Humus- Podsole)
- Braunerde- Podsole und Podsol- Braunerden
- Braunerden s.s., z.T. podsolig
- Gley- Podsole und Podsol- Gleye
- ● excursion profile / soil monolith
- Braunerde- Pseudogleye und Pseudogley-Braunerden
- Podsol- Pseudogleye und (z.T.) Pseudogley - Podsole
- Pseudogley- Gley und Gley- Pseudogley
- diverse Gleye und Hanggleye
- Pelosol- Pseudogleye und Pseudogley-Pelosole (z.T. vertisch)
- BS / PS (in allen Übergängen) über reliktischer Parabraunerde (r BtSd)

(after LÜDERITZ, 1985)

Soils (Hahnheide)

Owing to various facial interdigitations and multifarous morphogenetic features, we have an extraordinary variety of soils and soil communities. The soil map gives only a short glimpse to these facts, it is comprehensively generalized. According to the particular soil properties (like soil-parent-material, age, pre-weathering intensity ...), soil development intenseness and depth varies to wide limits. The soils are - except for small areas - polygenetic.

Most important soil groups in Hahnheide (referring to the soil map classification, very simplified):

P The original "raw material" is arenaceous: fluvioglacial sands (aged Weichselian or Saalian), dune sands (inland dunes, different aged) and, less frequent, also different grain-sized niveofluvial sands. Intensive pre-weathering processes and silicate decreases must be supported in the most cases. Therefore Humus-Podsole (Ph/Haplohumods) are more frequent than Eisenhumus-Podsole (Pn) or Eisen-Podsole (Pe/Haplorthods or -ferrods). Adhesive water influenced the subsoil mainly in deepseated locations. Partial intergrades to Braunerde-Podsol are common, expecially in sites, where the overhanging "Geschiebedeck-sand"is more silicateous (adjacent facial influences).

BP The parent-materials are mainly slight loamy, skeletal moraine sands (aged Weichselian) or deep founded "Geschiebedecksande", which have more silicates. One observes all intergrades and intensity degrees of Braunerde-Podsolen (B-P) and Podsol-Braunerden (P-B). In the granularity if predominantly fS, ffS or u'fS in the subsoil, effects by adhesive waters are also possible (see P).

B On sites, where the gravelly moraines sands (see BP) are more loamy and deeper founded, especially on domes and ridges, where the late Weichselian resp. early Holocene erosion could not weave in, Braunerden (B/Dystrochrepts) with low to medium base saturation developed. The uppermost parts of the profile are oftenly very slightly podzolized (pB). The solum is typical red coloured, sometimes even 5 YR. Fringe zones (on slopes for instance) show intergrades to Podsol-Braunerden and Braunerde-Podsolen (s.a.).

PG These soils originated along creeks /brooks, in closed depressions and lower course sites of periglacial dry valleys (which are nowadays moist sometimes) from similar "raw materials" like group P. Weichselian "groove sands" seem to be an additional parent facies. Typical soils are Gley-Podsole (G-P) and Podsol-Gleye (P-G), in downslopes and slopping head-waters also podzolized Hanggleye and Oxihanggleye (pNGn/NGo). These profiles oftenly have many black or dark grayish brown humified bands/ undulations (typical property).

BS The parent-rock combination, that is to say silicateous "Geschiebedeck-sande" resp. moraine sands (in the topsoil) over loamy-skeletal boulder clays, occuring as erosional rests or outher flakes, (in the subsoil), is predominantly present in the fringe regions of the Fuhlsbüttel-aged ground moraine plateau. Relictic horizons from banded Alfisol (Ger. Bänder-Parabraunerden) - like rBt/rBtSd - can also represent the subsoil in exceptional cases. According to the topsoil base saturation, the formed Braunerde-Pseudogleye(B-S) or Pseudogley-Braunerden (S-B) are often slightly podzolized (p B-S/S-B).

PS The topographic and parent-material combination is similar to case BS, but silicate content and base saturation in the topsoil is both quite lower here (mostly the uppermost sands are more altered). That caused a soil development, which tends rather to Podsol-Pseudogley (P-S) and Pseudogley-Podsol (S-P), both with intergrades to B-S and S-B (s.a.). Exceptionally moist (wet) spots have Podsol-Anmoorpseudogleye (P-Sa).

SG Pseudogley-Gleye (S-G) and Gley-Pseudogleye (G-S) were created under permanent impeded drainage, if the soil parent-material of case BS/PS in fringe zones of the ground moraine plateau (sometimes associated with tectonic frameworks) comes together with deepseated positions or slope waters. Particularly these soils became "Anmoor-Böden" (like S-GA/GA-S) on swamp forrestal aqúic regimes. Just so podzolization is at hand in some parts. Related to relief position and facial-genetic pecularity of strata, we have multiple transitions and interdigitations between the soil groups BS/PS and SG.

G This group comprises diverse Gleye (Gleysols), which developed from every available parent-material on brook banks, in closed depressions etc. Their features are very different therefore. Very common are typic Gleye (Gn), humic Gleye (Gh) and Anmoorlgeye (GA), the latter mostly associated with swamp forests. Many other types are further present: Oxigleye (aerated ground-water), Hanggleye/Nasshanggleye (aquiferous slopes) and Nassgleye (ground-water level near soil surface). According to its vivaceous, non-smoothed morphology, the excursion area Hahnheide got all these possibilities for Gleysols.

D The parent-rock is argillaceous: a low to medium sandy, slight skeletal clay, which occures as an imbricate structured outlier and swims among the Fuhlsbüttel-aged ground moraine (basal till) here. Low vertic, clayey soils, particularly Pelosol-Pseudogleye (D-S) and Pelosol-Anmoorgleye (D-GA), also Stagnogleye (SSn) - situated under freely-drained conditions-are present. These soils became less acid (non-acid) and decalcified comparatively little, mostly within 0,8 or 1 m to the soil surface. Slickensides are very common.

RL This symbol means all soil subgroups, which developed on a distinct bipartized parent-material, called "Geschiebedecksand" over boulder clay (loamy basal till), if the till has any form of relictic or fossil Alfisol (Ger. Parabraunerde) in its upper wall. (see also chapter "Palesols"). These conditions are mainly given on sites, where the skeletal loam is unturbated, less truncated and of moderate thickness. Alfisol-residues promoted the incident of "Pseudovergleyung", that means, it is a well marked Sd-horizon today. We have soils like Braunerde-Pseudogleye (B-S), Pseudogley-Braunerden (S-B), Pseudogley-Podsole (S-P) and Podsol-Pseudogley (P-S) in all variations and intergrades (that partly depends on the special properties of the uppermost "Geschiebedecksand"). The Sw horizon, created on the subjacent parts of the "Geschiebedecksand", obviously contains reworked rests of a former (Eemian-) Alfisol-Al-horizon in some locations

Profile 1 (A1):

location: Hp ^{59}43580 ~ 225 m SW top 99,1
Rp ^{35}96328 (Hahnheide hill) 'Jagen' 14b

relief: downslope region, plained
exposition: N; height 71 m

hydrology: Influences by downslope percolating waters in subsoil (adhesive). Main effects: bleaching and hydromorhic punctuation. Topsoil +/- dry (about over 30% coarse pores).

vegetation group: 6 (here Vaccinio-Piceion)

soil group: P

Soil Tax.: Sandy - non cemented - acid - mesic - entic Haplohumod (orthod)
FAO: Humic Podsol
FRG: Typischer Podsol

Profile 2 (A2):

location: Hp ^{59}43490 ~ 200 m SE top 99,1
Rp ^{35}96660 Jagen 32a

relief: transition slope foot - downslope, fairly plain
exposition: S-SSW (trifling); height: ~ 71 m
NW direction: Hahnheide hill
E/SE direction: ground moraine plateau } transition point

hydrology: Influences by downslope percolating waters and frequently stagnant waters (stower horizon) up to the topsoil. Distinct bleaching and gloomy mottling.

vegetation group: indifferent (Vaccinio-Piceion dominant)

soil group: RL

Soil Tax.: Coarse loamy - mixed - non acid - mesic - humodic arenic Hapludalf
FAO: Gleyic Podsoluvisol
FRG: Podsol - Parabraunerde - Pseudogley

Profile 3 (A3):

location:	Hp ^{59}43575 Rp ^{35}96855	315 m ESE top 99,1 Jagen 31b

relief: Small, WNW-ESE striking dune; culmination point
dune slight parable formed
exposition: W; height: 70 - 70,5 m
limitation S/SW: late Weichselian meltwater channel/groove

hydrology: Well drained, dry. No hydromorphic features.
Sometimes adhesive moisture in subjacent u'fS (very slight)

vegetation group: 6 or 7 (7 dominant)

soil group: B

Soil Tax.: Sandy - sceletal - mixed - acid - mesic - humodic umbric Dystrochrept
FAO: Dystric Cambisol
FRG: Rostbraunerde

Profile 4: not described

Profile 5 (A7):

location:	Hp ^{59}43255 Rp ^{35}97100	450 m NE Hahnheide farmyard Jagen 6c

relief: plain - slightly depressed plateau; culmination area
here: "micro-depression" (within above mentioned structure)
exposition: N/NW; height: 64,5 m

hydrology: Clay as an actual stower stratum. Distinct influences by
impeded drainage, stagnant waters.
Profil wet up to the soil surface most time of the year.
Features: desoxidationcolors; oxidation mottles /spots on
root channels only.
The underlying interbedded glacifluvial sand acts as an
aquifer.

Vegetation group: 3 and 4 (Luzulo-Fagion dominant)

soil group: D

Soil Tax.: Clayey - mixed - smectitic - non acid - mesic vertic Haplaquept
FAO: Eutric (vertic) Gleysol
FRG: Pelosol-Stagnogley

Profile 6 (A8):

location: some m S profile 5, also Jagen 6c
charcoal-burner

relief: see profile 5; here: plateau culmination
exposition: -; height: 65,5 m

hyrology: frequent, slight - moderate influences by static waters
(stower horizon). Slight, indistrict mottling.
These features are more intense: - on deeper seated sites
- if the stower becomes more compact.
ground-water-level (depth): 6-7m

vegetation group: 3 (Luzulo-Fagion)

Soil group: RL

Soil Tax.: Loamy - mixed - acid - mesic fragiaquic Paleudult
FAO: Gleyic Acrisol
FRG: Podsol-Braunerde über Pseudogley- Parabraunerde

Profile 7:

Soil Tax.: Sandy loamy - mixed - acid - mesic - umbreptic glossaquic Fragiudult
FAO: humic Gleysol
FRG: Podsoliger Pseudogley-Gley

Profile 8:

Soil Tax.: Sandy - petroferric - acid - mesic - typic Sideroaquod
FAO: Gleyic Podzol
FRG: Gley-Podsol

Profile 9

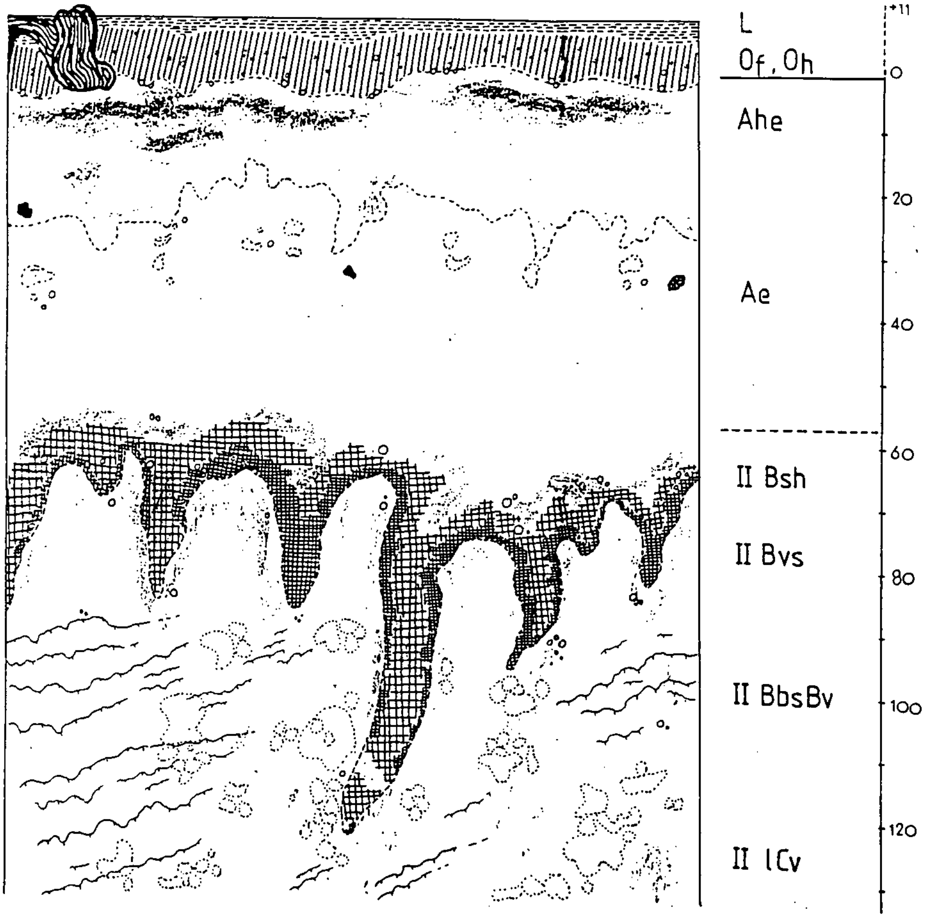
location: Hp ^{59}36750 gravelpit near 'Neukasseburg'
Rp ^{35}94530 some 940 m WSW railway station 'Möhnsen'

relief: height: 42 m
(smooth Weichselian end moraine walls)

vegetation group: weed community (field); secondary pioneer community on the outcrop slope (with Jasione montana, Tussilago farfara, Oenothera biennis ...)

soil group: BS and RL

Soil Tax.: Sandy over loamy - mixed - non acid - mesic aquic Fragiumbrept
FAO: Humic Cambisol
FRG: Pseudogley - Parabraunerde



Soil description:

coniferous raw humus, compact, in layers (easy to seperate)

solifluctive deposit, mixed of local subjacent sands and Weiselian aged moraine sands (occurring S and SSE); little skeletal content (gravel/ stones), low in silicates; frost splitted flints (periglacial features); mostly dry (more than 30% coarse pores)

Munsell : Ahe - 7,5 YR 6/2, little
Ae - 10 YR 7/2

non-skeletal, dislocated and compressed fluvioglacial sandr-sands particle size distribution similar to stratum I; pre-weathered, upper Saalian ('Nachschütt-sande') material. redeposited during Weichselian times; low silicate content, slight hydro-morphic bleaching, 'Wurzeltöpfe'; relictic cross-bedding structures and pressure faces (suture joints), nowadays occurring as 'Tüxen'laminae

Munsell : Bsh - 7,5 YR 3/2
Bsv - 10 YR 5/8
BbsBv - 10 YR 6/8, sometimes lighter with greenish bleaching shperes

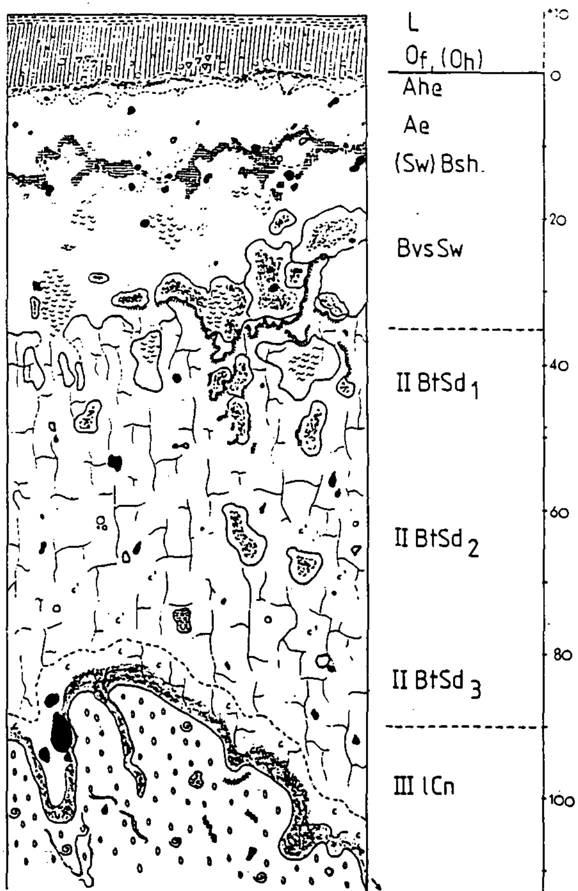
profile 1

profile 1

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	bulk dens. g/cm³	GPV %
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
113	Of	9- 3	n.d.											
114	Oh	3- 0	3,3											
115	Ahe	0- 10	1,6	4,9	43,5	44,3	92,8	3,9	1,6	0,5	6,1	1,2		
116	Ae	- 20	0,9	5,5	46,4	41,9	93,8	3,7	1,1	0,5	5,3	0.9		
117	Ae	- 30	1,0	7,9	43,2	43,4	94,6	2,9	0,8	0,1	3,9	1,6		
118	IIBsh	- 40	1,0	4,4	38,4	48,2	90,9	3,3	1,3	0,8	5,3	3,8		
119	IIBvs	- 55	0,9	4,0	30,0	57,1	91,1	4,1	0,6	0,6	5,2	3,7		
120	IIBvs	- 70	0,2	0,8	17,5	76,0	94,3	1,8	0,2	0,4	2,3	3,4		
121	IIBbsBv	- 90	0,1	0,4	32,6	62,4	95,5	1,6	0,2	0,3	2,1	2,4		
122	IIBbsBv	-105	0,1	0,5	48,7	47,3	96,5	1,2	0,2	0,4	1,8	1,7		
123	ICv	-120	0,1	0,5	35,3	52,0	87,8	9,7	0,4	0,2	10,3	1,9		

No.	hor.	pH H_2O	pH $CaCl_2$	Fe_o mg/g	Fe_d mg/g	Fe_o : Fe_d	Al_o mg/g	Al_d mg/g	Al_o : Al_d	Mn_o mg/g	Mn_d mg/g	P_a mg/g	$C_{org.}$ %	N_t mg/g
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
113			n.d.										43,6	16,4
114			2,5	0,77	0,94	0,8	0,62	n.d.		< 10	10		24,5	8,3
115			2,7	0,14	0,26	0,5	<0,40	<0,50	-	< 10	< 10	1	2,9	1,2
116			3,3	0,03	0,20	0,2	0,0	0,0	-	< 10	0	1	0,3	n.d.
117			3,4	0,02	0,24	0,1	<0,40	0,0	-	< 10	0	-	0,2	n.d.
118			3,1	3,39	5,16	0,7	0,52	0,60	0,9	< 10	< 10	68	1,0	0,6
119			3,7	2,24	3,88	0,6	1,52	1,55	1,0	< 10	< 10	19	0,8	0,7
120			4,2	1,56	2,24	0,7	1,59	1,42	1,1	< 10	< 10	9	0,5	n.d.
121			4,3	0,62	1,52	0,4	0,88	0,76	1,2	< 10	< 10		0,2	
122			4,2	0,34	1,23	0,3	0,42	0,52	0,8	< 10	< 10		0,2	
123			4,2	0,38	1,37	0,3	0,54	<0,50	> 1,1	< 10	< 10		0,2	n.d.

