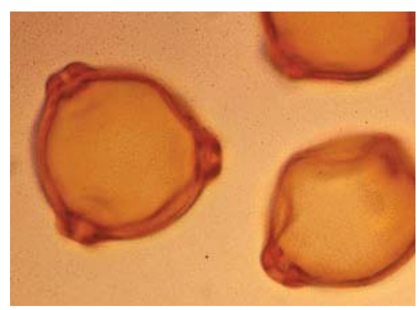
Pingo remnants in the northern Netherlands and adjacent north-western Germany



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Abstract

In this study, a comparison was made between pingo remnant depressions in the northern Netherlands and north-western Germany. For this purpose, the dimensions, substrate and infill of 17 depressions have been studied. These depressions are located in four separate study areas: Friesland, Drenthe (the Netherlands), Ost-Friesland and the region between Cloppenburg and Visbek (Germany). In most cases, lithological cross sections have been constructed. In the laboratory, Loss on Ignition measurements were performed on the deepest infill of three cores, each derived from a different study area. Two cores were selected for the construction of an age model of the deepest infill. This model has been made based on correlation of important transitions in pollen assemblage in the records to the well-known vegetation development in the Netherlands, reflected in a high-resolution pollen diagram of the Uteringsveen pingo remnant in Drenthe. For several other depressions, the age of deepest infill was determined based on a pollen quickscan.

All pingos are situated in areas where sands are covered by glacial till belongs to the Drenthe Formation, which are in turn covered by coversands of the Boxtel Formation. Morphologically, four different types of depressions have been distinguished; (1) flat-based pingo remnant depressions, (2) cone-shaped pingo remnant depressions, (3) possible underdeveloped pingo remnant depressions, (4) depressions of which the origin is unclear and (5) depressions that are not pingo remnants. A clear geographical trend is evident, as flat-based pingo remnants all occur in the northernmost study areas, which is thought to be caused by regional differences in the substrate.

Infill of the depressions is roughly similar for most sites, showing a hydroseral succession or organic material. Two depressions contain an infill of mainly sands. Vegetation development and aeolian activity during the time of earliest infill are derived from pollen assemblages and LOI measurements. Results are consistent with pre-existing literature.

Pollen analysis on samples of the deepest organic infill indicate that pingo collapse initiated in the Pleniglacial and Bølling. Pingo remnants with a Pleniglacial infill are thought to have formed by collapse because of mechanical failure of the former pingo, whereas remnants with an infill of Bølling age may have formed by climate-induced pingo collapse during the transition to a warmer climate. Possible indicators for climate-induced collapse are proposed: more of the (weathered) pingo skin will have descended back into the depression, which is likely to be relatively small and should have an infill dating from a period of transition to warmer climate.

Former pingos in the study area are thought to have been of the hydraulic type, where pressurised water is forced upward, penetrating the glacial till in the substrate through weaker spots. This is implied by the presence of the impermeable substrate, the cone-shape of several of the pingos and by indicators for both former and modern seepage conditions.

Preface & Acknowledgements

This master thesis is an integral part for the MSc graduation project. The research is conducted within the track Quaternary Geology and Climate Change of the MSc study Earth Sciences at Utrecht University, the Netherlands.

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Chapter 1. Introduction

Pingos are perennial, ice-cored hills that can form under specific geological and hydrological circumstances in a periglacial environments. They typically have a diameter of 300 m at maximum and can attain heights of 3 to 60 m (French, 2007). Active pingos have been found in the Arctic region of Alaska, Canada, Greenland, Scandinavia and Russia Flemal (1975). Some authors claim to have found pingos at high elevation, e.g. in the Himalaya (Wu et al., 2005), though these do not always have a perennial character.

Pingos can only be active for a limited period of time, because of internal mechanisms or external factors such as climate change. Eventually, the hill becomes unstable and melting of the ice core leads to collapse of the hill, forming a residual lake with an maximum depth in the order of several meters to tens of meters. This lake slowly fills up with peat, aeolian sediments and possibly products of chemical precipitation. Because of the gradual infilling of the depression after collapse, the infill of a pingo remnant depression may provide a continuous high resolution palaeo-climatic proxy record. This record is usually of good quality, because acidity and oxygen conditions enable good preservation of organics. Furthermore, because pingos can only exist in a permafrost environment, they are one of the few features that demonstrate the presence of past permafrost. Minimum thickness of past permafrost is indicated by the deepest infill of the remnant depression, as the ice lens cannot have existed in a non-permafrost substrate.

Pingo remnant depressions are not only found in regions where permafrost is present, but also in areas that experienced permafrost conditions in the past. Throughout the Quaternary, climate has frequently changed. In cold phases, periglacial conditions extended far further south than it does today. During the Middle and Late Weichselian, permafrost was present in north-western Europe (Van Vliet-Lanoë, 1989), which was then subject to a periglacial climate regime. This is evident from multiple acknowledged pingo remnants of (Late) Weichselian age in the northern provinces of the Netherlands (e.g. (Paris et al., 1979; de Gans and Sohl, 1981; de Gans, 1982; Heiri et al., 2007; Kluiving et al., 2010) and even further south (e.g. (?)). Because many of these pingos collapsed near the end of the Late Glacial, this period of rapid climatic changes is often recorded in great detail. Although similar depressions occur in Germany, they have not been acknowledged as pingo remnants in recent literature. Unpublished work from the Department of Physical Geography (Utrecht University) by dr. W.Z. Hoek, H.J. Pierik, Msc. and J. van Dijk, MSc. indicated that pingo remnants exist beyond the eastern borders of the Netherlands.

This study aims to make a comparison between pingo remnants north-western Germany and the Netherlands in terms of dimensions, substrate, infill and age. In order to make a well-founded comparison, a uniform dataset of pingo remnants is required. Therefore, data on the infill of 17 possible pingo remnant depressions was collected during a field work that was conducted in four separate study areas: Friesland (the Netherlands), Drenthe (the Netherlands), Ost-Friesland (Germany) and the region between Cloppenburg and Visbek (Germany). Consequently, depression dimensions and infill are investigated to determine whether depressions are pingo remnants, and if so, to evaluate their spatial and temporal similarities and differences. Loss on Ignition and pollen analysis has been performed on a set of cores that were further investigated in the laboratory. Furthermore, results are used to discuss the type of pingos that existed in the study area and the timing and cause of their collapse.

1.1 Research aims

This research primarily aims to evaluate differences between pingo remnants in different research areas in the Netherlands and Germany, therefore the main research question is:

- **Are pingo remnants in north-western Germany similar to those in the Netherlands in terms of dimensions, infill and substrate, and which geographic and temporal trends can be recognised?**

  The subject has been divided in the following set of subquestions:

  - **Are pingo remnants in Germany of similar dimensions as those in the Netherlands?**
    Dimensions of pingo remnants have been established based on evaluation of air photos and field observations. Lithological cross sections have been constructed to determine the subsurface outline of the depressions.
  - **When were active pingos present in the study areas and when did they collapse?**
    The first activity of pingos could have only occurred in a period when permafrost was present; this information can be obtained from the literature. In this report, the timing of initiation of collapse has been determined based on pollen assemblages of the earliest infill of several depressions and in a single case based on a ^{14}C-date.
  - **What were the palaeogeographical and climatological conditions during pingo decay?**
    These have been investigated based on a literature study, cross sections of the infill of the depressions and loss on ignition measurements and pollen analysis on the deepest section of three, respectively two pingo remnants.
  - **Is there a geographical trend in shape and/or infill of the pingo remnants?**
    This is evaluated based on cross sections that are constructed for 11 out of 17 depressions.
  - **Is there a temporal trend in the infill of the pingo remnants?**
    Trends in infill are also studied based on the constructed cross sections. Trends in the deepest infill have been studied by the construction of an age model for two pingo remnant depressions.
  - **Can such trends be related to lithology of the surrounding substrate or climate?**
    This is evaluated based on field results and the literature study.

1.2 Thesis outline

This thesis is set up in eight different chapters. After the introduction, chapter 2 consists of a literature review on the growth and collapse of pingos, to give the reader some background information on pingos and pingo remnants. In chapter 3, the geological and climatological background of the study area are shortly assessed. In chapter 4, the methods that are used for site selection within these study areas will be described, as will be the methods in the field and laboratory and those of the construction of an age model. Chapter 5 presents the results of the field work: for each presumed pingo remnant the location, an air photograph and when available a lithological profile are presented, with description and interpretation of what has been found. For each depression that was investigated, a short conclusion on the origin of the depressions is drawn based on lithology and morphology. Chapter 6 shows the results and an interpretation of Loss On Ignition (LOI) measurements and pollen analysis, performed on cores from two of the sites and on a set of separate single samples from other depressions. For the two cores, a pollen based age model is presented. The chapter provides the reader with a conclusion on the age and origin of the depression, based on the laboratory results. Chapter 7 provides an integral discussion on the field work and laboratory results, including an overview of conclusions based on geomorphology, lithology and pollen analysis all together. Some possible trends in dimensions and infill are mentioned, and possible pitfalls on the interpretation of the pollen and LOI results are noted. Finally, formation and collapse in the research area are discussed. The discussion chapter is followed by chapter 8, which provides conclusions answering the research questions and a set of recommendations for possible follow-up research and further use of the data.