No.	hor.	C:N	carbon %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %	Fe_{py} mg/g	C_{py} mg/g
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
113		27				n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		
114		30				n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		
115		24		66,4		2,26	0,34	0,66	0,59	11,3	9,3	6	0,11	4
116				6,8		0,94	0,21	0,26	0,50	2,6	2,0	28	0,03	2
117				4,8		0,88	0,22	0,25	0,48	1,5	1,9	38	0,04	-
118		17		75,6		1,26	0,47	0,46	0,59	4,3	24,8	4	1,84	15
119		11		57,2		0,89	0,36	0,40	0,55	0,7	21,9	4	0,94	4
120				36,4		0,88	0,30	0,31	0,55	0,4	11,2	6	0,54	6
121				20,4		0,77	0,26	0,26	0,50	0,3	6,5	9	0,38	-
122				14		0,76	0,22	0,25	0,43	0,5	5,8	12	0,28	2
123				18		0,92	0,24	0,26	0,55	0,4	6,1	11	0,24	2



Soil description:

preponderant fresh - moist raw humus dominated by an Of-layer

mixture of solifluctive sands (slope wash from 'Hahnheide' hill) and reworked sandy loam from the subjacent ground moraine (Geschiebedeck-sand'), gravels /stones locally enriched; quite inhomogeneous

Munsell : Ahe/Ae - 7,5 YR 5/2
BvsSw - 7,5 (10) YR 4/4)

Younger Saalian (Fuhlsbüttel advance) sandy loam, boulder bearing, with moderate content of - often weathered - primary dark minerals, some glauconite; polyhedron structure

$BtSd_1$ more sandy than the following horizons (SL, partially even lS), possibly AlSw-relict?

$BtSd_2$ more clay skins (orange coloured illuvial clay), occurring as grain wraps or pore coatings, mostly relictic (secondary ruptured)

$BtSd_3$ here also recent/subrecent, undestroyed clay skins and humilluvic features, abruptic acidity change

Munsell key colour : $BtSd_{1-3}$ - 7,5 YR 5/4

discordant contact: marl (calcareous sandy loam), rich in soft powdery lime and cretaceous chalk pieces; belongs to a small upthrown fanet from deeper parts of the same ground moraine section (II), or from an older, subjacent moraine complex (middle Saalian) - indicated by the high chalky proportion.
chalk pieces are sedimentary, mostly rounded off, fossiliferous (marine assemblage);
'mortar-structure' sensu KUBIENA, low porosity;
Munsell : lCn - 10 YR 6/4

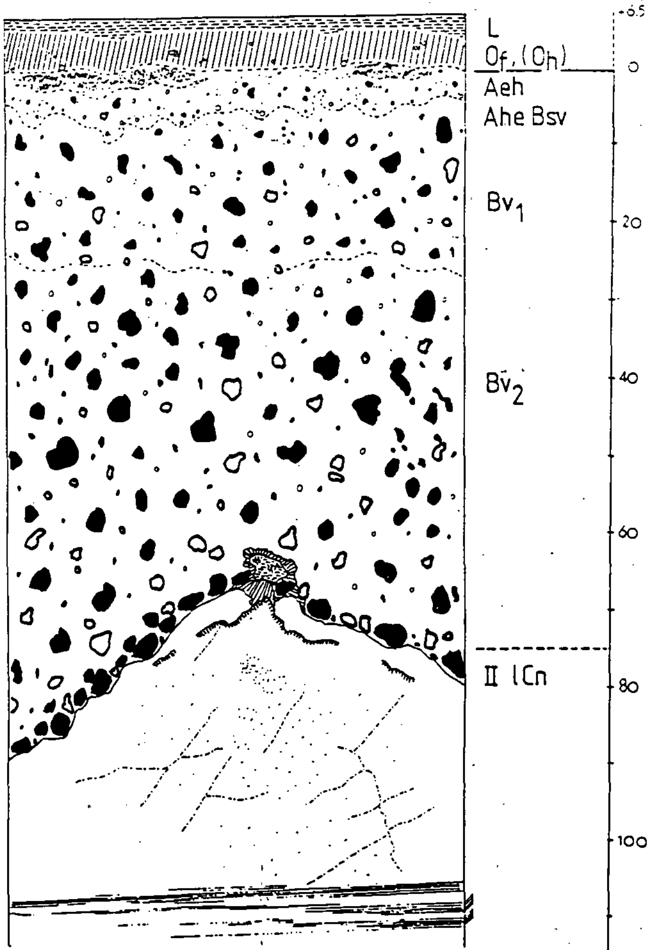
profile 2

profile 2

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand $\sum$	silt c	silt m	silt f	silt $\sum$	clay	bulk dens. g/cm³	GPV	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
228	Of	10- 0	n.d.												
229	Ae	- 20	3,2	5,3	41,7	38,5	85,4	6,4	4,1	0,8	11,3	3,2	1,51	46,9	
230	(Sw)Bsh	- 30	3,2	6,2	38,2	36,3	80,7	6,7	4,3	2,5	13,5	5,8	1,51	43,5	
231	BvsSw	- 45	3,1	5,2	33,7	34,5	73,4	8,5	6,2	4,0	18,7	7,9	1,58	40,9	
232	$IIBtSd_1$	- 60	3,9	4,0	27,8	30,8	62,6	7,2	6,9	3,8	17,9	19,6	1,60	40,1	
233	$IIBtSd_2$	-110	6,2	3,8	24,9	29,4	58,1	9,8	3,3	4,3	17,4	24,5	1,72	36,6	
234	IIIlCn	-130	2,8	4,0	24,6	32,1	60,7	9,6	7,0	4,6	21,2	18,1	1,84	36,1	

No.	water content in % at pF 0,6	1,8	2,5	4,2	pH H_2O	pH $CaCl_2$	Fe_o mg/g	Fe_d mg/g	Fe_o : Fe_d	Al_o mg/g	Al_d mg/g	Al_o : Al_d	Mn_o mg/g	Mn_d mg/g	P_a mg/g
228					4,1	n.d.									
229	31,0	19,9	9,9	1,7	4,5	3,1	0,16	0,54	0,3		0,21		2	12	2
230	32,9	23,1	15,5	4,4	3,9	3,3	1,77	2,66	0,7		0,79		4	20	16
231	31,9	21,3	17,0	4,1	4,1	3,9	1,33	2,67	0,5		0,86		22	33	> 0
232	33,2	29,5	25,0	12,9	4,1	3,8	1,16	4,49	0,3		1,46		11	28	-
233	33,2	30,0	25,1	17,7	4,7	3,9	0,79	6,77	0,1		1,51		34	59	-
234	30,4	26,9	23,4	14,1	7,3	7,5	0,30	2,86	0,1		0,56		116	144	1

No.	$C_{org.}$ %	N_t mg/g	C:N	carbon %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %	Fe_{py} meq/g	C_{py} meq/g
228	25,2	8,1	31												
229	1,0	0,2	50		35,9		2,2	0,4	0,5	0,6	3,5	9,0		0,09	4
230	1,3	0,4	33		103		1,8	0,5	0,6	0,5	2,5	39,8		1,10	9
231	0,3				55,4		5,7	0,6	0,7	0,6	0,5	26,1		0,75	4
232	0,3				152,8		2,2	1,4	0,9	0,7	0,6	79,3		0,50	3
233	0,2				189,2		32,7	2,3	11,2	1,1	0,5	73,0			
234	0,0	0,1		2,4	127,4		463,5	1,6	7,9	1,1					



Soil description:

temporary type between raw humus and mould, meagered

sandy-skeletal, carbonateless moraine facies with rel. high proportions of silt, slight loamy (partly even skeletal soil); interpreted as 'cover' - or ablation till, remained from several erosional processes on a dune elevation; moderate silicate content (weatherable), rel. high in ferrous oxides/hydrous oxides (probably some hematite)

Munsell : Aeh - greyish
AheBsv - 7,5 YR 3/4, little violet
Bv_1 - 7,5 - 5 YR 4/6
Bv_2 - 10 YR 4/6

structure : very loose, intense browning affected a grain aggregation by brown iron

non-skeletal, carbonateless aeolian fine sands, slight silty; fossil dune, deposited early Weichselian (periglacial) or latest Saalian, nearly silicateless, no signs for soil development

Munsell : lCn - 10 YR 6/4, partly lighter

EXPLANATION OF SYMBOLS

horizon boundary

stratum boundary

unconformable boundary (discordant)

dislocation/ fault lines, shear joints .... (often coated oxidic)

" Tüxen "- laminae

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slight impregnations/ coatings with iron-(manganese) oxides and hydrous oxides

more intensive enrichment/ precipitation of iron-(manganese) oxides, hydrous oxides (esp. ribbons)

iron-(manganese) concretions and cementations around weathered rocks

manganese oxides/ hydrous oxides (speckles)

mottling by static water; mottles with desoxidation and oxidation spheres (greenish/ reddish) ox. desox.

hydromorphic spots, punctuations

desoxidation spheres (more sandy, bleached)

frost cracks resp. crack- like bleaching zones (percolating waters)

---

organic surface layers : litter (L)

O_f and O_h

humic zones on wormholes, root channels ... (black - dark grey)

roots (fine, medium, coarse)

roots, torpid

wood or lignin - fragments

charcoal

humilluvic areas

---

gravels, rocks (often boulders); roundness and size indicated

enrichment of gravels and rocks

flint / frost splitted flint

pieces of chalk (mostly cretaceous), calcareous

weathering residues : weather- worn (often granitic)

weathering rests of mica / chlorite

---

fossils (zoölith)

artifacts

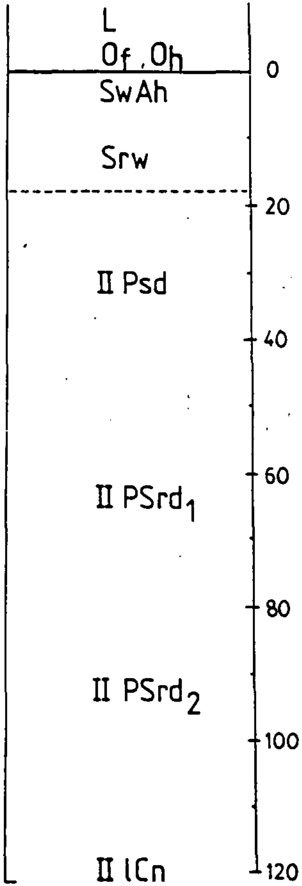
clay skins, undestroyed (often younger) c c c

clay skins, secondary ruptured, relictic (often older) c'c'c'

fabric faces (esp. polygonal, prisms ...)

bedding / cross- bedding or foreset beds

profile 5



Soil description:

temporary type between raw humus and mould, moist (most time of the year), nonacid

autochthoneous 'Geschiebedecksand', mixture of loamy sand, sandy loam and sandy-clayey loam, very inhomogeneous, boulder bearing

Munsell : SwAh - 5 Y 6/2
Srw - 5 Y 6/3

---

sandy clay or pure clay with little boulder content, carbonateless up to 110 cm, then calcareous (powdery lime and chalk pieces likewise)
belongs to an allochthoneous clayey outlier of 250 · 100 · 5 - 10m (depth) minimum extension; sedimentated here by glacial action during the Fuhlsbüttel advance (indicated by intense interfingering with the loamy ground moraine body);
striking direction (from the exposure): westerly
general decalcification depth : between 0,8 and 2,8 m
original stratification : investigations in microfossils are required

II PSd has iron oxides, concentrated in spots and mottles, mainly on root channels, some manganese oxides are obviously concentrated in veins

II PSrd intense desoxidation, bleaching
slickensides (tectogenetic) up to 0,5 m extent (also in PSd)

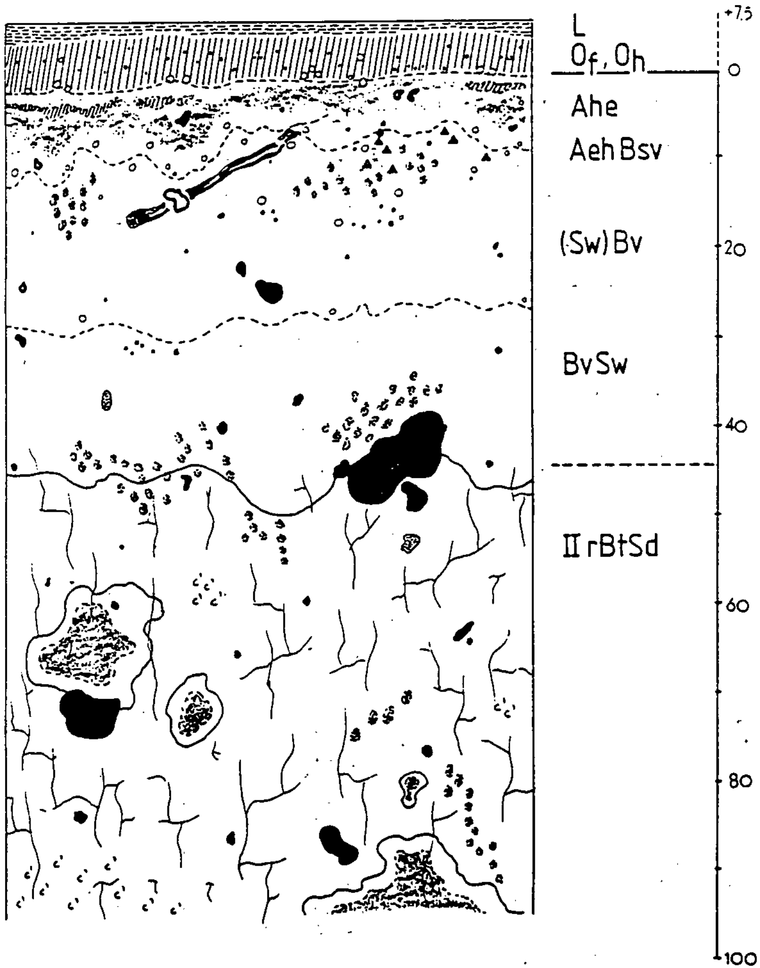
Munsell : PSd - 5 YR 5/8 (oxid.), 5 Y 6/3 (red.)
PSrd$_{1,2}$ - 5 Y 6/2 (red.)
lCn - 2,5 Y 5/2 - 4/2

profile 5

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil sand c	m	f	Σ	silt c	m	f	Σ	clay	bulk dens. g/cm³	GPV	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
92	Of	7- 5	n.d.												
93	Oh	5- 0	0,0												
94	Srw	0- 15	0,5	3,4	21,6	29,6	54,6	15,0	8,2	5,4	28,6	16,8	1,72	38,9	
95	IIPSd₁	- 35	0,1	1,4	6,7	8,0	16,2	6,2	9,2	8,7	24,1	59,7	1,43	49,0	
96	IIPSd₂	- 50	0,0	1,6	14,2	5,5	21,6	3,9	8,5	9,0	21,4	57,4	1,43	49,0	
97	IIPSrd₁	- 65	0,1	1,8	8,9	5,2	15,9	5,3	9,6	7,6	22,5	61,7			
98	IIPSrd₂	- 80	0,5	4,2	23,3	5,7	33,2	9,1	6,8	5,4	21,3	45,5			
99	IIPSrd₃	-100	0,7	2,0	10,9	8,0	20,8	5,7	7,7	9,8	23,2	56,0			
100	IIPSrd₄	-125	0,2	1,2	4,4	5,2	10,8	6,4	8,9	10,3	25,6	63,7			
101	IIlCn	-140	0,0	1,0	3,1	5,1	9,1	5,6	10,7	9,7	26,0	64,9			

No.	water content in % at pF 0,6	1,8	2,5	4,2	pH H_2O	$CaCl_2$	Fe_o mg/g	Fe_d	Fe_o : Fe_d	Al_o mg/g	Al_d	Al_o : Al_d	Mn_o mg/g	Mn_d	P_a mg/g
92						n.d.									
93					3,8	3,3									
94	32,8	30,0	26,0	12,6	4,2	3,7	2,24	1,94	1,2	0,68	0,99	0,7	44	25	26
95	47,4	47,3	44,9	38,8	4,8	3,8	8,32	10,47	0,8	1,86	1,66	1,1	182	188	4
96	47,4	47,3	44,9	38,5	4,8	4,0	6,97	8,84	0,8	1,34	1,27	1,1	88	103	4
97						4,0	3,58	4,99	0,7	1,22	1,29	0,9	76	72	4
98						4,1	2,02	3,93	0,5	0,75	0,97	0,8	77	111	
99						4,3	2,94	4,48	0,7	0,63	1,13	0,6	203	285	
100						5,8	2,72	5,52	0,5	0,41	n.d.	n.d.	269	326	
101						7,5	2,35	5,09	0,5	<0,40	n.d.	n.d.	914	763	

No.	$C_{org.}$ %	N_t mg/g	C:N	carbon %	CEC p meq/kg	a	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %	Fe_{py} meq/g	C_{py}
92	41,8	17,8	23												
93	17,5	8,2	21												
94	1,6	1,0	16		139		22,8	1,96	5,71	0,77	1,0	45,0	23		
95	0,4	n.d.			362		115,2	5,98	33,4	1,56	0,7	115,1	43		
96	0,3	n.d.			410		167,8	5,80	44,9	1,82	0,5	73,6	54		
97	0,2	n.d.			392		186,2	6,04	43,0	1,89	0,8	66,5	60		
98	0,2	n.d.			309		152,1	4,58	31,3	1,54	0,7	41,6	61		
99	0,2	n.d.			383		223,8	5,71	38,8	2,10	2,1	1,76	71		
100	0,3	n.d.			433		328,7	7,95	44,9	2,75	n.d.	n.d.	89		
101	0,4	0,7	57	0,9	362		629,4	4,21	37,9	2,84	n.d.	n.d.	186		



Soil description:

temporary type between raw humus and mould, 'meagered' and acidified

slight or moderate loamy, boulder bearing 'Geschiebedecksand' with distinct silt content; arised autochthoneous from the subjacent loam; inhomogeneous, charcoal in Ahe, AehBsv; fines mainly detrital (products of rock trituration), moderate content of - mostly weathered - primary dark minerals, some glauconite; numerous coarse organic residues, but very low fine humus

Munsell : Ahe - 5 YR 3/2, little violet
AehBsv - 7,5 YR 3/4
(Sw)Bv - 10 YR 6/8
BvSw - 10 YR 6/6

Younger Saalian aged, boulder bearing sandy loam - part of a more extensive ground moraine plateau -; upper part more sandy; mineralogy similar stratum I, but with more orange coloured illuvial clay (distributed very inhomogeneous): oriented fine clay strips, mostly ruptured clay skins on parting surfaces ...; polyhedron structure

Munsell : rBtSd - 10 YR 5/4 in general
decalcification depth : 435 m

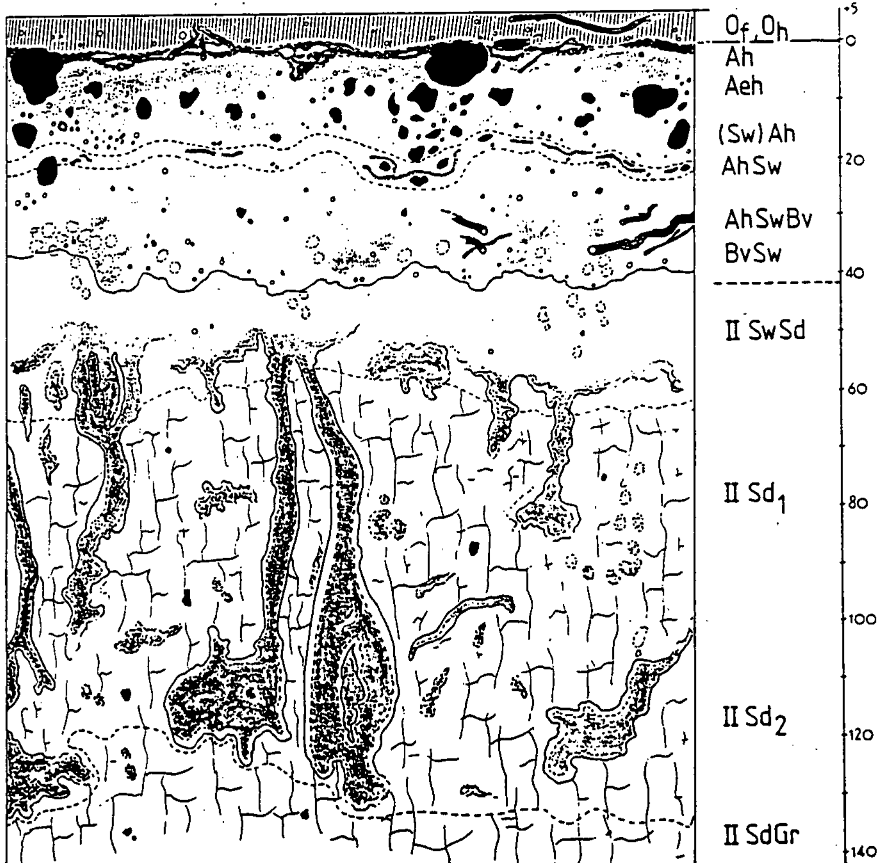
profile 6

profile 6

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	bulk dens. g/cm³	GPV	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
102	Of	5- 2	n.d.												
103	Oh	2- 0	0,0												
104	Ahe	0- 3	1,4	2,6	25,0	35,8	63,4	17,1	8,9	3,8	29,8	6,8			
105	AehBsv	- 10	3,5	3,1	21,9	36,4	61,4	17,7	8,6	3,4	29,7	8,9			
106	(Sw)Bv_1	- 20	5,6	5,3	21,4	35,8	62,4	17,1	8,6	4,1	29,8	7,9			
107	(Sw)Bv_2	- 30	4,9	3,4	21,9	34,6	59,8	18,1	9,5	3,9	31,5	8,7			
108	$BvSw_1$	- 50	7,4	4,7	23,5	32,1	60,2	18,8	7,7	3,4	29,9	9,9			
109	$BvSw_2$	A)- 90	20,8	7,3	41,8	35,5	84,6	8,1	2,6	1,2	12,0	3,5			
110	SwSd	B)- 90	8,5	8,0	34,0	27,7	69,7	11,5	3,9	3,1	18,5	11,9			
111	IISd	-105	0,0	0,9	3,9	5,5	10,3	7,2	12,2	9,2	28,5	61,2			
112	IISd	-120	0,1	3,0	14,1	10,7	27,7	5,9	9,9	8,0	23,7	48,6			

No.	water content in % at pF 0,6	1,8	2,5	4,2	pH H_2O	pH $CaCl_2$	Fe_o mg/g	Fe_d mg/g	Fe_o : Fe_d	Al_o mg/g	Al_d mg/g	Al_o : Al_d	Mn_o mg/g	Mn_d mg/g	P_a mg/g
102						n.d.									
103						2,9									
104						3,0	0,51	0,52	1,0	0,24	<0,50	>0,5	< 10	< 10	4
105						3,0	2,99	3,09	1,0	0,49	0,61	0,8	17	33	7
106						3,7	2,51	3,56	0,7	0,86	1,05	0,8	227	226	-
107						3,9	1,99	3,69	0,5	0,82	1,30	0,6	223	119	-
108						3,9	1,93	4,48	0,4	0,87	1,20	0,7	178	235	-
109						3,9	0,71	1,28	0,6	<0,40	<0,50	-	35	32	5
110						3,9	3,25	7,95	0,4	0,69	0,96	0,7	119	175	
111						4,2	2,78	6,89	0,4	0,76	1,13	0,7	146	151	
112						4,7	1,71	5,91	0,3	0,51	n.d.	n.d.	306	314	

No.	$C_{org.}$ %	N_t mg/g	C:N	carbon %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %	Fe_{py} meq/g	C_{py} meq/g
102	43,6	16,3	27												
103	25,7	10,8	24												
104	3,0	1,3	23		94,4		5,40	1,05	1,30	0,65	7,6	21,0	9	0,46	10
105	2,2	0,4	55		118		4,44	1,04	1,14	0,70	6,2	42,7	6	1,93	9
106	0,8	0,5	16		73,6		1,94	0,66	0,53	0,52	0,9	31,3	5	1,23	3
107	0,6	0,6	10		61,2		1,55	0,57	0,44	0,52	0,7	29,9	5		
108	0,2	n.d.			53,2		1,48	0,56	0,41	0,66	0,5	28,7	6		
109	0,1	n.d.			19,6		2,43	0,37	0,56	0,61	0,6	10,9	20		
110	0,1	n.d.			70		12,2	0,80	2,42	0,66	0,5	21,8	23		
111	0,2	n.d.			392		239,9	7,53	42,0	3,86	2,2	19,2	75		
112	0,2	n.d.			365		248,4	6,17	36,0	3,57	n.d.	n.d.	81		



Soil description:

autocnthoneous 'Geschiebedecksand' with rel. high boulder content (namely in the upper part); dark coloured (fossil or relictic Ap-horizon ?);
AhSwBv with diverse organic residues

Munsell : Aeh - 10 YR 3/2
AhSw - 10 YR 4/3
AhSwBv - 10 YR 5/6

Younger Saalian (Fuhlsbüttel advance) aged sandy loam with different fines, esp. detrital mica, also illuvial clay; glauconite bearing, primary dark minerals weatehred or partly weathered (also some heavy minerals)

II Sd_1 with illuvial clay concentrated in defineite zones grain coatings and clay skins on pores, interstices

II Sd_2 with much brown iron impregnated illuvial clay, esp. concentrated in reddish brown mottles. Munsell key colour $(Sd_{1/2})$: 7,5 YR 5/4
II SdGr has also illuvial clay, but lower bulk density; more intense bleaching

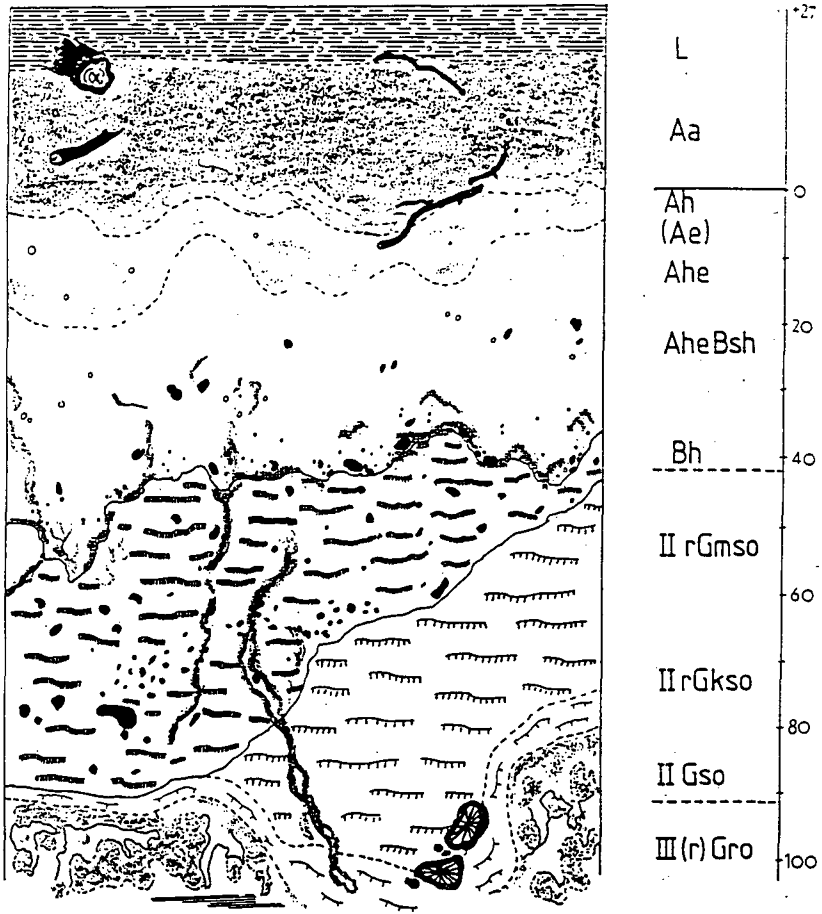
profile 7

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	bulk dens. g/cm³	GPV	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
217	Of	5- 0	n.d.												
218	Aeh	0- 3	7,0	2,2	26,9	31,5	60,6	21,7	9,0	2,6	33,2	6,2			
219	SwAh	- 18	2,3	2,6	24,8	30,9	58,3	22,6	8,9	3,1	34,7	7,0	1,21	53,1	
220	AhSwBv	- 35	1,9	3,4	25,1	27,1	55,6	24,5	9,4	3,3	37,1	7,3	1,25	54,6	
221	BvSw	- 45	2,5	3,9	26,7	34,7	65,2	15,5	7,7	3,4	26,6	8,2	1,52	47,0	
222	II Sd_1	- 80	3,0	4,2	24,4	36,5	65,1	10,8	7,0	4,3	22,1	12,9	1,76	35,9	
223	II Sd_2	A)-115	2,5	4,5	24,2	36,2	64,9	8,8	6,0	4,7	19,5	15,6	1,83	33,6	
224	II Sd_2	B)-115	1,5	3,1	31,2	39,4	73,7	8,3	5,9	4,0	18,1	8,2	1,92	28,1	
225	IISdGr	A)-160	1,3	5,0	24,0	35,4	64,4	9,9	7,1	4,3	21,3	14,3			
226	IISdGr	B)-160	1,2	4,3	25,5	37,1	66,9	10,2	6,9	3,7	20,8	12,3			

No.	water content in % at pF 0,6	1,8	2,5	4,2	pH H_2O	pH $CaCl_2$	Fe_o mg/g	Fe_d mg/g	Fe_o : Fe_d	Al_o mg/g	Al_d mg/g	Al_o : Al_d	Mn_o mg/g	Mn_d mg/g	P_a mg/g
217						n.d.									
218					4,1	2,8	0,74	1,64	0,5		0,35		8	28	8
219	49,2	45,1	26,6	6,1	3,9	3,3	2,19	2,54	0,9		1,24		5	24	7
220	48,6	42,3	31,9	7,2	4,2	4,2	2,46	3,47	0,7		4,05		3	25	21
221	38,5	35,2	27,1	4,8	4,4	4,2	2,28	4,57	0,5		2,06		8	26	8
222	28,0	23,2	17,4	9,0	4,2	3,8	1,50	6,17	0,2		0,96		9	31	4
223	26,2	22,3	17,0	11,4	4,9	4,0	0,92	6,96	0,1		0,96		12	27	16
224	24,6	22,1	17,8	5,9	4,9	3,9	0,49	1,10	0,5		0,52		3	20	
225						4,1	0,34	1,14	0,3		0,68		6	24	
226						4,1	0,18	0,51	0,4		0,60		3	12	

No.	$C_{org.}$ %	N_t mg/g	C:N	carbon %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %	Fe_{py} meq/g	C_{py} meq/g
217	39,2	15,0	26												
218	4,5	1,6	28								9,6	23,1		0,71	8
219	2,3	0,8	29		135,2		2,37	0,6	0,8	0,7	2,4	37,3		1,96	7
220	1,6	0,7	23		144		1	0,3	0,4	0,7	0,7	23,0		2,12	16
221	0,4				65,7		0,8	0,3	0,3	0,7	0,5	15,3		1,29	4
222	0,1				83,7		4,5	0,9	4,2	0,7	0,5	30,5			
223	0,1				95,4		17,8	1,4	17,5	1,1	0,5	16,1			
224	0,1				61,2		5,0	0,8	4,9	0,7	0,8	19,8			
225	0,1				88,6		23,0	1,5	22,7	1,1	0,5	10,8			
226	0,1				81,7		20,7	1,3	20,7	1,1	0,6	12,5			

profile 8



Soil description:

inital leaf mould

relictic half-bog layer, with numerous fine roots, dead wood fragments

unstratificated, boulder bearing sands (obviously 'Geschiebedecksand')

slight humilluvic zones

brown iron cementations, affected by lateral groundwater transport; groundwater depressions (about 5-7 m) during the last few years (road construction nearby) rendered all Go-horizons to a relictic state:

Gmso - brown iron occurred as massive, banked cementation

Gkso - " " " an enrichment of solid concretions

Gso - " " " unconsolidated sedimentation (earthy)

Munsell : Gmso - 7,5 YR 3/3

Gkso - 7,5 YR 3/3

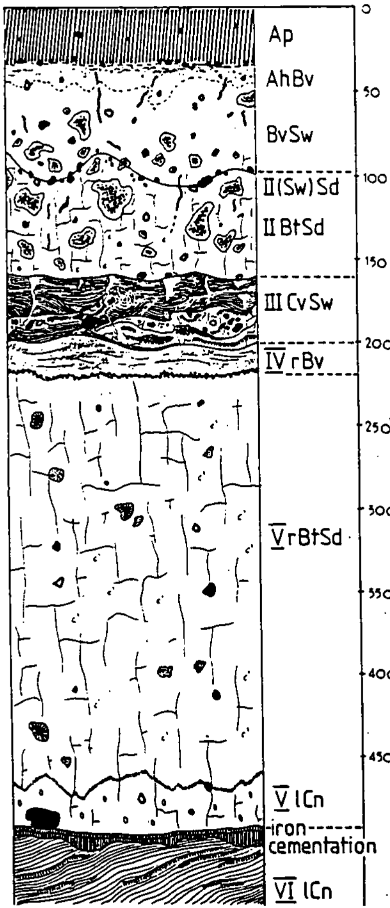
Gso - 7,5 YR 3/4

profile 8

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	bulk dens. g/cm³	GPV	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
187	L	27- 22	n.d.												
188	Aa	22- 0	n.d.												
189	(Ae)Ah	0- 10	2,1	2,4	34,6	32,0	69,0	19,7	6,2	2,3	28,2	2,8	1,55	43,2	
190	Ahe_1	- 20	1,9	2,4	33,4	33,8	69,6	18,4	5,8	2,2	26,4	4,0	1,42	46,2	
191	Ahe_2	- 30	3,3	3,5	32,6	27,9	63,9	21,5	7,4	2,0	30,9	5,3	1,42	46,2	
192	Bh	- 40	6,9	4,4	33,1	25,7	63,3	21,9	6,7	1,6	30,0	6,7	1,38	47,4	
193	$IIrGmsd_1$	- 50	7,1	4,6	34,3	30,2	69,1	17,1	6,0	1,2	24,3	6,6			
194	$IIrGmsd_2$	- 60	26,0	8,6	39,3	35,8	83,7	7,1	3,5	1,8	12,4	3,9			
195	$IIrGmsd_3$	- 70	34,6	10,6	43,0	35,6	89,2	3,2	2,9	1,7	7,7	3,1			
196	$IIrGksd_1$	- 80	25,4	9,4	48,4	31,1	88,8	2,4	2,9	2,3	7,6	3,6			
197	$IIrGksd_2$	- 90	16,2	6,9	46,5	39,6	93,1	2,8	0,3	0,8	3,9	3,0			
198	$IIIGro_1$	-100	0,8	2,2	21,5	61,6	85,3	4,1	1,7	1,3	7,1	7,6			
199	$IIIGro_2$	-110	3,3	4,8	34,2	47,5	86,5	3,8	1,0	1,0	5,8	7,8			
200	$IIIGro_3$	-120	22,4	3,6	51,7	32,9	88,2	3,1	1,5	1,1	5,8	6,1			

No.	water content in % at pF 0,6	1,8	2,5	4,2	pH H_2O	pH $CaCl_2$	Fe_o mg/g	Fe_d mg/g	Fe_o : Fe_d	Al_o mg/g	Al_d mg/g	Al_o : Al_d	Mn_o mg/g	Mn_d mg/g	P_a mg/g
187					n.d.	n.d.									
188					4,1	n.d.									
189	36,3	29,3	15,6	2,8	3,9	2,9	0,10	0,13	0,8	0,0	<0,50	-	< 10	12	1
190	41,4	31,9	20,9	3,6	4,0	2,8	0,16	0,22	0,7	<0,40	<0,50	-	< 10	< 10	79
191	41,4	31,9	20,8	4,9	4,0	3,1	0,37	0,46	0,8	1,10	1,50	0,7	< 10	11	67
192	43,3	31,0	18,8	9,3	3,9	3,7	8,05	10,50	0,8	6,36	6,62	1,0	< 10	40	43
193					4,3	3,8	11,26	11,40	1,0	6,29	6,46	1,0	30	101	48
194					4,3	3,9	10,88	15,10	0,7	5,66	6,10	0,9	73	248	105
195					4,3	4,0	6,10	5,98	1,0	4,71	4,87	1,0	60	119	172
196					4,1	4,1	4,39	4,50	1,0	4,15	4,06	1,0	93	125	161
197					4,1	4,0	2,50	3,03	0,8	3,64	3,48	1,0	26	67	121
198					4,4	4,0	1,70	1,83	0,9	2,79	2,47	1,1	24	48	33
199					4,4	4,1	1,68	1,70	1,0	1,84	1,13	1,6	40	63	
200					4,4	4,1	2,38	1,90	1,2	2,38	1,25	1,9		381	

No.	$C_{org.}$ %	N_t mg/g	C:N	carbon %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %	Fe_{py} meq/g	C_{py} meq/g
187	47,2	17,5	24												
188	45,6	18,8	25												
189	1,1	0,3	37		54,5		3,2	0,4	0,6	0,6	5,9	5,9		0,10	4
190	1,1	0,4	28		60,1		3,2	0,5	0,6	0,6	5,9	17,1		0,18	4
191	1,8	0,7	26		121		1,5	0,5	0,4	0,7	4,6	40,1		0,36	11
192	2,7	0,9	30		292,5		1,3	0,4	0,5	0,8	0,7	55,0		3,90	27
193	2,4	0,7	34		271,6		0,9	0,4	0,4	0,6	0,5	59,3		4,80	25
194	2,0	0,6	33		228,2		0,9	0,4	0,4	0,6	0,5	33,5		5,12	19
195	1,7	0,5	34		189,7		1,0	0,4	0,3	0,6	0,4	30,3		2,40	15
196	1,3	0,3	43		132,2		1,1	0,3	0,3	0,6	0,5	21,5		1,89	10
197	1,2	0,3	40		116,9		0,8	0,3	0,3	0,5	0,3	20,9		1,38	10
198	0,6	0,2	30		101		1,2	0,5	0,4	0,7	0,4	21,5		0,93	3
199	0,4				72,6		0,8	0,4	0,2	0,5	0,4	18,0			
200	0,4				67,4		0,9	0,3	0,3	0,5	0,3	12,8			



Soil description:

mollic epipedon, crumb structure, sharp defined subboundary

slight loamy, boulder bearing (namely basal) 'Geschiebedecksand'; derived from the subjacent moraine; charcoal in Ap/AhBv and BvSw
great amount of unweathered primary minerals, nemely biotite, some glauconite; fines mainly detrital mica, low illuvial clay; some iron/manganese concretions and spot accumulations; slightly developed subpolyhedron structure;
Munsell : AhBv - 10 YR 4/3, BvSw - 10 YR 5/6, partly mottled

Weichselian aged sandy loam (moraine A) with rel. low proportion of 'fresh' boulders, carbonateless; humic material only on wormholes, root channels fines also cryogenic detrital mica, but more illuvial clay on pores, natural parting surfaces (with undisturbed cutanes); numerous little iron/mangan. concretions and spots; partly static water bleaching; coars polyhedron structure; Munsell : II BtSd - 10 YR 6/6, mottled

diverse fine bedded, partly compressed and dislocated glaciofluvial sands with intercalations of loam, peat, gravel layers ..., very heterogeneous 'single-grain' structure in general, but partial tectogenetic squeezing zones (higher bulk density); iron/manganese concentrations small nodular (dark brown or black speckling), cone- like bleachings by percolating waters, generally browned with 10 YR-colours

slight loamy medium/coarse sand and silt with striking 'crumb-aggregation' structure (grains are impregnated by browned illuvial clay); macroscopic very homogeneous layer, sharp limited, possibly Eemian aged soil relict;
Munsell : rBv - 7,5 YR 5/6

Younger Saalian (Fuhlsbüttel advance) aged sandy loam (moraine B) with remarkable higher boulder content than moraine A; skeletal material weathered or partly weathered; decalcification depth : some 470 cm, the underlying calcareous loam bears chalk pieced and detrital lime; polyhedron structure;
Munsell key colour : 7,5 YR 5/4 in rBtSd, partly lighter in lCn horizon

parent ground moraine material, unweathered

stratificated meltwater sands / fine gravels (worked here), probalbly belonging to the Borgfelde Interstadial

profile 9

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	bulk dens. g/cm³	GPV %
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
124	Ap	0- 20	9,0	6,0	28,9	30,4	65,3	14,9	8,2	3,2	26,3	8,4	1,45	45,5
125	AhBv	- 30	26,1	6,5	28,1	28,9	63,6	17,3	9,0	3,1	29,4	7,0		
126	BvSw	- 47	10,4	9,2	27,0	29,5	65,7	16,3	7,8	2,8	26,8	7,5	1,64	40,1
127	AlSw	- 63	11,0	7,3	24,8	23,4	55,4	18,0	12,3	4,8	35,1	9,5	1,64	39,3
128	IIBtSd$_1$	- 80	0,8	3,6	21,3	17,1	42,0	11,7	19,9	8,4	40,0	18,0	1,53	44,0
129	IIBtSd$_2$	- 94	0,5	1,5	7,5	9,2	18,1	20,0	28,7	9,8	58,5	23,3	1,65	39,4
130	IIBtSd$_3$	-105	0,3	1,9	9,5	13,7	25,1	12,5	27,3	10,4	50,2	24,7		
131	IIICvSw$_1$	A)-115	6,8	29,7	48,2	13,8	91,8	2,4	1,3	0,9	4,6	3,7		
132	IIICvSw$_2$	B)-115	2,4	15,9	57,7	16,0	89,6	2,7	3,5	1,5	7,6	2,8		
133	IVSd$_1$	-123	18,7	31,9	25,5	7,4	64,9	6,8	9,7	3,9	20,3	14,8		
134	VCvSw$_3$	-130	2,9	16,0	59,2	10,4	85,6	2,5	4,2	2,0	8,7	5,7		
135	VISd$_2$	-143	29,4	27,0	28,6	7,1	62,7	8,6	11,2	5,3	25,1	12,3		
136	VIIrBv	-153	1,5	8,0	75,2	13,3	96,5	0,8	1,0	0,3	2,1	1,5		
137	VIIBtSd$_1$	-166	0,1	4,7	73,7	12,0	90,5	0,8	0,5	0,2	1,5	8,1	1,72	36,1

No.	water content in % at pF 0,6	1,8	2,5	4,2	pH H$_2$O	pH CaCl$_2$	Fe_o mg/g	Fe_d mg/g	Fe_o:Fe_d	Al_o mg/g	Al_d mg/g	Al_o:Al_d	Mn_o mg/g	Mn_d mg/g	P_a mg/g
124	40,5	29,2	19,6	6,7	5,7	4,9	2,98	5,31	0,6	1,80	n.d.	n.d.	657	754	114
125					5,7	5,0	2,47	4,42	0,6	1,83	n.d.	n.d.	525	612	116
126	34,8	27,9	15,3	6,4	5,5,	4,8	2,54	3,90	0,7	1,78	n.d.	n.d.	323	377	144
127	33,9	26,0	21,6	6,9	5,0	4,4	2,46	4,98	0,5	0,91	1,31	0,7	280	305	92
128	37,6	33,1	30,2	13,9	4,9	4,1	2,39	7,89	0,3	1,04	1,13	0,9	368	416	25
129	36,0	34,2	31,6	20,8	4,7	4,0	2,12	10,67	0,2	1,15	1,25	0,9	247	281	14
130					n.d.	4,0	5,93	23,36	0,3	1,27	1,22	1,0	826	881	8
131					5,0	4,2	0,94	3,15	0,3	<0,40	<0,50	-	140	186	26
132					5,0	4,2	0,43	1,32	0,3	<0,40	<0,50	-	19	33	
133					4,9	4,1	2,23	5,05	0,4	0,62	0,77	0,8	109	112	
134					5,2	4,2	0,56	2,53	0,2	<0,40	<0,50	-	102	110	
135					n.d.	4,3	3,09	6,75	0,5	0,50	0,77	0,6	85	136	
136					n.d.	4,5	0,54	3,29	0,2	<0,40	<0,50	-	51	68	
137	26,5	16,3	13,0	6,7	5,3	4,5	1,12	4,75	0,2	<0,40	0,65	<0,6	71	83	

No.	$C_{org.}$ %	N_t mg/g	C:N	carbon %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %	Fe_{py} meq/g	C_{py} meq/g
124	2,6	1,3	20		147		53,6	2,87	2,37	0,90	n.d.	n.d.	41		
125	0,9	0,6	15		76,8		19,0	2,74	1,35	0,68	n.d.	n.d.	31		
126	0,4	n.d.			61,2		10,6	2,33	1,00	0,59	n.d.	n.d.	24		
127	0,2	n.d.			65,6		18,7	2,39	2,67	0,50	0,5	9,8	37		
128	0,1	n.d.			145		31,9	2,13	12,8	0,85	0,5	26,8	33		
129	0,1	n.d.			157		35,5	2,26	24,0	1,19	0,5	40,4	40		
130	0,1	n.d.			193		32,1	2,10	27,3	1,36	0,3	44,0	33		
131	>0,0	n.d.		>0,0	18		5,24	0,48	3,51	0,59	0,6	6,4	317		
132	>0,0	n.d.		>0,0	14,4		3,94	0,36	2,39	0,59	0,8	11,3	297		
133	0,1	n.d.			101		21,9	1,51	17,1	1,03	0,5	32,4	41		
134	>0,0	n.d.			32,8		9,84	0,71	6,85	0,77	0,6	6,5	325		
135	0,1	n.d.			76		21,8	1,26	13,8	1,03	0,5	10,3	50		
136	>0,0	n.d.			11,2		3,07	0,44	0,63	0,43	0,5	1,8	41		
137	0,1	n.d.			36,8		19,5	1,10	7,46	0,68	0,5	3,3	78		

profile 9 (cont.)

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	bulk dens. g/cm³	GPV	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
138	$BtSd_2$	A)-180	1,4	5,3	27,0	32,5	64,8	9,7	7,3	3,8	20,7	14,6	1,76	34,7	
139	$BtSd_2$	B)-180	3,8	6,7	24,7	30,1	61,6	11,4	7,0	4,3	22,6	15,8	1,76	34,7	
140	$BtSd_3$	-200	1,9	5,8	25,9	30,0	61,8	11,5	6,5	5,0	23,1	15,2	1,76	34,7	
		380											1,73	35,0	

No.	water content in % at pF 0,6	1,8	2,5	4,2	pH H_2O	pH $CaCl_2$	Fe_o mg/g	Fe_d mg/g	Fe_o : Fe_d	Al_o mg/g	Al_d mg/g	Al_o : Al_d	Mn_o mg/g	Mn_d mg/g	P_a mg/g
138	30,0	28,0	23,0	12,0	5,2	4,7	0,82	3,99	0,2	<0,40	n.d.	n.d.	118	157	
139	30,0	28,0	23,0	13,9	5,2	4,7	1,72	3,06	0,6	<0,40	n.d.	n.d.	101	136	
140	30,0	28,0	23,0	13,1	5,2	4,7	1,63	2,94	0,6	<0,40	n.d.	n.d.	90	143	
	30,6	30,0	24,6		5,2										

No.	$C_{org.}$ %	N_t mg/g	C:N	carbon %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %	Fe_{py} meq/g	C_{py} meq/g
138	0,1	n.d.			37,2		37,7	1,64	16,5	0,91	n.d.	n.d.	153		
139	0,1	n.d.			97,2		44,1	1,81	18,9	0,99	n.d.	n.d.	68		
140	0,1	n.d.			110		43,8	1,85	18,8	1,03	n.d.	n.d.	60		

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Guidebook for a tour of landscapes, soils and land use in the Federal Republic of Germany

Tour I
Freshwater-marsh of the Elbe river

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1. Introduction

Hamburg is marked by two heavily contrasting landscape units: "geest" and "marsh". The "geest" includes the higher situated areas of Pleistocene origin which will be visited on excursion K. The river Elbe has incised its way into these sediments and has created a low lying freshwater-marsh that crosses the Hamburg territory from east to west as a valley 6 - 14 kilometers wide.

It is the intention of this excursion to show you the soils of the Elbe valley. You will see the regions of the Moorwerder and Vier- und Marschlande in the southeast of Hamburg, covering with their 135 square kilometers almost 20 % of the Hamburg territory. This area is used for horticulture and farming and only few people live here (about 1.5 % of the Hamburg population).
There will be four sections in our excursion:

1. The almost undisturbed development of the recent freshwater-marsh will be demonstrated in the nature reserve "Heuckenlock" (profile 1 and 2).
2. The effect of cultivation like diking, polder farming and filling of sand will be shown in profile 3 and 4.
3. As an example for a young anthropogene influence on the marsh we will show you an upland landfill of harbour mud.