Chapter 2. Pingo growth and collapse: a literature review

The formation of pingos is restricted to permafrost areas. It occurs through injection of water into near-surface permafrost because of a pressure gradient in ground water (Harris and Ross, 2007). Permafrost is defined as ground that is at or below a temperature of 0°C for two successive years and is classified in four units. Permafrost in which 90-100% of the area is considered continuous; unfrozen areas usually exist beneath lakes and river channels. In discontinuous permafrost, the frozen ground spans 50-90% of an area and bodies of frozen ground are separated by areas of unfrozen ground. Sporadic (10-50% of frozen ground) and isolated (0-10%) permafrost is restricted to separate islands of permafrost, which often occur beneath peaty organic sediments (French, 2007). Permafrost classification into similar classes also occurs based on the mean annual temperature (e.g. Van Vliet-Lanoë, 1989), but in past permafrost environments, this is not easily applicable. Initiation of the ice lense formation occurs below the active layer of the permafrost, i.e. below the layer that thaws in summer. Pingo ice thus is an integral part of the permafrost. The ice core is not solely built up from ground water under pressure. A considerable amount of the core may consist of segregation ice (Ross et al., 2007).

Currently, pingos are subdivided in two types: hydrostatic (or closed-system) pingos and hydraulic (or open-system) pingos. This subdivision of pingos in two classes is not unambiguous. Therefore, Gurney (1998) advocates to add a third category of polygenetic or mixed pingos. This category would account for all pingos that do not fall within the proposed categories.

2.1 Hydrostatic pingos

Hydrostatic (or closed-system) pingos occur in former lake environments (Mackay, 1979). Presently, hydrostatic pingos exist in the MacKenzie delta in Canada and in Siberia. The basic concept for the formation of hydrostatic system pingos (figure 2.1) was proposed by Porsild in 1938, and further developed by Müller in 1959 and Mackay, from 1962 onwards (French, 2007). In permafrost environments, lenses of unfrozen sediments (taliks) may occur below lakes with a depth that exceeds the depth of the active layer, i.e. lakes that do not completely freeze to their base during winter. Such a lake withholds the sediment below from freezing, so a body of unfrozen sediment called a talik is sustained within the permafrost. When the lake is drained (e.g. by an ice-wedge intersecting the lake shore), the sediment below is no longer protected from freezing. The surrounding permafrost aggrades along all sides of the lake towards the centre, and the excess water is expelled ahead of the freezing front. This pressurised water seeks the path of least resistance, leading to local upheaval at the centre of the lake where permafrost is relatively thin. In this position, it is slowly freezing up, forming the ice-core of the pingo. Generally, hydrostatic pingos occur solitary, i.e. the water source does not feed multiple ice cores Gurney (1998).

In the past, hydrostatic pingos were called closed-system pingos. Mackay (1979) considers this as an inappropriate term, because sub-surface conditions are often unknown and interconnected taliks from different lakes result in a theoretically 'open' system. However, the term closed-system pingo can still be found in the literature.

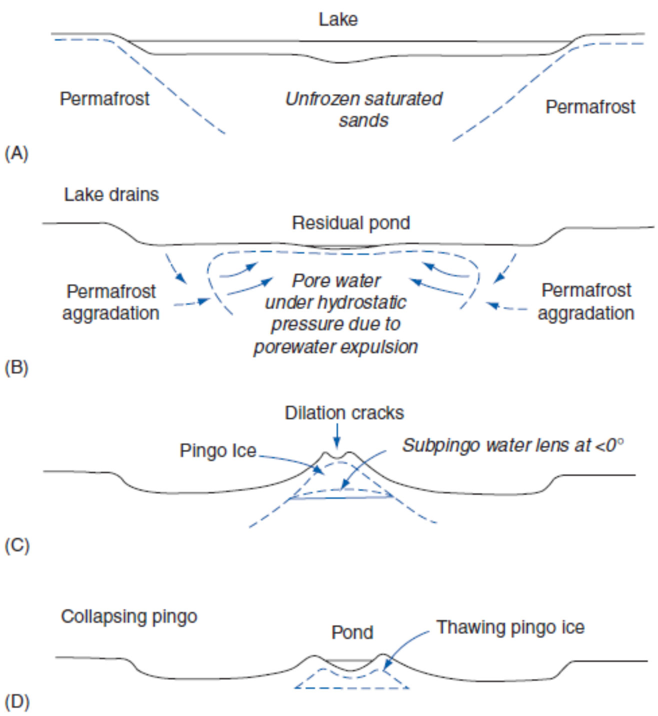

Figure 2.1: Formation and decay of hydrostatic pingos (Harris and Ross, 2007).

(a) a talik below a lake

(b) lake draining results in permafrost aggradation and pore water expulsion

(c) progressive freezing of a pressurised water lense leads to pingo growth and subsequent tension cracks in the overburden sediments

(d) partial melting of the ice-core leads to pingo collapse and formation of a central pond.

Generally, it was believed that hydrostatic pingos can only occur in continuous permafrost conditions (Flemal, 1975). However, this is not necessarily the case, as the impermeable layer beneath the talik can also consist of an impermeable substrate in stead of permafrost, for example clay (Mackay, 1979).

2.2 Hydraulic pingos

Hydraulic (or open-system) pingos are less well understood than their hydrostatic counterparts. The best-known regions where hydraulic pingos are present are Greenland, Alaska, Siberia and Spitsbergen. They are located on weak slopes and in valleys (Holmes et al., 1968). The general model for the growth of hydraulic (or open-system) pingos (figure 2.2) was first described by Müller in 1959.

In open-system pingos the source of upwelling groundwater is a pressure gradient. In mountainous regions this is caused by elevation differences. Water enters the groundwater system at high altitude from beneath a glacier or underneath permanent snow, where a talik is present. It then surfaces at lower elevation at a weak spot in the permafrost, where the water will freeze up to form the ice-core of the mount. Modern open-system pingos typically occur near the base of slopes (Flemal, 1975).

Hydraulic pingos almost always occur in ‘swarms’, which probably is caused by relocation of the upwelling groundwater. It also seems that when one pingo collapses, another one will grow alongside the original (e.g. Yoshikawa, 1993). This may result in complex rampart systems in the landscape (e.g. Watson and Watson, 1974; Seppälä, 1972; Watson, 1971). In literature it is sometimes stated that hydraulic pingos can only occur in discontinuous permafrost (Holmes et al., 1968; Ballantyne and Harris, 1994), but it has been proven that this is not the case (e.g. Hamilton and Obi, 1982; Worsley and Gurney, 1996). Groundwater flow and upwelling in continuous permafrost may be influenced by a variety of subsurface geological controls, that in certain situations enables hydraulic pingo

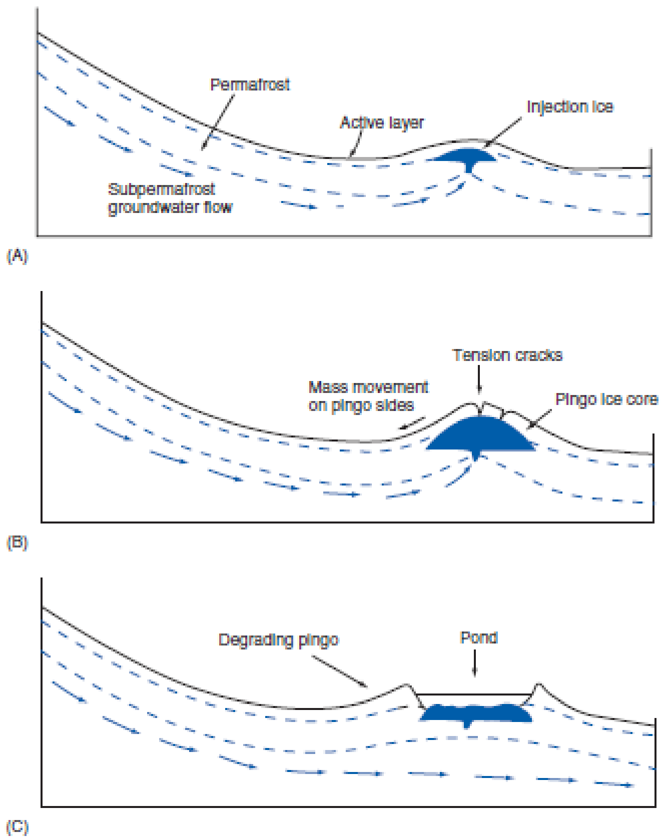

Figure 2.2: Formation and decay of hydraulic pingos Harris and Ross (2007).

(a) permafrost is percolated by groundwater from a sub-permafrost aquifer;

(b) due to tensional stress, cracks form in the overburden sediments;

(c) the ice core has melted leaving a residual pond with a peripheral rampart.

growth (Wiegand, 1968).

2.3 Pingo collapse

Pingo growth may continue until the source of water has been exhausted, and afterwards, the ice core may still persist. Ultimately, however, the pingo will become unstable and start to collapse. There are different processes which may cause this instability. In a region where permafrost is persistent and climate remains suitable for pingos, a growing pingo eventually collapses because of mechanical failure. Change of climate towards unsuitable conditions for permafrost can also be the cause of pingo collapse.

2.3.1 Mechanical failure

Due to the volume expansion of subsurface material that occurs during freezing of water, the overburden sediments of the pingo have to cope with an increase in surface area. This can be done either by stretching of the overburden, or by rupturing due to excess tension (figure 2.3). Stretching of the overburden cannot go on endlessly and will eventually lead to summit failure, resulting in a dilation crack through the summit, propagating downward into the pingo ice. Continued pingo growth results in widening of the dilation crack and outward radial movement of the overburden sediment. This is enhanced by mass transport processes such as creep. As the dilation crack widens, the ice-core is less well protected from heat by the overburden sediments. Thawing of the ice-core then results in development of a summit crater and possibly a summit lake, which further enhances the transport of heat to the ice core. The increase in circumference because of pingo growth also results in stretching of the overburden sediments. This tension is relieved by the development of radial dilation cracks (Mackay, 1998). Besides tension cracks, another type of overburden rupture can occur. When addition of water to the bottom of the pingo exceeds the rate by which it freezes, a sub-pingo water lens develops. This water lens exerts hydraulic pressure to the overburden of the pingo. When the hydraulic pressure exceeds the strength of the overburden sediment, a hydrofracture develops (Mackay, 1998). Either type of fracture may propagate through the circumference of the pingo. Past this circumference, often, the crack continues in the form of an ice wedge.