4. Particularities at the border between marsh and geest will be illustrated in the nature reserve "Boberger Niederung" (profile 5).

The Hamburg marsh and the properties of its soils can only be understood by considering the different processes which formed the Elbe valley including the cultivation efforts of the people living here. Therefore, we will try to combine the aspects of geology, physiography, hydrology and cultivation by man into a description of the development of landscape.

2. Development of landscape

The simplified description is based on ARGE ELBE 1984, BAUBEHÖRDE 1983, BENZLER 1971, EHLERS 1986, FINDER 1922 and 1935, GRIMMEL 1973, HINTZE 1977 and 1982, HÜBBE 1869, ILLIES 1952, KLEINEIDAM 1983, LINKE 1979 and 1982, MIEHLICH 1982, PALUSKA 1975 and 1976, SCHINDLER 1960, SIMON 1964.

During the Middle Saalian glaciation (about 150,000 to 130,000 b.p.) the area of the excursion was covered up to the height of more than 40 meters above sea level with melt water sand and till. These glacial sediments today are forming the slopes of the Elbe valley (figure 1). During the Younger Saalian glaciation (about 130,000 to 100,000 b.p.) the incision of the Elbe valley began. But only by the enormous water quantities resulting from the Weichselian glaciation (about 70,000 up to 10,000 years b.p.) that flow off the Elbe, the valley was excavated to its present width and down to a maximum depth of 35 meters below the present sea level. Thereby Pleistocene and Tertiary layers in the subsoil were incised (figure 1). Towards the end of the Weichselian glaciation the valley of the Elbe was filled first with gravel and later on with sands up to a height of about 5 meters above sea level. Formed into dunes some of these sands still exist at the edges of the Elbe valley (profile 5). Often they are combined with moors originating from the late glaciation. Later the central part of the Elbe valley was excavated for a second time to a maximum depth of 15 meters below today's sea level.

The Holocene sedimentation (since about 10,000 years b.p.) began with medium and fine sands. During the post glacial sea level rise the tidal influence reached our region at about 5,000 years b.p., causing a strong change in sedimentation conditions.
Along the main river channels sandy levees arose, while in the deeper lying

FRESHWATER MARSHES OF THE ELBE RIVER EAST OF HAMBURG

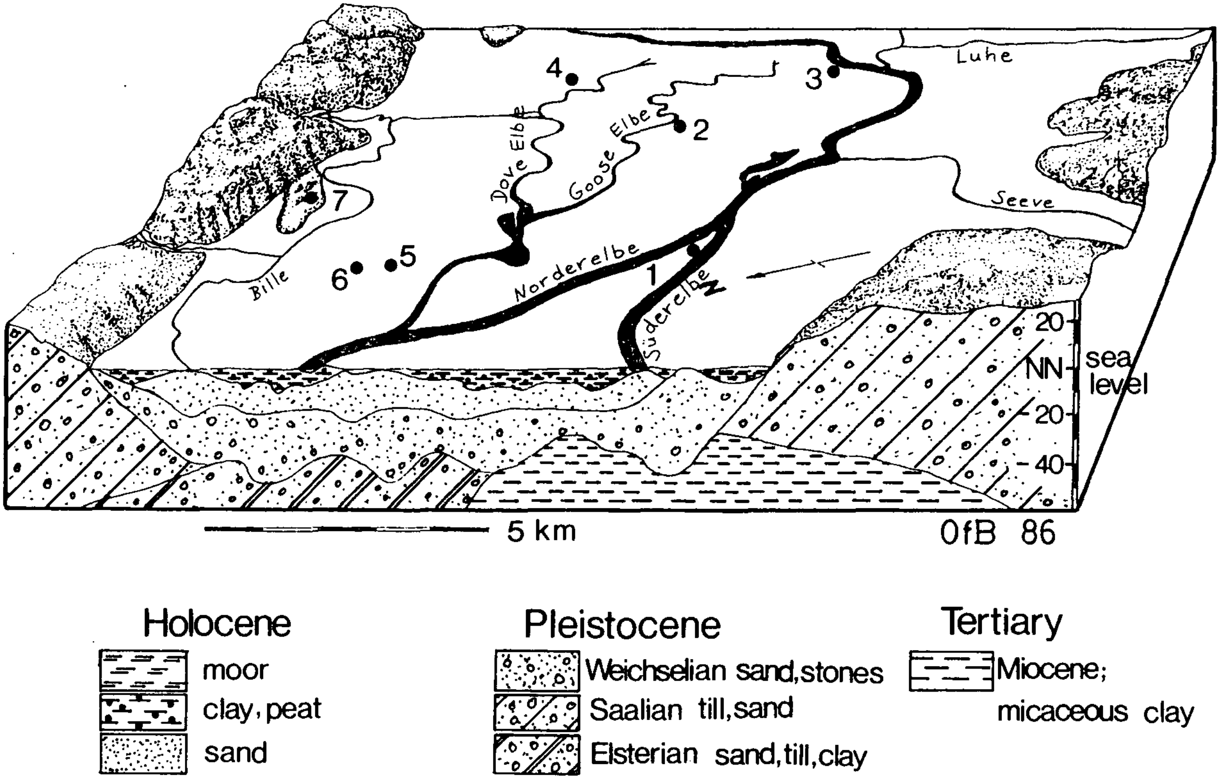

Fig. 1: perspective block of the excursion area; excursion sites see fig. 2.

intertidal regions a humus-poor, silt-rich clay ("lower clay") was sedimentated through a tidal channel network.
From about 4,000 up to 2,000 years b.p. the sea level rise slackened and finally stopped. At this time vast areas turned into a swamp covered by an alder forest. Its remains superimpose the lower clay as mud and peat. Many prehistorical discoveries prove that at this time man settled intensely on the border dunes (neolithic tools in profile 5).

Since about 2,000 years b.p. the sea level rose again and by clearings at the upper course the sediment load of the Elbe increased heavily. Both factors led to a reactivation of sedimentation, so that the organic layers are covered by a 30 - 80 cm thick deposition of a humus-rich silty clay ("upper clay"). The sedimentation came to an end about 1 to 2 meters above sea level when between the 12th and the 16th century the greater part of the areas between the main tributaries of the Elbe were diked. Now sedimentation only was possible when the dikes broke on account of storm tides. The numerous ponds along the dikes show that the marsh areas have been flooded frequently after dike breaks. Even today the marsh is threatened by storm tides. During the storm tide of 1962 vast parts of the excursion area were flooded and many people lost their lives.

The river marsh has been cultivated methodically. The farm houses follow the line of the dikes with their grounds extending in narrow stripes rectangular from the dike. On account of the high ground-water level and also of the water supply via the semi-artesian upper aquifer, the diked areas must be constantly drained. The water is drained from the fields to the higher situated receiving streams by a regular system of open ditches, in historic times via locks, later on via water-mills operated by wind, and today by pumping units. As the excavated material was deposited on the fields, there were formed narrow arching field stripes, some of them still existing. By draining and raising it was possible to obtain a ground-water level of about 60 - 80 centimeters, necessary for horticulture and farming (profile 4). In some areas the soil has so much clay to make horticulture impossible. In consequence some of the land close to the farms has been covered with sandy sediments up to 80 centimeters (profile 3).

During the diking of the Elbe two of her tributaries (Dove Elbe and Goose Elbe) were closed by dams at their up-current branching. Therefore the tributary in the far south became the main stream. Shortly before the harbour area, the main current today is divided into the "Norderelbe" and the "Süderelbe". Above all by the current construction devices (maintaining the depth of the navigable channel at 13.5 meters below low water level, narrow dike construction, erection of barrages) the tidal range has changed drastically. In 1850 the tidal range of the Elbe in Hamburg amounted to about 50 centimeters only. In 1900 it rose to about 100 centimeters. Today it is 320 centimeters. This enormous rise influences the sedimentation and the soil development in the areas in front of the dikes (profile 1 and 2).

3. Climate

The closeness to the sea causes a climate that is influenced by the ocean. In long-standing average in Hamburg there are about 740 mm of rain throughout 230 days of the year. The excursion area is in the lee of the Harburg mountains and therefore it gets about 100 mm less rain. The air humidity is high with an average of 80 %. Sun is shining in 36 % of the possible sunshine length and there are almost 90 days without sunshine. The yearly average temperature is about 8.5 °C. On 22 days it is warmer than 25 °C and on 82 days the temperature is below zero. In winter time we have cold weather with drizzling rains known throughout Germany as the typical "Hamburg weather". In summer time, often there are sun, clouds, and rain showers, all during one day.

Winds blow mostly from the southwest. But there are also winds from the southeast and the northwest. During the winter, there are storms, even hurricanes. If the wind blows from the southwest, it may cause the dreaded storm tides. Almost half of the rain fall evaporates and there are about 370 mm per year of deep sepage or surface run-off. Areas with deep ground-water level have an "udic soil moisture regime" (USDA 1975) and the soil temperature regime is "mesic". The high ground-water level causes an "aquic moisture regime" in most parts of the marsh.

4. Natural Vegetation

The potential natural vegetation of the marsh depends on the duration and the frequency of the flooding as well as on the kind of sediments. According to PREISINGER (1985) there are reed swamps within the tidal range. Above the high water line there are soft wood and hard wood alluvial forests. The moors were covered with alder fenwood and the dunes had woods of oak and birch. By intensive farming the natural plant growth has been nearly destroyed. Only in nature reserves (profile 1,2,5) and along ditches and small ponds some remains can be found (UMWELTBEHÖRDE 1983).

5. Land Use

In the 17th century the cultivation of vegetables, berries, and ornamental plants already predominated in the eastern Hamburg marshes. The products were shipped to Hamburg by boat and sold at the markets. Today there are, according to the BEHÖRDE FÜR WIRTSCHAFT, VERKEHR UND LANDWIRTSCHAFT (1984), about 1,200 horticultural and about 200 farming establishments in the Vier- und Marschlande. About 1,300 ha are used for horticulture. About 55 % of the area is for vegetables and on 40 % of the ground ornamental plants are being cultivated. This is about 10 % of the ornamental plant cultivation of the entire Federal Republic of Germany. Remarkable are the vast areas of green houses and hotbeds. They cover an area of about 200 hectares. Many kinds of Flowers and early vegetables are raised under glass. In farming meadows predominate the cultivation of cereals and root crops.

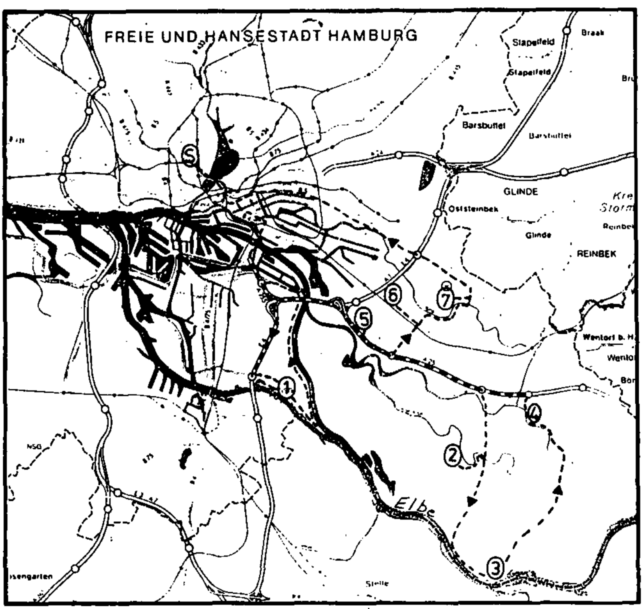

Fig. 2: route of excursion and points of visit; s=starting point, 1=site 1, 2=site 2, 3=lunch, 4=Rieck museum, 5=site 3, 6=site 4, 7=site 5.

6. Route description and time table

The starting point of our excursion, the Congress Center Hamburg, is situated on the Saalian geest at about 20 m above sea level (S in fig. 2). After a few hundred of meters the street goes down to the Alster river, which has been dammed up to its present form in the 17th century. We see parts of the harbour, cross the northern main stream of the Elbe and come to the island of Moorwerder. The nature reserve "Heuckenlock" is situated in front of the dike slightly down-stream of the branching of the Elbe river into Norderelbe and Süderelbe (point 1 in fig. 1 and 2).

On our tour to site 2 we cross the industrial area in the east of Hamburg. Main problems of this region are

- the strong immission of heavy metals from a copper melting plant,
- the immission of organic compounds from a closed plant having produced pesticides, and
- ground-water contamination from the disposal area Georgswerder highly polluted by dioxines.

This industrial area borders to the eastern Elbe marsh intensely used by horticulture and farming. We will pass it on our way to site 2 (point 2 in fig. 1 and 2).

Lunch will be served in a restaurant right at the Elbe river (point 3 in fig. 1 and 2). From there on narrow dike roads we will reach the Rieck museum (point 4 in fig. 1 and 2), an old farmhouse with a thatched roof, showing the life conditions of a marsh farmer of the 17th century. We will follow the dike road up to a landfill of harbour mud (site 3, point 5 in picture 1 and 2). The development of the marsh lands along the margin of the Elbe valley is shown on site 4, situated little to the north of site 3 (point 6 in fig. 1 and 2). The last site of the excursion (site 5, point 7 in fig. 1 and 2) is situated on the dunes of the nature reserve Boberger Niederung. We return to the point of departure along the upper slope of the Elbe valley.

Time table:

	arrival	departure
start of excursion		8.30
site 1 (soil profiles 1 and 2)	9.00	10.30
site 2 (soil profile 3)	11.00	12.00
lunch	12.15	13.30

	arrival	departure
Rieck museum	14.00	14.30
site 3 (landfill of harbour mud)	15.00	15.30
site 4 (soil profile 4)	15.45	16.45
site 5 (soil profile 5)	17.00	18.00
Following the excursion I would like to ask you to a little garden party and I will be happy to see you as my guests:		open end
In case you cannot take part the bus will bring you back to our starting point:	18.45	

7. Acknowledgements

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PROFILE 1

Site description:

Location: 10°02'35" E, 53°28'23" N **Elevation:** 3.0 m

Landform: top of levee of the Elbe-river

Slope: flat

Drainage: well drained, ground-water level at 200 cm, inundated during winter in 9 of 10 years

Vegetation: alluvial forest (Populus spp., Salix spp., Fraxinus excelsior, Urtica dioica, Senecio fluviatilis)

Use: nature reserve

Parent material: tidal influenced alluvial sands and preweathered sandy loams of the Elbe-river

Soil classification:

FAO : Eutric Fluvisol
GER : Typische Kleimarsch
SOIL TAX.: Mollic Udifluvent

Profile description:

No	horizon	depth	
1	Ah(1) Ah1	0- 15	very dark gray (10YR3/1m), dark gray (10YR4/1d), weak loamy sand (l'S), very weak medium to coarse granular and subangular blocky, very friable (moist), soft (dry), common roots, gradual wavy boundary.
2	Ah(2) Ah2	15- 25	dark grayish brown (10YR4/2m), light brownish gray (10YR6/2d), sand (S), very weak coarse subangular blocky, very friable (moist), soft (dry), few roots, gradual broken boundary.
3	Cn C	25- 40	light yellowish brown (10YR6/4m), very pale brown (10YR7/3d), sand (S), single grain, loose, clear wavy boundary.
4	IIaM 2Cw	40- 60	dark yellowish brown (10YR4/4m), loamy sand (l'S), moderate coarse subangular blocky, friable (moist), soft (dry), few roots, gradual smooth boundary.
5	IIaMC 2Cw	60- 90	yellowish brown (10YR5/6m), mottles (10YR4/4m), weak loamy sand (l'S), moderately weak medium subangular blocky, very friable (moist), soft (dry), few roots, gradual wavy boundary.
6	IIICM 3C	90- 130	light yellowish brown (10YR6/4m), sand (S), single grain, loose, clear smooth boundary.

PROFILE 1

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil									kf	
				sand				silt				clay	med. m/d	var.
				c	m	f	Σ	c	m	f	Σ			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ah1	- 15	n.d.	0.1	35.1	54.4	89.5	2.3	1.5	1.3	5.2	5.3	27.0	n.d.
2	Ah2	- 25	n.d.	0.1	38.3	57.7	96.1	1.0	0.2	0.6	1.8	2.1	n.d.	n.d.
3	C	- 40	n.d.	<0.1	55.9	42.6	98.6	0.4	0.1	0.1	0.6	0.9	7.4	n.d.
4	2Cw1	- 60	n.d.	<0.1	5.2	63.8	69.1	10.2	6.1	4.3	20.6	10.3	<0.1	n.d.
5	2Cw2	- 90	n.d.	<0.1	2.4	77.9	80.3	8.8	2.7	1.7	13.1	6.6	2.2	n.d.
6	3C	-130	n.d.	0.1	13.9	82.8	96.4	1.2	0.6	0.1	2.0	1.6	1.4	n.d.