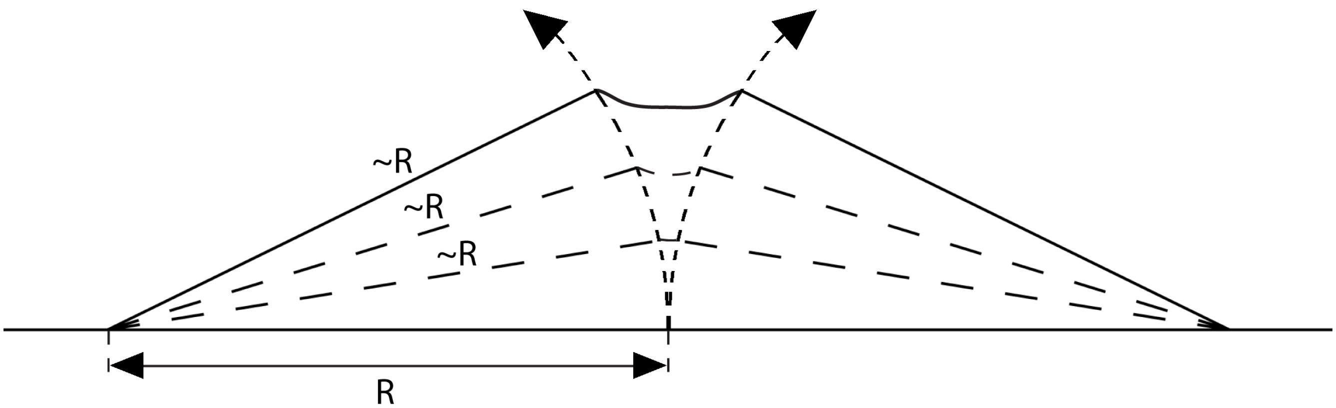

Figure 2.3: Schematic view of the development of a dilation crack, where stretching of the overburden is relieved through a crack through the pingo summit (after Mackay, 1979).

When ground ice in the pingo is exposed through for example tension cracks, collapse occurs rapidly on the scale of decades to centuries Mackay88. In the MacKenzie delta, several pingos are known to have collapsed within 60 years. However, if the (previously exposed) ice core is covered with slumped sediments, pingo collapse may stall (Mackay and Burn, 2011) and the ice core may even become stable again. Thus, pingos do not necessarily collapse in one stage, as during the collapse an equilibrium state may be reached, resulting in a partially collapsed but stable pingo that can persist for a very long time under permafrost conditions (e.g. Bijlsma and de Lange, 1983; Mackay, 1988; Kasse and Bohncke, 1992).

2.3.2 Failure because of climate change

Besides very few exceptions (Mackay, 1988) pingos can only exist when the surrounding substrate is perennially frozen, i.e. permafrost. As long as climate remains stable, pingos will grow, possibly retain in a stable state and eventually mechanically collapse (figure 2.4a). If climate is warming up (figure 2.4b), only small pingos can grow to their full size before the maximum temperature of pingo growth is exceeded. Pingos that havef (mechanical) potential to grow to a larger size would start thawing before they reach their maximum. When climate is cooling (figure 2.4c) further below the maximum temperature conditions possible for pingo growth to occur, pingos of all sizes may reach their maximum size, and long-term pingo growth for all sizes is possible (Mackay, 1988). The current distribution of pingos in North America and Russia reflects pingo growth over the last hundreds or

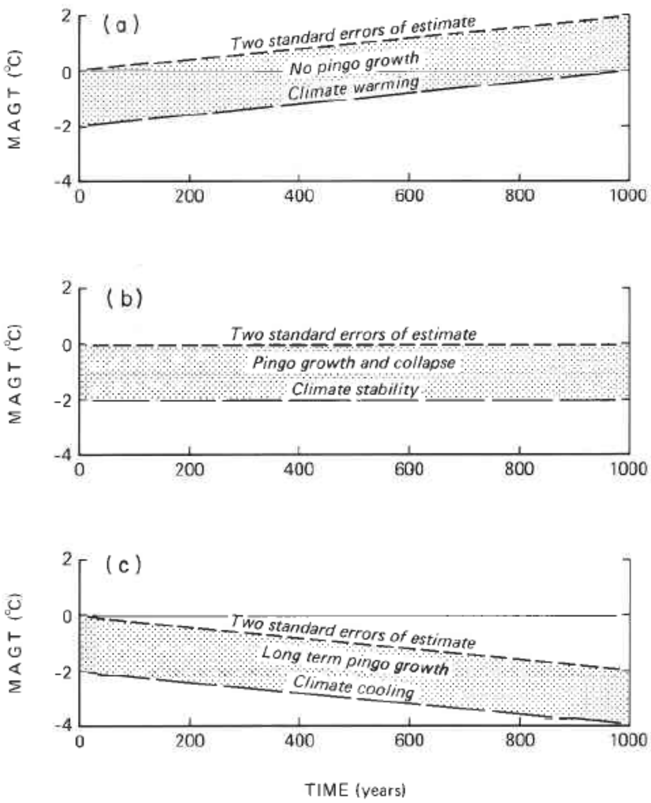

Figure 2.4: The relation between pingo growth and collapse and the long-term climatic trend (Mackay, 1988).

(a) long-term climate warming
(b) climate stability
(c) long-term climate cooling

M.A.G.T. = mean annual ground temperature.

thousands of years and has evolved during a long period of climate change (Mackay, 1988). In the literature, no descriptions have been found on pingo collapse specifically by climate change. On the time-scale of measurements, deterioration of pingos because of climate change is not observed, possibly because in the regions where pingos are present, the maximum temperature has not been exceeded yet and/or the time scale of pingo deterioration by climate is too large.

2.4 Pingo remnants

After the ice core has completely melted, a relief inversion has taken place. A circular depression with a surrounding rampart is left in the landscape. The rampart is formed by multiple processes during pingo collapse, along which (1) radial outward movement of the overburden sediments, as the pingo grows higher, (2) mass movement along the pingo slope, by processes such as (permafrost) creep and slumping and (3) debris and stream flow radially carrying overburden material outward from the thawing ice-core (Mackay, 1988). Note that sediment transport along the slopes probably starts as soon as the topography difference exists. However, the formation of a well-established rampart probably takes longer and will be enhanced once the pingo has reached full size and during later stages of decay.

The depression that is left in the landscape gradually fills up, mainly by peat growth, aeolian sedimentation. Precipitation of chemicals such as $CaCO_3$ and siderite can also take place, especially in seepage conditions, although this is a minor constituent of the infill. Peat growth may continue even after the depression has completely become filled in, resulting in peat beyond the remnant ramparts (Woltinge, 2011).

2.4.1 Recognising pingo remnants in the field

It can be expected that not all pingos that have existed have left recognizable evidence in the present-day landscape. Preservation potential of pingo remnant is dependent on site conditions and on geomorphological (and anthropogenic) history. Interpretation of pingo remnants in the field may be difficult because of a range of similar landforms in the periglacial environment (Harris and Ross, 2007).

Pingo remnants in the field are recognisable by the following proposed criteria:

- A circular or oval depression in the landscape (Wiegand, 1968).
- The depression should be filled with peat (Wiegand, 1968; Mackay, 1998).
- (Part of) a surrounding (collapsed) rampart is present (Wiegand, 1968; de Gans, 1982; Mackay, 1998). However, this remnant rampart often is heavily disturbed due to egalisation practices (Woltinge, 2011).
- The bottom of the central depression must lie within sediments that allow ground water percolation (de Gans, 1988), at least for open-system pingos.
- The minimum depth of the depression should be greater than that of the active layer (Mackay, 1972), which can be estimated based on cryoturbation features in a palaeo-setting.
- Evidence (casts) of radial dilation cracks perpendicular to the rampart exist on or outside of the rampart ring (Mackay, 1998).
- Unsorted material from mass wasting/ can be found in the rampart periphery (Mackay, 1988).
- Debris and stream flow material may be found at a few sites in and around the periphery, with indications of a water source towards the depression (Mackay, 1998).
- The (original) rampart volume should approximate the volume of the central depression (Mackay, 1998). Possibly part of the rampart in fossil pingos is buried, eroded or egalised by humans, so this might not apply (de Gans, 1982).
- Occurrence in all layers of relief and formations (Wiegand, 1968). The author disagrees: pingo formation is dependent on the type of substrate. Furthermore, differences preservation potential in different may result in the abscence of pingo remnants in certain substrates.
- A source of water such as presence of water under pressure in permeable layers or near geological disturbance e.g. faulting (Wiegand, 1968).
- Other evidence of permafrost in the environment (cryoturbation, signs of ice segregation etc.) (Mackay, 1998).
- Deviant (oligotrophic) vegetation in the depression (Steenbeek et al., 1981).

When boring transects across a (buried) fossil pingo remnant, not all of these features can be expected to be found, as some occur only at a few sites along the periphery. In the literature, no descriptions have been found on differences in pingo remnants dependent on the manner of their decay. It is imaginable that pingo decay because of climate warming could result in deposition of a larger part of the overburden sediment in the central depression itself instead of mainly on the rampart. If a pingo cannot grow to its maximum size, less outward mass transport of the overburden would take place, and a larger part of the sediment will descend into the depression. Depending on the manner of thawing of the ice core, also inward transport of overburden sediment may be affected. These processes may influence the size and shape of the remnant depression.

2.4.2 Pingo remnants and palaeoclimatic reconstruction

As mentioned earlier, the presence of pingo remnants in the field can be an important (qualitative) indicator for permafrost in the palaeo-environment. Since the ice core can only exist in perennially frozen ground, the permafrost thickness must have been at least that of the depth of the ice core (de Gans and Sohl, 1981). Therefore, the depth of a pingo forms an indication for the minimum depth of permafrost. Note that the depth of the ice core may exceed that of the remnant depression, as the ice core does not necessarily consist of pure, intrusive ice, but can also consist icy sediments (Mackay, 1978). It should also be noted that the absence of these remnants does not rule out that permafrost may have been present, as there are many other criteria that must be satisfied. For example, for hydrostatic pingo formation, appropriate sized taliks must be present, along with a process that can trigger catastrophic drainage (Mackay, 1988). Also, local topography is a major contributing factor in (hydraulic) pingo distribution (Hughes, 1969).

It is difficult to reconstruct the exact timing of pingo formation and collapse. Especially the formation of pingos cannot be precisely dated, as no material is left as evidence. However, one can state that the initiation of pingo growth is always later than deposition of the sediment the remnant depression is found in. Similarly, pingo collapse must have initiated before deposition of the youngest infilling of the remnant depression. The earliest infill of the remnant depression can already be deposited in the summit crater (figure 2.5), while part of the ice core still exists (de Gans, 1982). At this stage, the crater may either host a small lake in which organic material is deposited, or it is dry, in which case the summit depression can be partly filled with aeolian deposits or pingo skin material transported inward. During pingo collapse, a layer of overburden sediments (possibly containing datable macro remains) can descend back into the depression, directly covering the substrate (e.g. Kasse and Bohncke, 1992). The age of the substrate and timing of the start of infill of the remnant depression together bracket the timing of pingo activity. The infill of pingo remnants also is valuable in reconstructing palaeoclimate, as it often provides a continuous record that is suitable for multiproxy analysis of the Last Glacial - Interglacial transition.

Figure 2.5: Summit crater of a partially collapsed pingo, Parry Peninsula, West Arctic Coast, Canada (Mackay and Burn, 2011).

Chapter 3. Study area

The focus of the study on pingo remnants in the Netherlands and Germany lies in four different areas: Friesland and Drenthe in the Netherlands, and Ost-Friesland and the region between Cloppenburg and Visbek in Germany (figure 3.1). In every region, several depressions have been studied. Throughout the report, locations of all study sites are given in the WGS 84 coordinate system. Additionally, for study sites located in the Netherlands, coordinates are given in the national coordinate system Rijksdriehoekstelsel (RD).

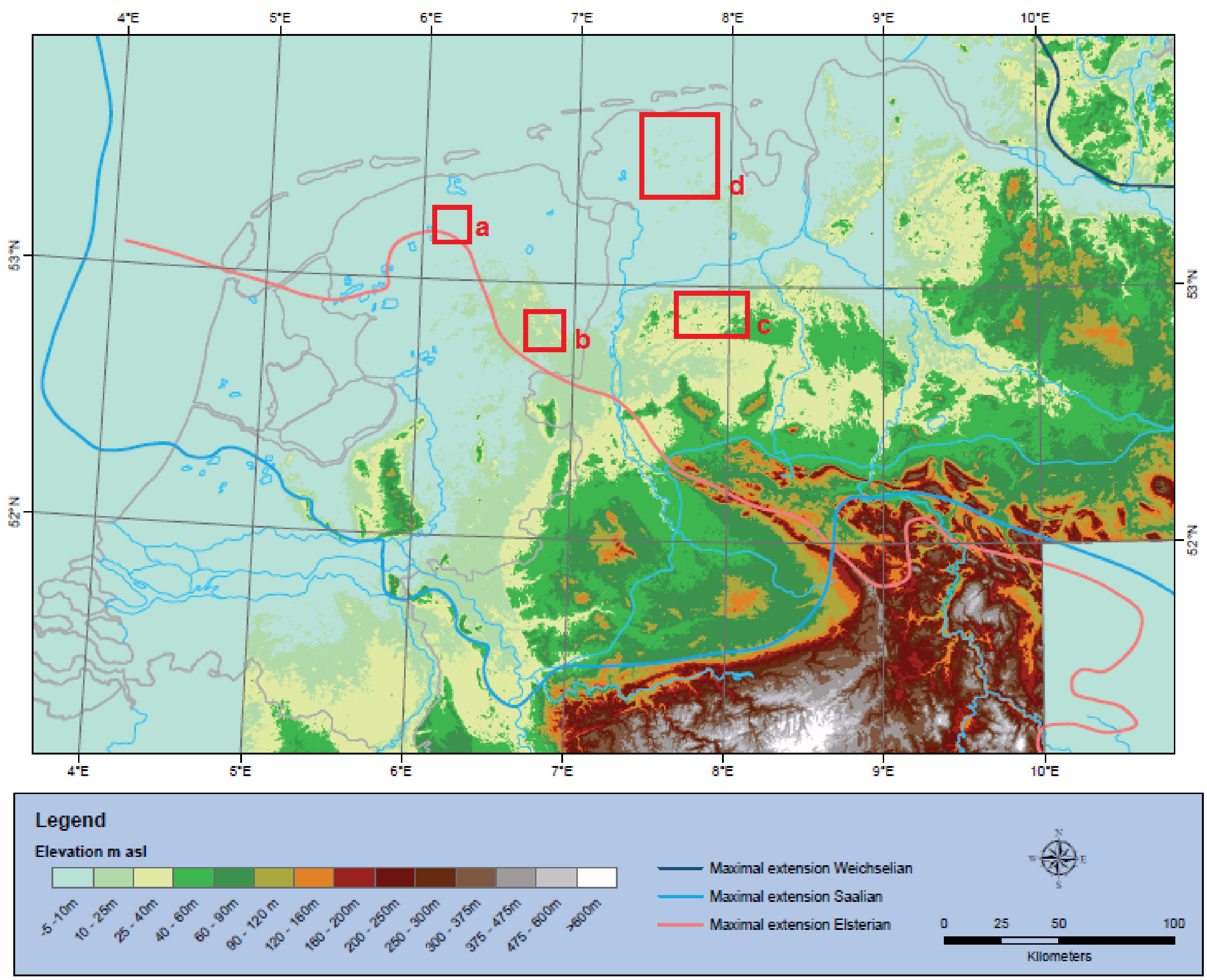

Figure 3.1: Maximum extension of the Elsterian, Saalien and Weichselian glaciations. Modified after Pierik (2010). Red squares indicate the study areas: (a) Friesland, the Netherlands, (b) Drenthe, the Netherlands, (c) Cloppenburg/Visbek area, Germany and (d), Ost-Friesland, Germany. Modified after Pierik (2010).

In the Quaternary, worldwide climate fluctuations occurred, resulting in large-scale expansion and regression of ice sheets and changes in the abiotic and biotic landscape. The glaciations that have most affected the current morphology and geology of the study areas are the Elsterian (474-410 ka), Saalian (370-130 ka) and Weichselian (115-10 ka) glaciations. This chapter describes the geology formed in the Middle and Late Pleistocene (section 3.1), Late Glacial climate and vegetation (section 3.2) and Weichselian permafrost distribution in the study area. Also, the selected sites in the four study areas are presented (section 3.4).

The extent of the last three glaciations in the Netherlands and north-west Germany is indicated in figure 3.1. A morphologically distinct margin of the Elsterian ice sheet in the Netherlands is absent (Laban and Van der Meer, 2004), but in north-western Germany the ice sheets extended towards the margin of the Central German Uplands (Ehlers et al., 2004). Although the Elsterian glaciation is generally considered the largest, in the study area the maximum Saalian glaciation extends further to the south (Pierik, 2010). In Germany, the ice sheet advanced to line from the margin of the Hartz mountains, via Eisleben, Freyburg, Zeitz, Altenburg, Grimma, Döbeln, Kamenz to Görlitz Ehlers et al. (2004). The southernmost extent of the ice sheet in the Netherlands is marked by the pushed moraines of the Utrechtse Heuvelrug, de Veluwe, Nijmegen and the Montferland (Berendsen, 2001b).

In the Weichselian glacial, the Arctic ice sheet never reached the Netherlands or north-western Germany. The maximum extent of the Weichselian ice sheet in Germany is marked by the Brandenburg Moraine that lies east of the study area (Nilsson, 1983) and the British ice reached the western part of the Dutch sector of the North Sea (Laban and Van der Meer, 2004). During the (Late) Weichselian, the period of interest within this study, periglacial conditions required for pingo formation prevailed in the study area (see sections 3.2 and 3.3).

3.1 Regional geology

The Middle and Late Pleistocene glaciations have had a major effect on the geology of the studied area. Formations that have been described in the Netherlands are presented in figure 3.2. Although a lithostratographic overview in German nomenclature is not provided, regional geology is very similar.

In the Early Pleistocene, the large Eridanos river system brought in coarse, silica-rich white sands from the Baltic Sea area and north Germany. In the Netherlands these sediments belong to the Peize and Appelscha Formations (Berendsen, 2001b) and upstream deposits continue into Lower Saxony and Bremen (Pierik, 2010). The influence of the river system decreased during the Bavelien (De Mulder et al., 2003), but deposition of the Appelscha Formation occurred until in the Cromerian (850-475 ka) (Berendsen, 2001b). Later, the river Rhine became more important in the northern Netherlands. This led to the deposition of the gravel containing sands of strongly variable grain size of the Urk Formation (De Mulder et al., 2003).

During the Elsterian glaciation a lot of erosion took place, and deep valley systems developed underneath the ice sheet covering the study areas. Deposits that are related to the Elsterian glaciation belong to the Peelo Formation (De Mulder et al., 2003). Part of the formation consists of meltwater deposits; very fine to very coarse grey sands that occasionally contain gravel. In Germany, glacial tills of Elsterian age have been found at several localities (Ehlers, 2011), however, in the Netherlands such deposits are rare (De Mulder et al., 2003). Other sediments from the Peelo Formation include the sediments that filled the (previously) subglacial valleys; glaciofluvial fine sands and almost black glaciolacustrine to marine clays (Nieuwolda member), that are also known as ‘Lauenburger Ton’ or ‘potklei’ (Berendsen, 2001a).