No.	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF				pH		Fe_d	Fe_o	Fe_o : Fe_d	Mn_o	P_a
				0.6	1.8	2.5	4.2	H_2O	$CaCl_2$	mg/g			mg/kg	
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Ah1	0.88	67.1	53.5	38.2	27.1	12.5	7.3	6.6	3.7	1.1	0.3	0.5	108
2	Ah2	1.38	49.0	40.5	18.0	10.2	5.8	7.9	6.6	1.5	0.6	0.4	0.1	38
3	C	1.50	44.4	33.2	13.2	9.0	2.7	7.6	6.5	0.8	0.2	0.3	<0.1	7
4	2Cw1	1.46	46.7	40.0	33.6	23.2	9.2	7.2	6.1	5.7	2.5	0.4	0.3	22
5	2Cw2	1.40	47.7	40.9	34.9	23.1	7.2	7.3	6.3	3.6	1.6	0.4	0.2	34
6	3C	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	7.0	6.4	1.1	0.4	0.4	<0.1	21

No.	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC meq/kg		exchang. cations in meq/kg						V
						p	a	Ca	K	Mg	Na	H	Al	%
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ah1	4.4	3.3	13.5	0	136	n.d.	154	4.0	19.1	4.9	2	0	>100
2	Ah2	0.9	0.7	13.3	0	36	n.d.	41	1.1	5.9	1.9	2	0	>100
3	C	0.2	0.1	11.4	0	12	n.d.	10	0.3	2.1	1.2	2	0	>100
4	2Cw1	0.6	0.6	10.3	0	76	n.d.	68	1.6	14.0	2.9	2	0	>100
5	2Cw2	0.3	0.2	14.2	0	48	n.d.	41	1.0	8.8	2.3	2	0	>100
6	3C	0.1	<0.1	6.0	0	12	n.d.	13	0.4	3.2	1.6	2	0	>100

PROFILE 1

1. Genesis

We can differentiate three phases of sedimentation: holocene sands, characteristic for the banks of the main arms of the river (hor. 6); meadow loam, originating from medieval clearings at the upper course of the Elbe and deposited as allochthonous soil sediment (hor. 5 and 4); recent sands, caused by the rise of the tide since 1850. Humus accumulation in the topsoil and mottles in the subsoil are the only indications of soil formation. It cannot be decided to which degree the properties of the meadow loam were changed in situ.

2. Classification

Diagnostic horizons, -properties (FAO/SOIL TAXONOMY):
hor.

1+2 ochric A horizon/-epipedon (not more than 25 cm thick; in hor. 2 colour value >3.5 moist and >5.5 dry)

3 C layer

4+5 C layer (no cambic horizon because horizon consists of alluvial transported soil material; lying below a C layer; stratification within the horizon)

Classification FAO:

Fluvisol (recent flucial sediment; only ochric A horizon is diagnostic; organic matter decreases irregularly with depth)

Eutric Fluvisol (no sulfuric horizon or sulfidic material; not calcareous; base saturation >50%)

Classification SOIL TAXONOMY:

Entisol (only ochric epipedon is diagnostic)

Fluvent (no aquic properties; no fragments of diagnostic horizons; in hor. 4 texture is finer than loamy fine sand; >25 cm thick; slope <25%; org. carbon decreases irregularly)

Udifluvent (udic moisture regime)

Mollic Udifluvent (hor. 1+2 >15 cm; colour value moist <3.5)

Classification FRG:

Typische Kleimarsch (profile within the marsh; horizon sequence Ah-(C-aM-C-)Go-Gr; free of lime >4 dm; upper limit of Go >8 dm)

3. Soil association

The area between dike and river can be divided into two mapping units. Close to the river there are sandy levees, which are transformed by erosion and

PROFILE 1

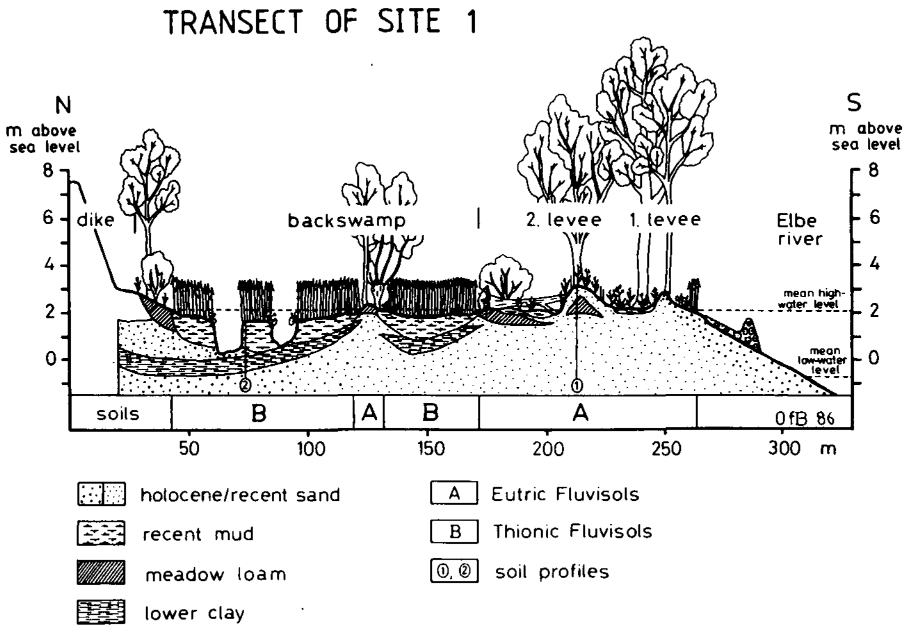

Fig. 3: transect of site 1, vegetation according to PREISINGER 1985

sedimentation every year. In this part different forms of Eutric Fluvisols are developed. Their properties mainly depend on mikro-topography. Profil 1 is situated on the second levee and represents the most developed stage of these young soils. The plain ground between the levees and the dike is flooded twice daily. The reduced rapidity of flow results in sedimentation of recent mud in the reed bank, in which Thionic Fluvisols are developed.

4. Soil ecology

The water regime of profile 1 shows large seasonal variations. During winter the soil is inundated about 50 times. In summer the ground-water level is at appr. 200 cm below surface. The plant-available water capacity to a depth of 1 m is about 225 mm, so that even longer dry periods will not limit the water supply of the vegetation. Soil reaction of the whole profile is slightly alkaline. CEC and the amount of exchangeable cations are low to moderate. The nitrogen supply is high, in part because of small portions of mud sedimentated during inundations.

PROFILE 2

Site description:

Location: 10°02'40" E, 53°28'27" N **Elevation:** 1.5 m

Landform: backswamp, dissected by tidal channels

Slope: flat

Drainage: very poorly drained, below middle tidal high-point

Vegetation: reed bank (Phragmites australis, Caltha palustris)

Use: nature reserve

Parent material: tidal influenced recent mud of the Elbe river

Soil classification:

FAO : Thionic Fluvisol
GER : Ästuarines Schlick-Übergangswatt
SOIL TAX.: Typic Sulfaquent

Profile description:

No	horizon	depth	
1	Fr(1) Lr1	0- 30	very dark grayish brown (10YR3/2m), dark brown (10YR4/3d), weak clayey loam (t'L), moderate very fine and fine subangular blocky, very friable (moist), slightly hard (dry), common very fine roots, few large rhizomes of Phragmites australis, n-value >0.7 (field test).
2	Fr(2) Lr2	30- 60	very dark grayish brown (10YR3/2m), dark brown (10YR4/3d), weak clayey loam (t'L), moderate very fine and fine subangular blocky, very friable (moist), slightly hard (dry), common fine roots, few large rhizomes of Phragmites australis, n-value >0.7 (field test), gradual smooth boundary.
3	Fr(3) Lr3	60- 90	black (5Y2/2m), dark grayish brown (10YR4/2d), sandy clayey loam (stL), moderately weak very fine and fine subangular blocky, very friable (moist), hard (dry), few very fine to fine roots, few large rhizomes of Phragmites australis, n-value >0.7 (field test), clear smooth boundary.
4	IIGr(1) 2Cr1	90- 100	dark olive gray (5Y3/2m), dark gray (10YR4/1d), loamy sand (l'S), very weak fine and medium subangular blocky, very friable (moist), soft (dry), few fine roots, clear wavy boundary.
5	IIGr(2) 2Cr2	100- 110+	black (N2m), after several hours of air exposure dark olive gray (5Y3/2m), dark gray (10YR4/1d), sand (S), single grain, loose (moist), soft (dry), many fragments of shells.

PROFILE 2

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf med. m/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Lr1	- 30	n.d.	<0.1	4.5	27.0	31.5	10.8	16.0	10.1	36.8	31.7	n.d.	n.d.
2	Lr2	- 60	n.d.	0.3	7.1	26.0	33.4	9.7	13.9	11.6	35.1	31.5	n.d.	n.d.
3	Lr3	- 90	n.d.	0.2	10.2	36.2	46.6	7.8	10.2	8.9	26.9	26.5	n.d.	n.d.
4	2Cr1	-100	n.d.	0.7	22.8	55.2	78.7	4.2	3.3	2.7	10.3	11.1	n.d.	n.d.
5	2Cr2	-110+	n.d.	0.5	24.1	66.4	90.9	1.5	2.9	< 0.1	4.2	4.9	n.d.	n.d.

No.	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Lr1	0.44	84.5	n.d.	n.d.	n.d.	n.d.	7.3	6.4	39.5	32.8	0.8	2.3	842
2	Lr2	0.40	86.8	n.d.	n.d.	n.d.	n.d.	7.3	5.9	41.9	30.5	0.7	2.1	675
3	Lr3	0.57	78.9	n.d.	n.d.	n.d.	n.d.	7.2	5.8	40.6	30.9	0.8	1.5	533
4	2Cr1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	7.4	4.5	11.1	8.7	0.8	0.3	175
5	2Cr2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	7.5	6.5	4.6	4.5	1.0	0.1	292

No.	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Lr1	9.0	5.8	15.5	0	496	n.d.	283	6.5	54.6	22.6	1.5	0.4	74
2	Lr2	8.4	2.8	29.6	tr.	444	n.d.	232	5.6	43.6	17.4	1.1	0.4	67
3	Lr3	6.8	4.2	16.2	tr.	398	n.d.	220	5.8	39.0	16.7	1.1	0	71
4	2Cr1	3.5	2.4	14.5	tr.	206	n.d.	216	4.1	39.7	12.2	5.6	13.2	> 100
5	2Cr2	0.9	n.d.	n.d.	tr.	42	n.d.	279	1.1	10.6	4.2	1.1	0	> 100

PROFILE 2

1. Soil genesis

Historical maps of the 18th century show, that at this time site 1 was a small island, which was seperated from Moorwerder by a small subsidiary river arm. On the bottom of this river arm sands were deposited (hor. 5). In the course of time the up-stream branching was dammed and the subsidiary river arm became a marsh creek. Analogous to the decrease of flow rapidity, the portion of fine grained humus-rich mud increased, reaching 70% in the sediments of the horizons 1 and 2. The organic matter of the horizons 1 - 3 consists in part of allochthonous humic substances of the mud and in part of autochthonous humus of the reed debris. In the first horizon the redox potential varies in a micro-pattern between +400 and -200mV. The deeper horizons are strongly reduced (KERNER 1985). In the partly oxidized first horizon the total content of sulfur varies from 0.4 to 0.7 %. It is raised to 0.7 - 1.6 % in the horizons 2 and 3 (ELBRACHT 1986). We assume that in the reduced horizons sulfides predominate. According to the position within the tidal range the soil development of profile 2 is marginal.

2. Classification

Diagnostic horizons, -properties (FAO/SOIL TAXONOMY):
hor.
1-3 ochric A horizon/ -epipedon (n value >0.7 by field test)
2+3 sulfidic material (>0.75% sulfur, $CaCO_3$:S <3)

Classification FAO:
Fluvisol (recent fluvial sediment; only ochric A horizon is diagnostic, sulfidic material within 125 cm)
Thionic Fluvisol (sulfidic material within 125 cm)

Classification SOIL TAXONOMY:
Entisol (ochric epipedon; sulfidic material within 50 cm; n value >0.7 between 20 and 50 cm)
Aquent (sulfidic material within 50 cm)
Sulfaquent (sulfidic material within 50 cm)
Typic Sulfaquent (sulfidic material within 50 cm, n value >1)

Classification FRG:
Ästuarines Schlick-Übergangswatt (profile within tidal range, salt-free sediments, tidal mud deposits (Σ clay and silt >50%) >4 dm, vegetation cover)

PROFILE 2

3. Soil association

see profile 1

4. Soil ecology

The natural vegetation is well adapted to the extreme water conditions within the tidal range and to the high levels of nutrients (nitrogen, soluble phosphorus, exchangeable cations).

The muds are strongly contaminated by arsenic and heavy metals (MIEHLICH and MELCHIOR 1985). In the first three horizons the mean contents of arsenic and heavy metals are 200 ppm of As, 12 ppm of Cd, 275 ppm of Cu, 240 ppm of Cr, 80 ppm of Ni, 275 ppm of Pb, and 1,800 ppm of Zn. More than 90% of As, Cd, Cu, and Zn and about 85% of Pb are of anthropogenic origin. Calculated for one hectare and 1 m depth, this soil is polluted by appr. 8.9 tons of zinc, 1.2 tons of copper and lead, 1 ton of arsenic, and 55 kg of cadmium. As long as the reduced conditions and the high pH-value persist the solubility of heavy metals will be low. Diking and draining of this soil will cause an oxidation and an acidification of the mud layer. In consequence the contents of zinc and cadmium will exceed the limits for drinking water considerably in the soil solution (WEITZ 1986).

PROFILE 3

Site description:

Location: 10°09'28" E, 53°27'04" N **Elevation:** 1.5 m

Landform: floodplain

Slope: flat

Drainage: imperfectly drained, ground-water level at 120 cm

Vegetation: no natural vegetation

Use: wheat, root crops, alternating with meadow

Parent material: alluvial sands (deposited by man) over tidal influenced alluvial clay

Soil classification:

FAO : -
GER : Kleimarsch-Auftragsboden
SOIL TAX.: Mollic Fluvent

Profile description:

No	horizon	depth	
1	jYAp(1) Ap1	0- 10	very dark gray (10YR3/1m), brown (10YR5/3d), weak loamy sand (l'S), weak medium granular and fine to medium subangular blocky, friable (moist), slightly hard (dry), pieces of brick, few roots.
2	jYAp(2) Ap2	10- 20	very dark gray (10YR3/1m), brown (10YR5/3d), weak loamy sand (l'S), weak fine to medium subangular blocky, friable (moist), slightly hard (dry), pieces of brick, few roots, gradual smooth boundary.
3	jYfAp(1) Apb1	20- 40	very dark grayish brown (10YR3/2m), brown (10YR5/3d), weak loamy sand (l'S), weak fine to medium subangular blocky, friable (moist), slightly hard (dry), pieces of brick, few roots, gradual smooth boundary.
4	jYfAp(2) Apb2	40- 60	dark brown (10YR3/3m), brown (10YR5/3d), strong loamy sand ($\bar{l}$S), very weak fine to medium subangular blocky, firm (moist), hard (dry), pieces of brick, clear smooth boundary.
5	jYfAp(3) 2Apb3	60- 80	very dark grayish brown (2.5Y3/2m), weak clayey loam (t'L), moderate angular blocky, some prisms, firm (moist), very hard (dry), pieces of brick, few roots, clear smooth boundary.
6	aMfAp(1) 2Apb4	80- 90	very dark grayish brown (2.5Y3/2m), light brownish gray (10YR6/2d), clayey loam (t˙L), strong fine to medium prismatic, very firm (moist), very hard (dry), pieces of brick, abrupt smooth boundary.
7	aMfAp(2) 2Apg	90- 110	75% dark grayish brown (10YR4/2m), 20% dark gray (10YR4/1m), 5% spots of reddish brown (5YR4/4m), loamy clay (l˙T), strong very fine to fine angular blocky, very firm (moist), extremely hard (dry), few small iron concretions, pieces of brick, gradual smooth boundary.
8	aMGo 2Cg	110- 120+	85% dark gray (5Y4/1m), 15% irregulary distributed spots of dark red (2.5YR3/6m), loamy clay (l˙T), strong very fine to fine angular blocky, firm (moist), extremely hard (dry), many small iron concretions.

PROFILE 3

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf med. m/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ap 1	- 10	n.d.	5.8	56.8	19.6	82.1	4.4	4.0	1.6	10.0	7.9	n.d.	n.d.
2	Ap 2	- 20	n.d.	5.1	58.8	20.0	83.8	2.6	4.1	2.4	9.1	7.1	n.d.	n.d.
3	Apb1	- 40	n.d.	4.0	56.9	22.6	83.5	3.5	3.2	2.5	9.2	7.3	n.d.	n.d.
4	Apb2	- 60	n.d.	4.5	48.3	17.8	70.6	4.5	6.1	3.4	13.9	15.5	n.d.	n.d.
5	2Apb3	- 80	n.d.	1.4	14.4	18.3	34.1	14.2	13.9	7.3	35.3	30.6	n.d.	n.d.
6	2Apb4	- 90	n.d.	0.3	4.6	5.4	10.3	22.2	15.1	7.8	45.1	44.6	n.d.	n.d.
7	2Apg	-110	n.d.	0.3	2.6	8.7	11.6	16.7	14.6	8.3	39.5	48.9	n.d.	n.d.
8	2Cg	-120	n.d.	<0.1	2.7	9.8	12.6	14.5	15.3	8.3	38.1	49.4	n.d.	n.d.