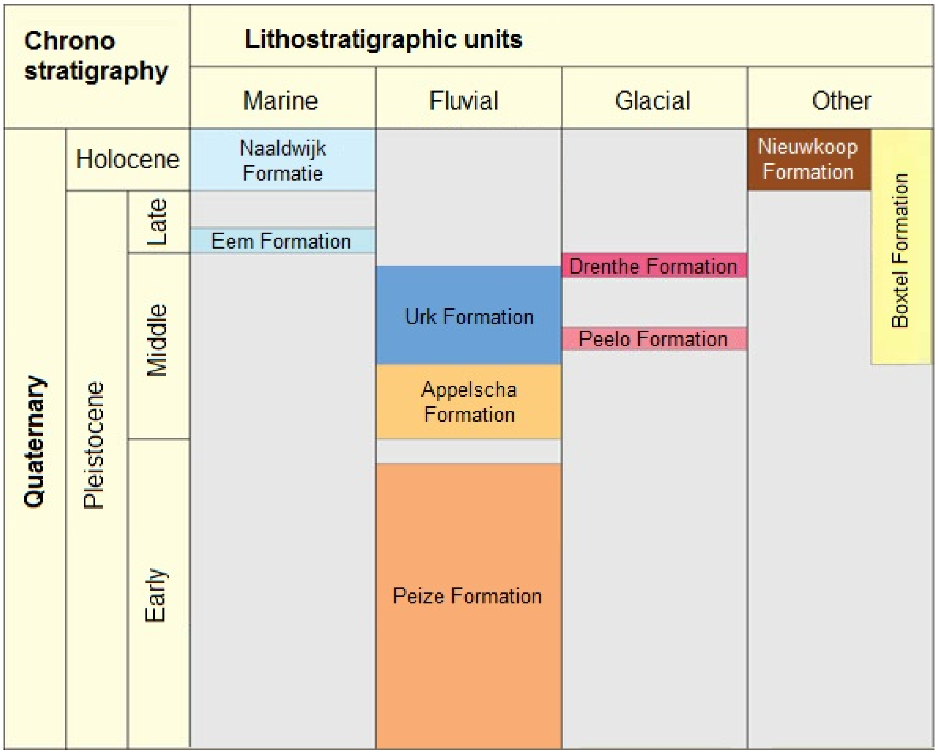

Figure 3.2: Late Pleistocene lithostratigraphic units of the northern Netherlands. Based on TNO, 2011.

In the Netherlands, all Saalian glacial sediments are placed in the same lithostratigraphical unit: the Drenthe Formation (Berendsen, 2001b). A simplified glacial map of the Saalian is shown in figure 3.3. The formation has a strongly variable lithological composition which varies from fine to very coarse sand containing gravel to sandy or silty clays. Glacial tills of the Drenthe Formation belong to the Gieten Member and are 1-40 metres thick. On the mainland, the sediments often lie discordantly on top of the sands of the Urk Formation, but due to local erosion it can also be found covering older sediments such as the Appelscha Formation (De Mulder et al., 2003, figure 3.4). The thickness of the Drenthe Formation varies from several decimetres to over a hundred metres.

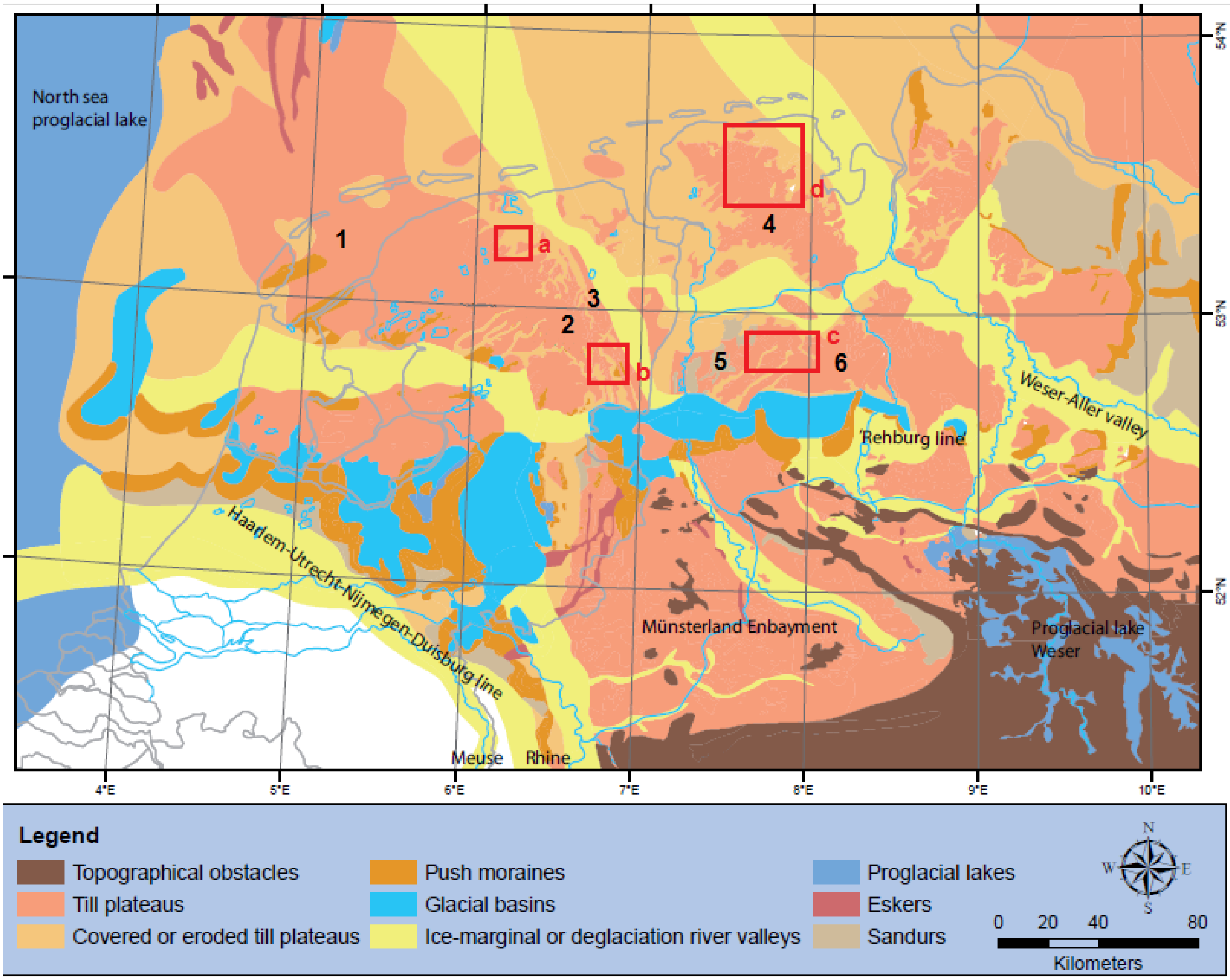

Figure 3.3: Simplified glacial map of the northern Netherlands and north-western Germany. Red squares indicate the study areas: (a) Friesland, the Netherlands, (b) Drenthe, the Netherlands, (c) Cloppenburg/Visbek area, Germany and (d), Ost-Friesland, Germany. Several till plateaus have been marked: (1) North Sea till plateau, (2) Drenthe plateau, (3) Hondsrug, (4) Ostfriesland plateau, (5) Hümling plateau and (6) Cloppenburg plateau. Modified after Pierik (2010).

The Drenthe Plateau is the area where the glacial till lies at or near the surface, which is the case in both study areas in the Netherlands. The plateau is tilted towards the north-west. The northern boundary is set where the Pleistocene deposits are covered by a peat and marine deposits from the Holocene (the Nieuwkoop Formation). The glacial meltwater rivers Vecht and Hunze form the southern and north-eastern boundary. The western slope of the Drenthe plateau is incised by many north-east to south-west oriented valleys, that are thought to have formed underneath the Saalian land ice cap. Some of these valleys cut through the till (Berendsen, 2001b). Because of exposure of the till at the surface after the ice had melted, part of the glacial till was affected by water- and wind-driven erosional processes. This resulted in the removal of fine material and development of a sandy till (Dutch: 'keizand'). A cross section of the Drenthe plateau from Steenwijk (Friesland) to Ter Apel (Drenthe) is shown in figure 3.4. The valley in the east is the Hunze valley. Another till plateau in the Netherlands is the North Sea plateau (Pierik, 2010), although this lies deeper in the subsurface.

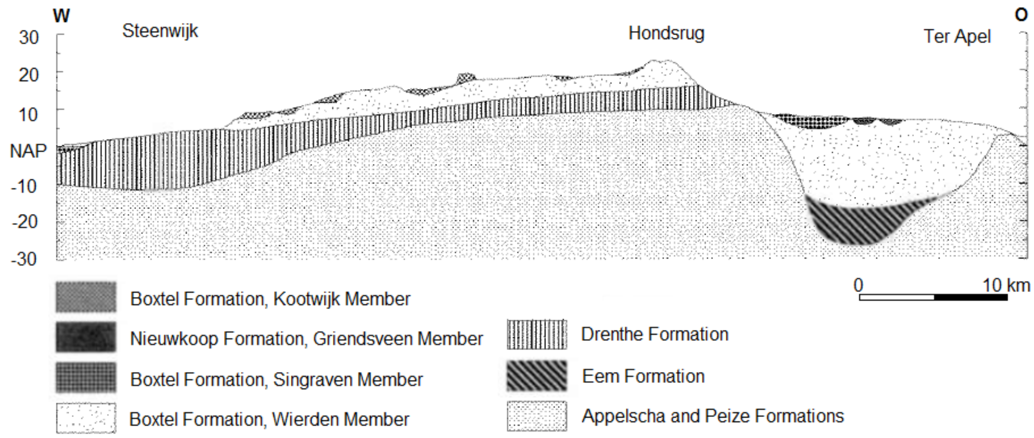

Figure 3.4: West-to-east oriented geological cross section along the Drenthe Plateau, the Netherlands. Modified after Berendsen (2001a).

In northern Germany, multiple layers of Saalian till have been deposited (figure 3.5), which were subdivided in the Older, Middle and Younger Saalian till. They are stratigraphically separated from each other by meltwater deposits of sand and gravels as well as glaciolacustrine clays, indicating that in Germany multiple phases of glaciation occurred during the Saalian glacial complex (Ehlers et al., 1984). Till plateaus in the surroundings of the studied areas in Germany are the Hümmling plateau, the Cloppenburg plateau and the Ostfriesland plateau. During deglaciations, large parts of the plateaus were eroded and dissected by incising rivers. Further erosion occurred through the incision by Weichselian ice marginal rivers and local streams (Pierik, 2010).

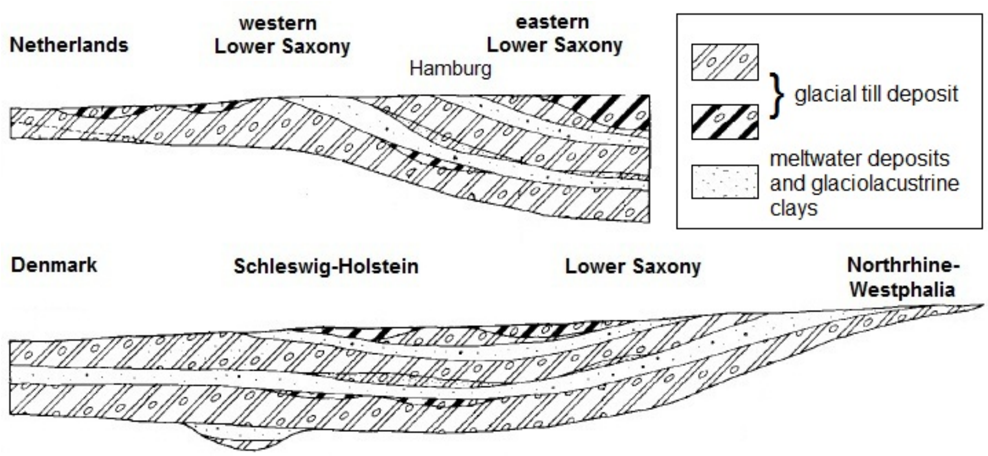

Figure 3.5: Schematic lithological cross section through Lower Saxony (a)from West to East, and (b) from north to south. Modified after Ehlers et al. (1984).

During the Eemian (130-115 ka), thick sedimentary deposits have formed in the glacial valleys that were left behind after the retreat of the ice (figure 3.3). On land, they consist of brackish water deposits that formed when the sea intruded glacial valleys after the retreat of the Saalian ice. These deposits belong to the Eem Formatie. Near the coast of Friesland, marine deposits have also been deposited in the Holocene. These sediments consisting mainly of very fine to fine sand or sandy to silty clay belong to the Naaldwijk Formation (De Mulder et al., 2003). Similar deposits possibly occur in Ost-Friesland.

During both the Saalian and the Weichselian, the older Saalian and Eemian deposits became covered with sands of the Boxtel Formation. The deposition of aeolian sediments over the Drenthe plateau conceals the older relief, so that it becomes difficult to distinguish between aeolian depressions, pingo remnant depressions or other depressions without performing borings (Cleveringa et al., 1977). The Boxtel formation often lies at the surface and can be of varying thickness (1 - 35 metres), although it is thin and relatively underdeveloped over the Drenthe Plateau (De Mulder et al., 2003). The formation mainly consists of aeolian material, that sometimes contains thin peat or soil layers that formed during periods of reduced aeolian activity. On a smaller scale, lacustrine and fluvial deposits occur. The Boxtel Formation is subdivided in eight members, between which subtile differences in composition exist (Schokker et al., 2007).

In the literature, coversands of the Middle and Late Weichselian are often subdivided in Older Coversand (I and II) and Younger Coversand (I and II) which are attributed to different periods in time. Changes in aeolian sedimentation rate are related to the variation in the openness of the vegetation cover during the Late Glacial 3.6, which is further discussed upon in section 3.2.

The Older Coversand I is often not preserved as a primary deposit, as permafrost resulted in strong overland flow and aeolian sediments were reworked (Kasse, 1999). Sands that were deposited in the Late Pleniglacial, are characterised by an alternation of fine sandy and loamy fine sandy layers in the lower part, and horizontal bedding of fine sands in the upper part, which have been called the Older Coversand II (Kasse, 1999). An aeolian lag deposit is present between the Older Coversand I and II; The Beuningen Complex is a desert pavement that formed during a period of deflation. It formed between 14.8 and 14.3 ka cal BP Hoek and Bohncke (2002) and has been found both in the Netherlands and north-western Germany (Kolstrup, 1980).

The Younger Coversands I were deposited during the Older Dryas (see section 3.2) from 14.1 to 14.0 ka cal BP. They are characterised by horizontally bedded fine sands (Kasse, 1999). At some localities, these deposits contain an organic or soil layer (the Usselo Soil) that formed during the Allerød Berendsen (2001b). The Younger Coversand II was deposited during the Younger Dryas and rarely contains loamy layers.

This differentiation between the cover sands cannot be made everywhere, as the lithology of different sands is very similar, the transition is asynchronous (Kolstrup, 2007) and organic layers separating them are not always present (Hoek and Bohncke, 2002).

Basically, the lithological sequence in all four study areas adds up to the following: the deepest sediments that are of interest in this study are sands deposited by the Eridanos and Rhine river systems (the Peize, Appelscha and Urk Formations). These sediments have been covered by one or multiple layers of glacial till (alternating with meltwater deposits in Germany) of variable composition and thickness (the Drenthe Formation or Saalian tills). The tills are affected by erosion such as incision by streams and aeolian erosion and regionally vary in strength, thickness and composition. They are in turn overlain by coversands (the Boxtel Formation) that were deposited in the Saalian and Weichselian, and within these cover sands, subtile spatial and temporal differences in composition and grain size and thickness exist.

3.2 Palaeoclimate and vegetation

The paragraphs underneath describe the development of Late Glacial and early Holocene climate, lake levels, vegetation and aeolian sedimentation primarily based on the paper by Hoek and Bohncke (2002), which is focused on the Netherlands. Vegetation development in the Netherlands is also presented schematically in Appendix A. The development of climate and vegetation in north-western Germany is expected to be roughly similar to that in the Netherlands, as study areas in Germany lie proximal (about 150 km at maximum) to the Dutch study areas and the distance to the former (Glacial) coastline is relatively large. Nevertheless, there may be some regional/local differences that are not accounted for.

In this section, the Late Glacial has been split up in Late Pleniglacial, Bølling, Earlier Dryas, Allrød and Younger Dryas in order to provide reference and clarity. Equivalent Greenland ice core stages and Pollen Assemblage Zones (PAZ) and are also mentioned (based on Hoek, 2008 and Hoek, 1997). An overview of the vegetational, climatological and geomorphological Late Glacial development is presented in figure 3.6. All described factors are closely interrelated: vegetation is dependent on climatic circumstances (and substratum), and aeolian erosion and deposition strongly correlate to openness of the vegetation and humidity, as these influence sediment availability and trapping.

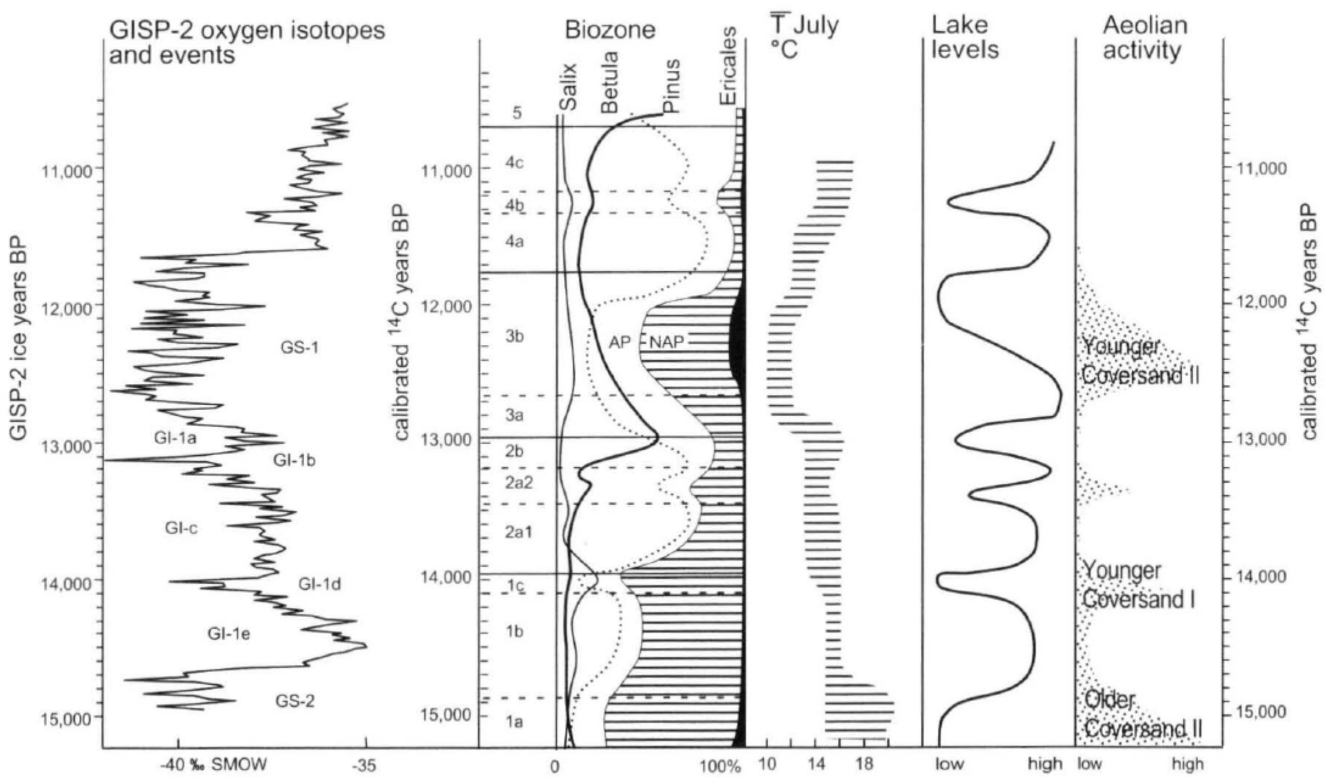

Figure 3.6: Schematic overview of Late Glacial developments of vegetation, climate and geomorphology compared to the GISP-II oxygen isotope curve. Modified after Hoek and Bohncke, 2002.