No.	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Ap 1	1.44	45.4	39.5	34.4	28.8	11.0	n.d.	4.9	5.7	3.8	0.7	0.4	350
2	Ap 2	1.40	47.5	37.5	30.3	25.9	10.8	n.d.	4.9	6.0	4.1	0.7	0.4	325
3	Apb1	1.55	41.3	34.0	29.9	23.9	11.4	n.d.	5.1	6.5	3.7	0.6	0.4	367
4	Apb2	1.51	42.8	36.3	32.4	28.0	16.1	n.d.	5.4	6.8	4.6	0.7	0.6	517
5	2Apb3	1.40	47.6	41.5	37.8	34.2	26.8	n.d.	5.6	14.9	10.4	0.7	1.3	742
6	2Apb4	1.33	49.3	46.1	44.8	41.8	31.4	n.d.	5.9	17.8	12.0	0.7	1.4	700
7	2Apg	1.33	49.7	47.6	46.7	43.7	31.9	n.d.	5.9	19.2	13.7	0.7	1.4	750
8	2Cg	1.31	51.0	49.3	48.3	45.3	38.5	n.d.	5.9	17.4	12.6	0.7	1.4	750

No.	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ap 1	1.5	1.5	9.9	0	108	n.d.	56	5.6	6.5	0.3	2.6	0	64
2	Ap 2	1.5	1.3	11.4	0	104	n.d.	57	5.7	7.9	0.2	1.9	0	68
3	Apb1	1.3	1.2	10.5	0	112	n.d.	66	5.1	8.2	0.3	1.5	0	71
4	Apb2	0.9	1.1	8.5	0	116	n.d.	79	5.0	10.4	0.8	1.1	0	82
5	2Apb3	1.6	1.7	9.6	0	292	n.d.	174	13.2	24.9	1.9	1.1	0	73
6	2Apb4	1.6	1.6	10.0	0	330	n.d.	176	21.6	32.2	2.5	1.5	0	70
7	2Apg	1.4	1.6	8.6	0	344	n.d.	181	21.9	39.2	2.7	1.1	0	71
8	2Cg	1.4	1.4	9.7	0	320	n.d.	176	23.2	37.0	2.6	1.1	0	75

PROFILE 3

1. Genesis

After the land was diked in the 13th century, the soil surface of profile 3 lay appr. 80 cm deeper than today. At that time the soil was a clay- and silt-rich Eutric Fluvisol (hor. 5 - 8). Pieces of brick in the horizons 5 - 7 demonstrate that this soil was in agricultural use, but there were severe problems to cultivate this fine grained soil with its high ground-water level. Horticulture, which was the favourite use of the grounds situated close to the rivers, was not possible. To improve the soil, the farmers deposited sandy river sediments. In winter, they shipped down the Goose Elbe to a sandy bank of the main stream with the ebb tide, loaded their ships with sediments and returned to their farms with the flood tide. The sediments were deposited in a stripe which follows the dike in a width of appr. 200 m. The 85 years old proprietess of the field on which profile 3 is located told us that she had to do this hard work in her youth. Intense application of manure led to an enrichment of organic matter and especially of soluble phosphorus.

2. Classification

Diagnostic horizons, -properties (FAO/SOIL TAXONOMY):

hor.

1-4 anthropic A horizon/-epipedon (meets all requirements of a mollic epipedon but soluble P_2O_5 >250 ppm)

Classification FAO:

No term, because the anthropic A horizon is not used for classification

Classification SOIL TAXONOMY:

Entisol (anthropic epipedon)

Fluvent (see profile 1, but organic carbon content >0.2% to 125 cm)

Mollic Fluvent (see profile 1)

Classification FRG:

Kleimarsch-Auftragsboden (profile within the marsh; horizon sequence Ap-Go-Gr (hor. 6-9); free of lime >4 dm; man-made deposition of sediments not more than 80 cm thick)

3. Soil association

Figure 4 shows a transect of two diked marsh-lands (Kirchwerder in the southwest and Neuengamme in the northeast) bordering the higher situated receiving

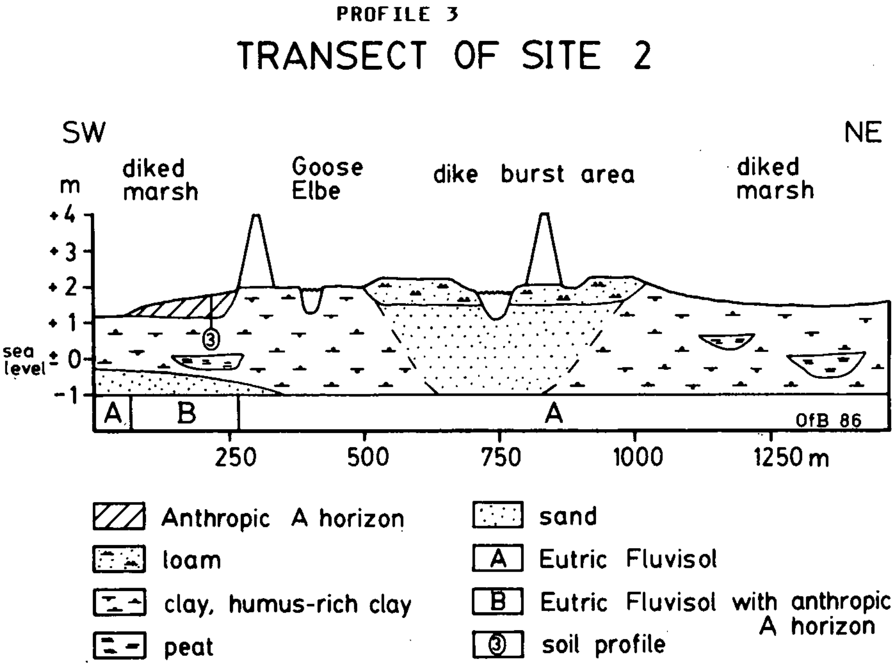

Fig. 4: transect of site 2

stream Goose Elbe. A little pond and a narrow bow of the dike are remaining signs of a dike burst. The former clayey marsh sediments were excavated and the hole was filled at first with sand and later on with loam. The soil association includes several forms of Eutric Fluvisols. Their properties vary in a wide range depending on particle-size distribution and the formation of an anthropic A horizon.

4. Soil ecology

The plant-available water capacity to a depth of 1 meter amounts to 163 mm. This indicates that even longer dry peroids during summer do not cause severe problems in water supply. The soil reaction of Ap1 and Ap2 is fairly low for soils used agriculturally. CEC and exchangeable cations are low to medium in the sandy anthropic A horizon. The soil contains high reserves of soluble phosphorus. On the sandy deposits soil cultivation is no problem.

SITE 3

A characteristic problem of a harbour town is the disposal of dredged material out of the harbour basins and canals. To maintain the water depth required for ocean-going vessels, nearly 2 million cubic meters of sediments (consisting of 1.1 mio. m^3 sand and 0.9 mio. m^3 mud) are dredged from the harbour basins annually and flushed on upland landfills in the fresh water marshes of the Elbe river. At present approximately 1.000 ha are covered by landfills of mud and mud/sand mixtures. Site 3 is the disposal area Feldhofe.

In order to assess the danger of ground-water contamination by infiltration from landfills of dredged material, since 1981 a project group of the soil department of the University of Hamburg is working on the

- stratigraphy of the landfills and their underground; the
- investigation of the properties of solid matter and percolation water of the dredged material and the
- hydrology of the landfill-marsh system (MIEHLICH, GRÖNGRÖFT u. MAASS 1986).

The main results are: Depending on the flushing technique used, the stratigraphy of the landfills comprises sequences of mud and sand of different complexity. As a consequence of processes of marsh formation, the underground sediments are inhomogeneous. They are not suited to prevent deep sepage from the landfills. The enrichment of mud by contaminants is considerable: In comparison to the regional standard of uncontaminated sediments the anthropogenic contamination reaches 10 to 60 times the natural levels of As, Cd, Cu, and Zn. The most important organic contaminants are polynuclear aromatic hydrocarbons, phtalathes, chlorinated hydrocarbons and low volatile chlorinated hydrocarbons. Percolation water in landfills of dredged material can be divided into two main types: The reduced type is found in the younger and in the mud-rich parts of older disposal areas. This type is characterized by high contents of ammonia, iron, and arsenic and very low levels of sulfate, nitrate and heavy metals (Pb, Cd, Cu, Zn). The oxidized type is observed in older surface-near layers with variable redox potential. Easily soluble salts have been leached partly. After de-calcination the pH-value decreases as a function of age. The percolation waters are low in ammonia, iron, and arsenic and contain high levels of nitrates, sulfates, Pb, Cd, Cu, and Zn. The mobilisation of heavy metals may be attributed to the combined effects of temperature, pH, Eh, and water saturation.

PROFILE 4

Site description:

Location: 10°06'38" E, 53°30'45" N **Elevation:** - 0.4 m below sea-level

Landform: flat depression in floodplain

Slope: flat

Drainage: imperfectly drained, ground-water level at 60 - 80 cm

Vegetation: no natural vegetation

Use: wheat, root crops, alternating with meadow

Parent material: tidal influenced alluvial clay over peat covering alluvial clay

Soil classification:

FAO : Eutric Fluvisol
GER : Moormarsch
SOIL TAX.: Humaquept

Profile description:

No	horizon	depth	
1	aMAp(1) Ap	0-10	dark grayish brown (10YR4/2m), loamy clay (l'T), strong very fine to fine angular blocky, very firm (moist), very hard (dry), common roots, gradual smooth boundary.
2	aMAp(2) Apg	10-20	85% dark grayish brown (10YR4/2m), 15% strong brown spots (7.5YR5/6m), loamy clay (l'T), strong very fine to medium angular blocky, very firm (moist), very hard (dry), common roots, gradual smooth boundary.
3	aMGo Lg	20-35	85% dark brown (10YR3/3m), 15% strong brown spots (7.5YR5/6m), clay (T), strong very fine to medium angular blocky, compact (moist), extremely hard (dry), few roots, clear smooth boundary.
4	IInH(1) 2Hg	35-60	dark reddish gray (5YR4/2m) peat, texture of mineral component silty clayey loam (utL), peat strong decomposed, pieces of Alnus sp. twigs and wood, very friable (moist), soft (dry), common roots, gradual smooth boundary.
5	IIFr 2Lr	60-80	dark brown (7.5YR3/2m) detritus mud, texture of mineral component clay (T), moderate fine subangular blocky, very friable (moist), soft (dry), few roots, gradual smooth boundary.
6	IInH(2) 2Hr1	80-120	dark reddish brown (5YR3/2m), after air exposure black (7.5YR2/0m) peat, texture of mineral component loamy clay (l'T), peat strong decomposed, few roots of Alnus sp., very friable (moist), soft (dry), diffuse boundary.
7	IInH(3) 2Hr2	120-150	dark reddish brown (5YR3/2m), after air exposure black (7.5YR2/0m) peat, texture of mineral component weak loamy silt (l'U), peat strong decomposed, very friable (moist), soft (dry), clear smooth boundary.
8	IIIGrh 3Lr	150-170+	very dark gray (7.5YR3/0m), some black spots (7.5YR2/0m), sandy clayey loam (stL), moderate fine to medium angular blocky, firm (moist), very hard (dry).

PROFILE 4

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf med. m/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ap	- 10	n.d.	0.1	1.4	4.0	5.5	9.0	18.6	12.9	40.5	54.0	n.d.	n.d.
2	Apg	- 20	n.d.	0	0.7	3.1	3.8	5.2	15.6	15.5	36.3	59.9	< 0.1	n.d.
3	Lg	- 35	n.d.	0	0.2	0.6	0.8	5.1	13.8	13.3	32.2	67.0	3.7	n.d.
4	2Hg	- 60	n.d.	0.1	3.8	3.3	7.2	10.1	20.6	20.8	51.5	41.2	30	n.d.
5	2Lr	- 80	n.d.	0	0.2	0.3	0.5	1.2	12.7	15.2	29.1	70.4	6.3	n.d.
6	2Hr1	-120	n.d.	0.2	0.6	2.2	2.9	4.8	15.1	16.1	35.9	61.2	0.4	n.d.
7	2Hr2	-150	n.d.	0.1	3.1	21.6	24.8	7.6	58.3	1.2	67.1	8.1	n.d.	n.d.
8	3Lr	-170	n.d.	0.1	9.4	23.4	32.9	6.1	8.8	9.8	24.7	42.5	n.d.	n.d.

No.	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Ap	0.98	60.7	51.9	48.0	45.4	29.2	n.d.	5.3	21.9	10.3	0.5	0.3	35
2	Apg	1.13	57.2	55.0	52.6	50.6	36.8	n.d.	5.4	23.3	9.0	0.4	0.2	10
3	Lg	0.82	66.6	64.8	62.0	59.5	35.7	n.d.	4.9	11.3	6.4	0.6	0.1	13
4	2Hg	0.40	81.4	67.6	66.6	60.0	21.7	n.d.	4.0	39.1	44.1	>1	<0.1	12
5	2Lr	0.41	81.1	81.6	80.0	74.1	18.1	n.d.	4.2	10.4	10.9	>1	0.1	15
6	2Hr1	0.30	84.7	86.1	81.5	73.0	15.1	n.d.	4.2	47.6	19.4	0.4	0.1	19
7	2Hr2	0.25	85.2	86.5	81.7	72.1	13.1	n.d.	4.6	61.1	18.5	0.3	0.2	13
8	3Lr	0.64	73.2	73.6	71.8	65.4	19.7	n.d.	5.2	11.0	6.2	0.6	0.1	25

No.	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ap	3.6	3.6	9.9	0	436	n.d.	220	4.4	29.6	3.0	1.1	0.8	59
2	Apg	2.6	2.8	9.2	0	412	n.d.	244	3.4	37.2	4.5	1.1	0.4	70
3	Lg	7.0	5.8	12.2	0	556	n.d.	287	3.1	43.3	5.9	1.9	0.3	61
4	2Hg	26.1	15.5	16.8	0	948	n.d.	173	2.3	25.6	6.2	6.0	62.6	22
5	2Lr	16.1	10.7	15.0	0	668	n.d.	279	2.6	50.0	8.8	6.0	79.5	51
6	2Hr1	26.8	15.7	17.1	0	728	n.d.	384	1.5	57.2	12.4	9.0	26.6	63
7	2Hr2	26.8	14.2	18.9	0	904	n.d.	522	0.8	79.0	21.9	33.0	62.6	69
8	3Lr	8.8	6.1	14.3	0	428	n.d.	299	1.5	51.7	13.3	10.9	26.6	85

PROFILE 4

1. Genesis

Profile 4 represents the soil development of the marshes at flood-plain margin. Clay-rich sediments ("lower clay") are covered with layers of peat and mud, which are superimposed by another clay-rich sediment forming the top of the profile. This sediment, called "upper clay", covers the largest part of the marsh. It is an allochthonous soil sediment originating from the medieval clearings up-stream. The high content of organic carbon in the first three horizons is caused in part by deep-plowing and mixing with the organic layers below. The drainage of the organic horizons results in a settling of the soil, and therefore the top of the profile now lies below the sea level. Mottles up to the second horizon demonstrate the influence of the high ground-water level.

2. Classification

Diagnostic horizons, -properties (FAO, SOIL TAXONOMY):
hor.
4 histic H horizon/-epipedon (thickness <40 but >20; org. carb. >18%;
mineral surface layer <40 cm)

Classification FAO:
Fluvisol (recent alluvial material; only histic H horizon is diagnostic;
org. matter >0.35% to a depth of 125 cm)
Eutric Fluvisol (see profile 1)

Classification SOIL TAXONOMY:
Inceptisol (histic epipedon)
Aquept (histic epipedon)
Humaquept (histic epipedon)
It is not possible to classify the subgroup because
- it is not a Typic Humaquept because chroma moist in horizon 3 is >2 and organic carbon decreases irregulary
- it is not a Fluvaquentic Humaquept because chroma moist in horizon 3 is >2.