Late Pleniglacial

In the period prior to the Late Glacial, climatic conditions were extremely cold and dry, as indicated by the wide-spread occurrence of cover sand deposits, the rareness of sedimentary structures (indicating running water) and the absence of organic deposits (Hoek and Bohncke, 2002). Prior to 15.5 ka cal BP, vegetation cover was sparse and the surface was often bare. Vegetation that was present comprised mainly grasses, herbs and shrubs of *Betula nana* (dwarf birch) and *Salix* (willow). Aeolian activity was high and deposition of cover sands prevailed (Older Coversand II, section 3.1). After 15.5 ka cal BP, a slight temperature rise resulted in the development of herbaceous plant communities and dwarf shrubs (Hoek and Bohncke, 2002).

Bølling (14.8 - 14.1 ka cal BP, equivalent to GI-1e or PAZ 1b)

In the Bølling, reconstructed mean summer temperature lies between 15 and 20 °C (van Geel et al., 1989). During this time, the presence of *Betula* was becoming more wide-spread (Hoek, 1997), although it did not reach full-interstadial or interglacial values comparable to those in the Allerød and Holocene. Due to the increase in vegetation cover, aeolian activity decreased. However, it did not completely diminish. Mainly as a result of melting of ground ice (3.3), shallow lacustrine conditions occur at the beginning of the Bølling. Later on, lake level increased and remained high (Hoek and Bohncke, 2002) until the transition towards the Older Dryas, which coincides with a lowering in lake level(Bohncke and Wijmstra, 2008).

Older Dryas (14.1 - 14.0 ka cal BP, equivalent to GI-1d or PAZ 1c)

In the period between 14.1 and 14.0 ka cal BP, summer temperature dropped to between 15 and 16 °C (Bohncke and Wijmstra, 1988; van Geel et al., 1989). Mean January temperatures would have exceeded -15 °C (Hoek and Bohncke, 2002). During this time, a temporary low-stand in lake-level occurred, caused by draught and a decline in precipitation (Hoek and Bohncke, 2002). This was recorded by an increased presence of plant species that live in lake fringe zones. The vegetation cover in this period was more open. The amount of *Betula* declined, and *Salix* shrubs became an important constituent of vegetation. (Hoek, 1997). As a result, aeolian activity increased (deposition of Younger Coversand I, section 3.1).

Allerød (14.0 - 13.0 ka cal BP, equivalent to GI-1a, b and c or PAZ 2)

Early in the Allerød, mean July temperature were within the range of 13 to 16 °C, and mean January temperatures ranged between -16 and 6 °C. Lake levels rose and fluvial discharge was high. This was possibly caused by an increase in effective precipitation or winter snow cover. A short phase of lower lake levels occurred around 13.5 kyr BP. Later in the Allerød, lake-levels experience another low-stand, sometimes leading to a hiatus in the sedimentary record (Hoek and Bohncke, 2002). In north-west Germany, soil formation occurred in the Allerød (Walker et al., 1994). Bohncke and Wijmstra (2008) also argue the Allerød was a period of fluctuating lake levels, with a strong decrease in lake level towards the end of the Allerød, possibly as a result of increased influx of drainage water. This may have led to an increase in chemical precipitation, as seems to be the case in the Uteringsveen pingo remnant, and to the absence of vegetation from the fringe zone (Bohncke and Wijmstra, 2008).

Vegetation cover during the Allerød became more dense, with warmer temperatures giving rise to *Betula* (PAZ 2a) and later on *Pinus* (pine) forests (PAZ 2b), splitting the Allerød in two phases. The increase in vegetation cover caused the substratum to become fixed, and aeolian activity ceased. The Allerød is a time of landscape stability and soil formation (Usselo soil, section 3.1), although in north-west Germany, there are indications for one or more short episodes of erosion (Walker et al., 1994). Around 13.2 ka cal BP, at the end of the Allerød, July temperatures further declined. Mean January temperatures also decreased to the range of -16 to -13 °C, enabling deep seasonal frost and more intensive action of the freeze-thaw cycle (Hoek and Bohncke, 2002).

Younger Dryas (13.0 - 11.8 ka cal BP, equivalent to GS-1 or PAZ 3)

During the Younger Dryas, a periglacial regime again prevailed in the Netherlands and north-western Germany. The transition to the Younger Dryas around 13.0 kyr BP is characterised by rapid climate change: July temperatures dropped from 15 - 18 °C to 10 - 13 °C (Bohncke and Wijmstra, 1988; Isarin, 1997), and January temperatures fall to between -15 to -7 °C (Bohncke and Wijmstra, 1988). The transition to the Younger Dryas is also marked by a rise in lake-level (Bohncke and Wijmstra, 2008; Hoek and Bohncke, 2002), resulting in increased erosion (Hoek and Bohncke, 2002) and enhanced mineral inwash into lakes (Walker et al., 1994). Soils from the Bølling/Allerød were destroyed (Walker et al., 1994). The development of the dense forests in the Allerød stopped, and forests gave way to a more open vegetation type in which herbaceous plant communities flourished (Hoek, 1997). The open character of the vegetation cover is paired with an increase in aeolian activity (Younger Coversands II, section 3.1; Hoek and Bohncke, 2002). At approximately 12.7 ka cal BP the second phase of the Younger Dryas sets in. Mean July temperatures increased to values between 13 and 15 °C. Towards the end of the Younger Dryas, another minimum in lake level occurs (Bohncke and Wijmstra, 2008). Soils were drier, possibly because of a decrease in precipitation and perhaps increased soil percolation because of thawing of the permafrost (Hoek and Bohncke, 2002) (section 3.3). Drier climate conditions are also implied by an increase in aeolian sedimentation (Walker et al., 1994). Plant species growing in the border zones of lakes increased (Hoek and Bohncke, 2002). In this second phase (PAZ 3b), Ericales (especially *Empetrum*) form an important constituent of vegetation (Hoek, 1997) and aeolian activity experiences its maximum in the Younger Dryas, possibly linked to the disappearance of discontinuous permafrost (Hoek and Bohncke, 2002 , section 3.3).

Holocene (after 11.8 ka cal BP, equivalent to PAZ 4 and 5)

At the onset of the Holocene (around 11.8 cal lyr BP) July temperatures probably increased rapidly to values similar to those in the Late Glacial interstadials, about 15 to 17 °C (Hoek and Bohncke, 2002). The high temperatures led to thawing of the permafrost (section 3.3) and soil formation initiated (Walker et al., 1994). Higher lake levels returned, although the increase in water depth is often interrupted by a short phase of shallow water conditions between 11.3 and 11.2 kyr BP. The early Holocene is sometimes also represented by a hiatus (Hoek and Bohncke, 2002). Mineral inwash into lakes ceased (Walker et al., 1994). Lake records often show a hydroseral succession in the Holocene, which naturally led to shallowing of the lakes. The onset of the Holocene is marked by a strong rise in *Betula* forests (PAZ 4). This rise is often preceded by a short period in which *Juniperus* (juniper) is relatively abundant - it is considered as a shrub belt in front of the *Betula* forest-line on dry soils (Hoek, 1997). After the rise in *Betula*, *Pinus* forests develop, followed by the successive immigration of thermophilous tree species, starting with the immigration of Corylus (PAZ 5) (Hoek, 1997). The development of a closed vegetation cover caused aeolian activity to decrease, and after 11.8 ka cal BP aeolian activity only sporadically took place until human disturbance caused opening of the vegetation cover later in the Holocene (Hoek and Bohncke, 2002).

3.3 Permafrost and pingo remnants

Although there are many indicators for permafrost in Europe, the thickness and type of permafrost is still speculated upon. It is unclear whether it has been cold enough for a time sufficiently long to form continuous permafrost. Permafrost related phenomena in pleniglacial sediments have been frequently recorded, yet similar fossilised structures in Late Glacial sediments are rare. Nevertheless, the presence of permafrost related phenomena indicates that permafrost in the Netherlands was present during the Early Late Glacial and Younger Dryas (Hoek and Bohncke, 2002). The paragraph below provides a summary of two articles in which Weichselian (Van Vliet-Lanoë, 1989) and Younger Dryas (Isarin, 1997) permafrost extent has been reconstructed. This is by no means an exhaustive discussion on permafrost development in north-western Europe during the Weichselian and it does not always correspond to permafrost occurrence described by Hoek and Bohncke (2002) as mentioned in section 3.2. However, a general framework on the type and timing of permafrost present in north-western Europe is important as it specifies when (and what type of) pingo activity could have occurred.