Classification FRG:
Moormarsch (situated within the marsh; horizons 4,6,7 are Hn;
mineral surface layer between 20 and 40 cm)

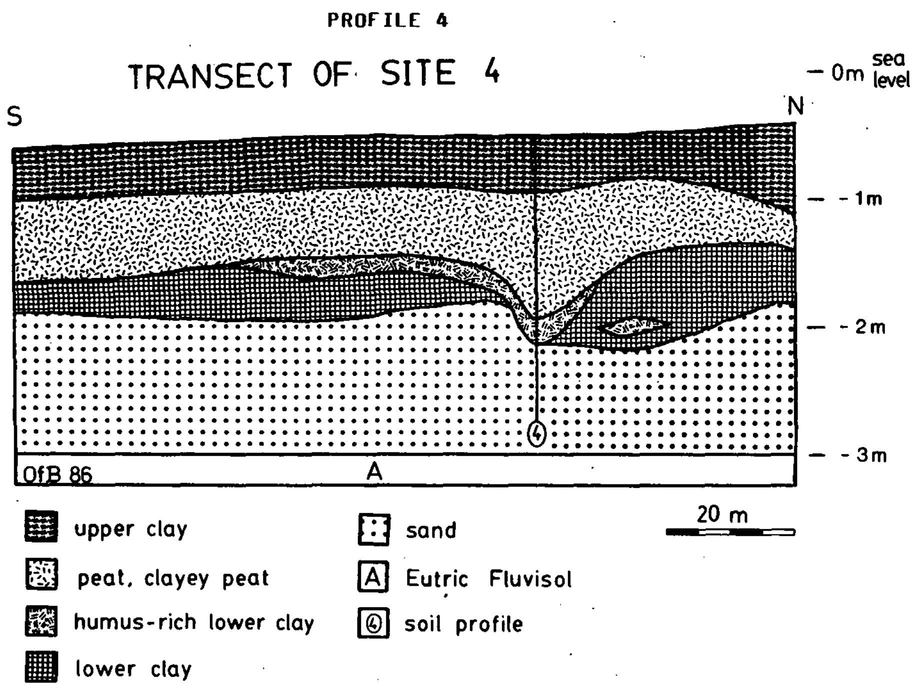

Fig. 5: transect of site 4

3. Soil association

Detailed mapping of about 170 ha in the area of profile 4 (KLEINEIDAM 1982) revealed that the stratification of the soil forming sediments varies considerably depending on local sedimentation conditions within the former intertidal regions. All soils belong to the Eutric Fluvisols but their properties vary according to the properties of the sediments.

4. Soil ecology

Because of the high ground-water level and the high plant-available water capacity of the "upper clay" there is no water deficit throughout the year. In winter and in spring the soil is wet, and in summer the topsoil is shrinking and becomes extremely hard, which causes severe problems with cultivation. CEC and exchangeable cations are very high but soluble phosphorus is low.

PROFILE 5

Site description:

Location: 10°09'22"E, 53°30'35" N **Elevation:** 5.0 m **Landform:** dune crest at floodplain margin **Slope:** rolling **Drainage:** well drained **Vegetation:** dune vegetation (Calluna vulgaris, Deschampsia flexuosa, Carex arenaria, Agrostis stricta, Quercus robur) **Use:** nature reserve **Parent material:** stratified dune sand **Soil classification:** FAO: Orthic Podsol, GER: Podsol-Äolium, SOIL TAX.: Typic Haplorthod

Profile description:

No	horizon	depth	
1	oMAh AC1	0-10	dark grayish brown (10YR4/2m), pale brown (10YR6/3d), sand (S), single grain, loose, many roots, merging smooth boundary.
2	IIoM 2AC2	10-15	very dark grayish brown (10YR3/2m), brown (10YR5/3d), sand (S), single grain and very weak medium subangular blocky, very friable (moist), loose (dry), common roots, merging smooth boundary.
3	IIIoM 3AC3	15-25	very dark grayish brown (10YR3/2m), brown (10YR5/3d), sand (S), single grain, loose, common roots, clear wavy boundary.
4	IVoM 5AC5	25-30	very dark gray (10YR3/1m), brown (10YR5/3d), sand (S), single grain and very weak medium to coarse subangular blocky, very friable (moist), loose (dry), pieces of pottery and brick, common roots, clear wavy boundary.
5	VoM 5AC5	30-45	dark brown (10YR3/3m), dark yellowish brown (10YR4/4d), sand (S), single grain and very weak medium to coarse subangular blocky, very friable (moist), loose (dry), neolithic flint tools, few roots, clear wavy boundary.
6	VIfAeh 6Ah	45-60	gray (7.5YR5/0m), mottles (10YR3/2m), sand (S), single grain and very weak medium subangular blocky, very friable (moist), loose (dry), few roots, clear smooth boundary.
7	VIfAe 6E	60-75	dark gray (5YR4/1m), gray (10YR6/1d), sand (S), single grain, loose, few roots, clear irregular boundary.
8	VIfBsh 6Bsh	75-85	black (5YR2/1m), dark reddish brown (5YR3/3d), ratio of pyrophosphate - extractable carbon to pyrophosphate - extractable iron: 8, sand (S), massive, extremely firm (moist), very hard (dry), few roots, clear irregular boundary.
9	VIfBs 6Bs	85-115	85% dark reddish brown (5YR3/4m), 15% strong brown spots (7.5YR5/8m), ratio of pyrophosphate - extractable carbon to pyrophosphate - extractable iron: < 3, few thin dark brown stripes, sand (S), massive, firm (moist), slightly hard (dry), diffuse boundary.
10	VIC 6C	115-145+	yellowish brown (10YR5/4m), pale brown (10YR6/3d), sand (S), single grain, loose.

PROFILE 5

No.	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf med. m/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	AC1	- 10	n.d.	0.2	53.7	44.8	98.6	0.3	0.1	0.1	0.5	0.9	n.d.	n.d.
2	2AC2	- 15	n.d.	0.5	57.0	41.1	98.5	0.5	<0.1	0.1	0.6	0.9	n.d.	n.d.
3	3AC3	- 25	n.d.	0.4	64.4	33.8	98.6	<0.1	<0.1	0.6	0.6	0.8	n.d.	n.d.
4	4AC4	- 30	n.d.	1.7	60.3	34.7	96.8	0.8	0.6	0.4	1.8	1.4	n.d.	n.d.
5	5AC5	- 45	n.d.	1.2	62.5	31.9	95.6	1.2	0.2	1.0	2.4	2.0	n.d.	n.d.
6	6Ah	- 60	n.d.	1.3	65.6	30.7	97.5	0.5	0.3	0.7	1.5	1.0	n.d.	n.d.
7	6E	- 75	n.d.	0.9	67.0	30.6	98.5	0.5	0.2	0.4	1.1	0.4	n.d.	n.d.
8	6Bsh	- 85	n.d.	1.1	59.5	36.3	96.9	0.4	0.5	0.5	1.4	1.7	n.d.	n.d.
9	6Bs	-115	n.d.	0.3	60.9	37.0	98.2	0.3	<0.1	0.2	0.5	1.3	n.d.	n.d.
10	6C	-145	n.d.	0.2	70.9	28.2	99.4	<0.1	<0.1	<0.1	<0.1	0.6	n.d.	n.d.

No.	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o:Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
1	AC1	1.36	48.7	36.3	15.4	8.1	1.0	6.4	4.2	0.6	0.3	0.5	<0.1	53
2	2AC2	1.29	50.7	44.6	15.6	11.6	4.5	4.5	4.1	0.6	0.3	0.5	<0.1	57
3	3AC3	1.45	45.7	31.4	4.7	4.3	2.0	4.7	3.9	0.6	0.3	0.5	<0.1	58
4	4AC4	1.42	46.4	32.2	8.1	7.1	2.5	4.6	3.8	1.5	0.6	0.4	<0.1	40
5	5AC5	1.55	41.9	32.6	14.5	7.2	3.1	4.4	4.0	1.7	0.9	0.5	0.1	61
6	6Ah	1.40	47.4	37.4	19.9	10.9	4.3	4.3	3.9	0.9	0.5	0.6	<0.1	19
7	6E	1.48	45.0	32.9	9.7	3.1	1.6	4.3	3.9	0.2	0.1	0.4	<0.1	10
8	6Bsh	1.47	44.9	36.7	23.6	17.6	9.0	4.5	4.4	3.6	3.2	0.9	<0.1	43
9	6Bs	1.47	45.3	33.5	10.4	9.2	5.4	4.6	4.7	1.0	0.4	0.4	<0.1	21
10	6C	1.60	40.5	28.3	7.3	5.1	1.6	4.7	4.7	0.4	0.1	0.3	<0.1	28

No.	hor.	C_{org} %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	AC1	0.5	0.02	22.3	0	12	n.d.	0.5	0.2	0.2	0.2	0.8	7.1	9.2
2	2AC2	0.9	0.03	32.7	0	22	n.d.	0.5	0.2	0.2	0.2	1.1	8.7	5.0
3	3AC3	1.0	0.04	27.1	0	22	n.d.	0.7	0.2	0.3	<0.1	0.8	10.8	5.9
4	4AC4	1.6	0.07	22.4	0	32	n.d.	0.5	0.3	0.4	0.3	0.8	16.1	4.7
5	5AC5	0.7	0.04	21.1	0	36	n.d.	0.6	0.2	0.3	<0.1	0.8	15.0	3.3
6	6Ah	2.0	0.05	37.7	0	60	n.d.	0.9	0.1	0.2	0.1	0.8	23.3	2.2
7	6E	0.4	0.01	40.0	0	16	n.d.	0.5	<0.1	0.1	0.1	0.8	13.4	5.0
8	6Bsh	1.6	0.04	40.8	0	136	n.d.	0.6	0.1	0.1	0.1	0.4	18.0	0.7
9	6Bs	0.2	0.01	20.0	0	24	n.d.	0.4	0.1	0.2	<0.1	0.4	4.1	3.3
10	6C	0.1	<0.01	n.d.	0	8	n.d.	0.4	0.1	0.1	<0.1	0.4	2.3	8.8

PROFILE 5

1. Genesis

In the early Holocene the Weichselian sands (hor. 6 - 10) were redistributed into dunes. In these quartz-rich sands we assume the following soil development sequence: The initial Regosol was followed by a Ranker under forest vegetation. With progressing hydrolysis and leaching the Ranker was transformed to a Podsol. The fact that most of the neolithic tools were found in horizon 5 (SCHINDLER 1960) demonstrates, that the Podsol must be older than at least 4,500 years b.p. Horizon 5 is an aeolian sediment consisting of a mixture of the different horizons of a Podsol. The mapping of the nature reserve (PFEIFFER u. MIEHLICH 1984) shows that this widespread layer covers different erosion stages of the Podsol below. Probably the erosion of the Podsol as well as the deposition of the aeolian soil sediment are the result of clearings by neolithic men. The horizons 1 - 4 are layers of young aeolian sediments consisting of dune sands, which contain a small amount of humus.

2. Classifications

Diagnostic horizons, -properties (FAO/SOIL TAXONOMY):
hor.
1-6 not diagnostic, regarded as a surface mantle
7 albic E horizon/albic horizon (lies above a spodic horizon, colour value moist 4, dry 5, colour chroma moist and dry <2)
8 spodic B horizon/spodic horizon (reddest hue near top of the horizon, colour changes within 50 cm, subhorizon >2,5 cm thick, cementated by organic matter and iron)

Classification FAO:
Podsol (surface mantle <50 cm, having a spodic B horizon)
Orthic Podsol (neither thin iron pan nor hydromorphic properties nor enrichment of organic matter without iron, ratio free iron: organic carbon <6, thickness of albic E >2 cm)

Classification SOIL TAXONOMY:
Spodosol (surface mantle <50 cm, no plaggen epipedon, spodic horizon within 2m)
Orthod (no properties qualifying for an aquic suborder, free iron: organic carbon <6 but >0.2)
Haplorthod (no placic horizon, no fragipan, mesic soil temperature regime)
Typic Haplorthod (meets all requirements)

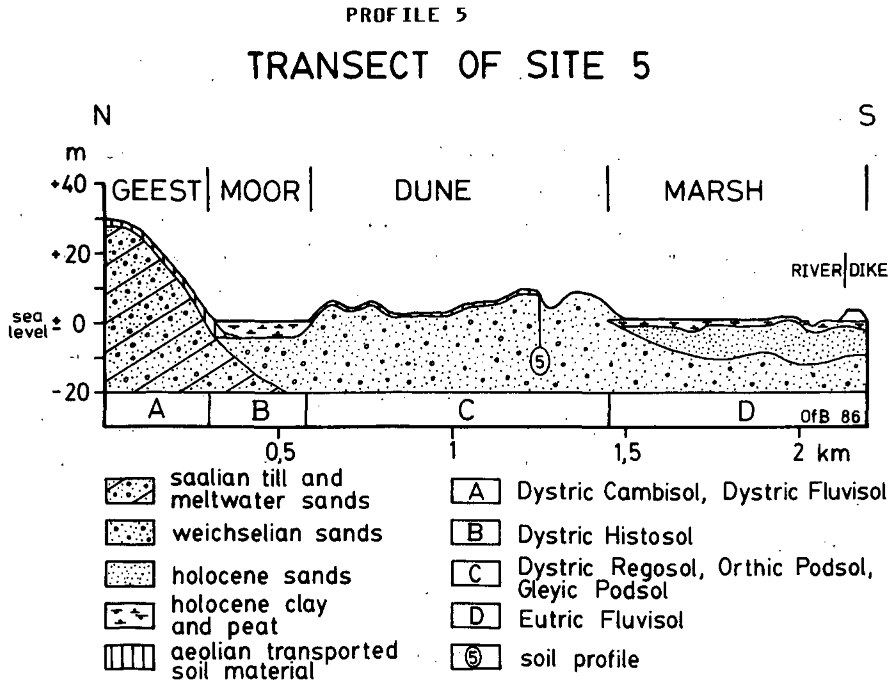

Fig. 6: transect of site 5

Classification FRG:

Podsol-Äolium (horizon sequence Ah-oM-Ahe-Ae-Bhs-Bs-C, top of Ahe is between 40 and 80 cm deep)

3. Soil association

In the marsh predominate Eutric Fluvisols, small areas are covered with Histosols. On the dunes the main soil unit is a Dystric Regosol, the accessory units are Podsols and Gleysols. In the moor Eutric Histosols predominate. The slopes of the Elbe river are covered mainly with Dystric Cambisols.

4. Soil ecology

The plant-available water capacity to a depth of 1 m amounts to appr. 100 mm, indicating that there are problems in the water supply during dry periods.
The soil data show that the amount of plant available nutrients in site 5 is low. But it is necessary to consider that in Hamburg the input of nitrate by precipitation amounts to appr. 50 kg/ha and year.

Methods for analytical procedures

The field and laboratory data compiled within this tour guide book have been collected (partly) from different research projects and authors. Therefore it is possible that different analytical procedures are followed. In some cases original publications of data are cited. In these cases please refer to the cited papers. In the following only the generally used procedures of the Dep. of Ecology, Soil units, are explained.

Profile description: The soil horizons are designated according to the new soil system of the Federal Republic of Germany (1985). Other features are described according to MÜLLER (1982). FAO-horizons are put into brackets. Colours are generally determined under moist conditions.

Soil sampling: For chemical analysis, representative samples of 1 kg to 4 kg have been taken from every horizon. For physical analysis have been taken:

6 cores à 100 cm^3 to determine pore size distribution

10 cores à 100 cm^3 to determine saturated water conductivity

Analytical procedures: Generally the methodes of SCHLICHTING & BLUME (1966) are followed.

Grain size distribution:

- dry sieving <2 mm; fine earth about 30-40 g
- destruction of organic matter by boiling with H_2O_2, decalcification with HCl at pH >4; dispersion with Na-pyrophosphate
- sieving >600 µm, >200 µm and >63 µm fraction from solution
- determination g <63 µm, <20 µm, <6 µm, <2 µm by Pipette-method

Pore volume and distribution:

- pF 0.6 and pF 1.0 at an equilibrium on a sand bed
- pF 1.8, pF 2.5, 3.2, 4.2 with "soil moisture" pressure plate extractors
- bulk density by balancing dried samples of 100 cm^3 volume
- pore volume calculated from specific weight of solid phase, determined by a pyknometer
- saturated water conductivity with a permeameter according to HARTGE

- unsaturated water conductivity from a desiccation curve according to BECKER

Chemical analysis:

- pH ($CaCl_2$ and H_2O) in a soil to solution ratio 1 : 2.5
- carbonates and org. C by burning and conductometric analysis of deliberated CO_2 (Wösthoff apparates)
- total N after KJELDAL
- Exchange Capacity (CEC) according to MEHLICH or with Na-acetate or effective CEC in NH_4Cl
- active nutrients with NH_4-lactate according to EGNER-RIEHM
- mobile heavy metals with EDTA-extraction (0.05 n EDTA for two hours)
- active oxides with NH_4-oxalat- extraction according to TAMM & SCHWERTMANN
- pedogenic oxides with Na-Dithionite-citrate according to MEHRA and JACKSON
- total element content with acid digestion by HF/HCO_4 mixture and solution in HCl
- element determination:
  P kolorimetric as blue molybdate complex
  Na, K and Ca with emission photometer
  other elements with atomic absorption spectrophotometer
- clay minerals
  after destruction of humus with H_2O_2 and carbonate with HCl, collection of clay fraction in an Atterberg cylinder. Determination by x-ray diffraction of Mg and K as well as Glycerol loaded textured specimens. Further readings after heating to 200, 400 and 550^{o}C

Abbreviations

grain size

S - sand
U - silt
T - clay
f - fine
m - medium
g - coarse

pores

pF - log mbar
kf - saturated water conductivity
ku - unsaturated water conductivity
GPV - total pore volume

chemical properties

CECp	- potent. CEC
CECa	- act. CEC
Ca, Mg, K, Na, H, Al: exchangeable cations	
V%	- potent. base saturation
$C_{org.}$	- org. Carbon
X_t	- total element content
K_a, P_a	- acetate soluble minerals
K_v, P_v, Mg_v	- weatherable minerals
Fe_d, Mn_d	- Dithionite-soluble minerals
Al_o, Mn_o, Fe_o:	Oxalate-soluble minerals
Cu_e-, Fe_e:	EDTA-soluble heavy metals