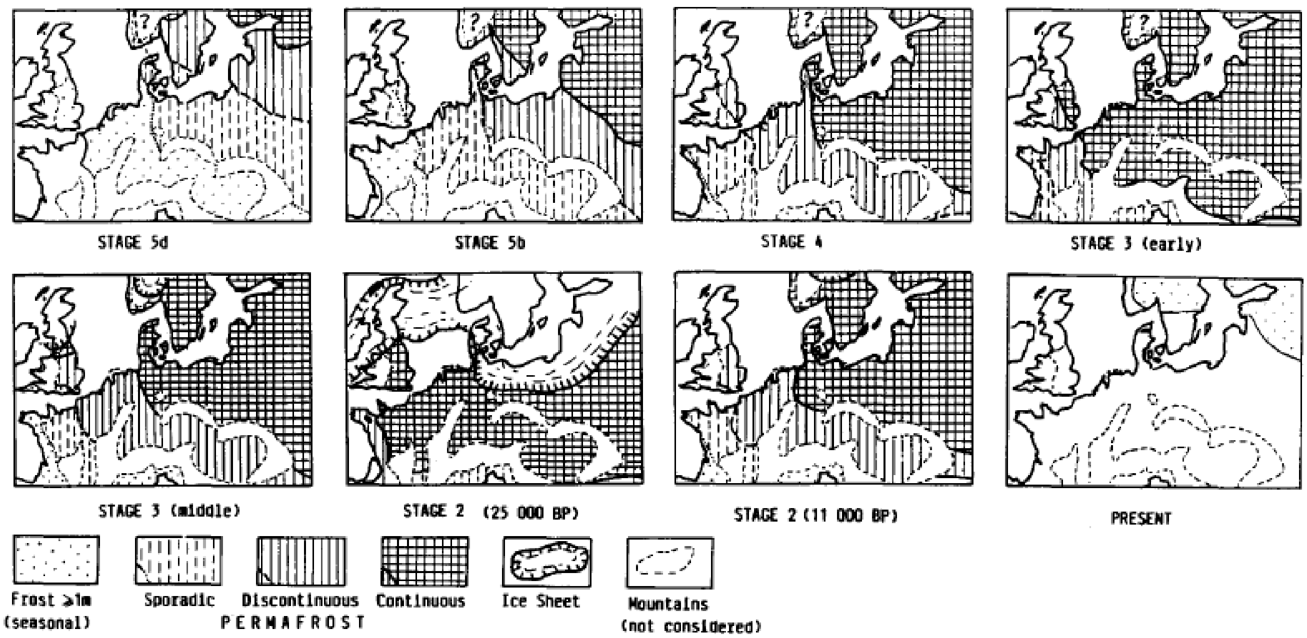

Figure 3.7: Extent of Weichselian permafrost based on cryopedological and paleopedological data (Van Vliet-Lanoë, 1989).

Multiple studies indicate that at least discontinuous permafrost must have existed some time during the Weichselian and until the Younger Dryas (Van Vliet-Lanoë, 1989). In a non-recent paper, permafrost dynamics in throughout the Weichselian glacial have been reconstructed based on a combination of theoretical data (solar insolation) and cryopedological and palaeopedological data (figure 3.7, Van Vliet-Lanoë, 1989). The author argues that permafrost did not exist in the Early Weichselian. However, in the Middle Weichselian (or Pleniglacial) permafrost was well-developed in Germany, and discontinuous permafrost reached the north of Belgium. Sporadic permafrost extended to northern France, developing to discontinuous permafrost and later on, around 60 kyr BP, nearly continuous permafrost was present. Between 60 and 30 kyr BP, conditions favourable in maintaining permafrost continued, although the continuous permafrost boundary migrated back towards the north. After 30 kyr BP, summer insolation decreased and permafrost again advanced towards the south. From 19.0 kyr BP onwards, increase in summer insolation would have caused degradation of the permafrost, which was only maintained in valley bottoms or in poorly drained depressions (Van Vliet-Lanoë, 1989).

Based on an evaluation of periglacial features such as large cryoturbation structures, (immature) ice wedge casts or frost cracks and frost mounds (e.g. pingo remnant depressions), Isarin (1997) concluded that during the Younger Dryas, the Netherlands and northern Germany were part of a larger area of discontinuous permafrost stretching from approximately 54 to 50°N. These structures are thought to originate from what is often described as the coldest period in the early Younger Dryas (Isarin, 1997). In the Netherlands, the maximum cold period of the Younger Dryas has been pinpointed to 10.8 - 10.5 kyr BP (Bohncke, 1993), and the majority of Younger Dryas thermal contraction phenomena are located north of the rivers Rhine and Meuse. Generally, these features were observed in aeolian sand situated above the Allerød (Usselo) soil or penetrate this marked horizon (Isarin, 1997). The low temperatures allowed the development of discontinuous permafrost, and in the lower part of the Younger Dryas (equivalent to PAZ 3a) periglacial structures are found (Isarin, 1997). These periglacial features may partially have occurred because the humidity of the soil enabled formation of segregation ice (Hoek and Bohncke, 2002). Initial degradation or permafrost at a locality in the southern Netherlands probably occurred after 18.0 kyr BP (Kasse and Bohncke, 1992), and before or at the very beginning of the formation of the Beuningen gravel bed, continuous permafrost had disappeared from the Netherlands (Kolstrup, 1980).

Pingo remnants in the study area

The presence of permafrost in the Netherlands is a.o. evident from the presence of pingo scars. An inventory of pingo remnants in the Netherlands (and Germany) has been made by Ruiter (2012). Especially in the northern part of the Netherlands, a high density of pingo remnants is present, which is comparable to the current situation in the MacKenzie delta in Canada (Ruiter, 2012). The density of pingo remnants in the Netherlands may be even higher, as only certain areas have been investigated extensively. However, it should be noted that the pingo remnants not necessarily were active simultaneously, hence the density of active pingos during the Late Glacial could have been lower than the density of pingo remnants. Although several pingo remnant depressions have been found in the south of the Netherlands (e.g. (?Kasse and Bohncke, 1992)), the occurrence there is far less numerous. This may be partially caused by the different geology, although it also seems plausible that the general absence of prominent pingo remnant depressions in the region is caused by the smaller thickness of the permafrost in comparison to the northern Netherlands (Kasse and Bohncke, 1992).

Even though similar depressions occur in the north-western region of Germany, to the authors knowledge none have been acknowledged as pingo remnants in recent literature. Pingo scars have been recognized in the state of Hesse, the Oberpfälzer Wald, in Spesse, the Fichtelgebirge and the Upper Rhine plain. They are of Weichselian age (Wiegand, 1968). In more recent literature, depressions that possibly are pingo remnants are often considered as windblown holes or in the case of the Hämelsee in Lower Saxony, as a dolina from a collapse over Permian salt deposits (Merkt and Müller, 1999).

Time of pingo activity

The formation of pingos in the Netherlands probably occurred during the coldest phase of the Late Pleniglacial, between 25.0 and 18.0 kyr BP, which corresponds to the time in which continuous permafrost was present in the Netherlands. The youngest date from below a pingo rampart remnant suggests that initial collapse occurred after 18.0 kyr BP (de Gans, 1988). Nevertheless, the earliest infill of different pingos is variable. The majority of pingo remnants described in the literature date to the Bølling, Earlier Dryas and sometimes to the Allerød, indicating a minimum age for pingo collapse is not isochronous (see Hoek, 1997, table 7.3). According to de Gans (1988), the youngest ^{14}C-date from below a rampart suggests initial pingo collapse after 18.0 kyr BP. of time is in agreement also with the maximum age of recent pingos investigated so far (Washburn, 1979).

Because a pingo rampart is primarily built up from the pingo overburden, the rampart volume is expected to approximate the volume of the remnant depression itself. However, in the Netherlands, ramparts are often too small in comparison with the volume of the depression (de Gans, 1988). Part of the decrease in rampart volume may be due to fluvial erosion or caused by anthropogenic disturbance (e.g. levelling practices). Furthermore, de Gans (1988) suggested that erosion may also have occurred by aeolian erosion during the period of deflation in which the Beuningen gravel bed was formed, between 19.0 and 14.0 kyr BP (Kolstrup, 1980) (see section 3.1). This erosion would account for the near-absence of remnant ramparts around pingo remnants of Pleniglacial age (de Gans, 1988). Frost mount scars of Late Glacial or Younger Dryas age (e.g. Watson, 1971; Pissart, 2003) often do possess a well-developed rampart as they have not experienced this period of severe aeolian erosion de Gans (1988). This suggests that the presence or absence of a remnant rampart may form an indication for the age of a pingo remnant.

Pingo remnant characteristics

Specifically for the Netherlands (and adjacent Germany), some other prerequisites have been formulated in addition to the criteria summarised in section 2.4.2.

- The minimum depth has been (arbitrarily) set to 2.0 m. This can be used as a rule of thumb to discrimi-ate aeolian depressions from pingo remnants. It approximately corresponds with the depth of Weichselian cryoturbation structures, representing the depth of the active layer (de Gans, 1988).
- In the Netherlands, basal infillings are approximately of (Late) Weichselian age (de Gans, 1982) (see also table 7.3 of Hoek, 1997).
- A remnant rampart is not required as it may have been heavily disturbed, e.g. because of erosion or during ploughing or levelling practises, during which the rampart is sometimes shoved into the depression (Woltinge, 2011).

3.4 Individual study sites

The selection procedure of the individual sites is described in section 4.1. Most circular depressions in Friesland seem to occur in the surroundings of Buitenpost (Bûtenpost) and Surhuisterveen (Surhústerfean; figure 3.8). In this region, three presumed pingo remnants were investigated: Egypte, Laarzenpad and Opende.

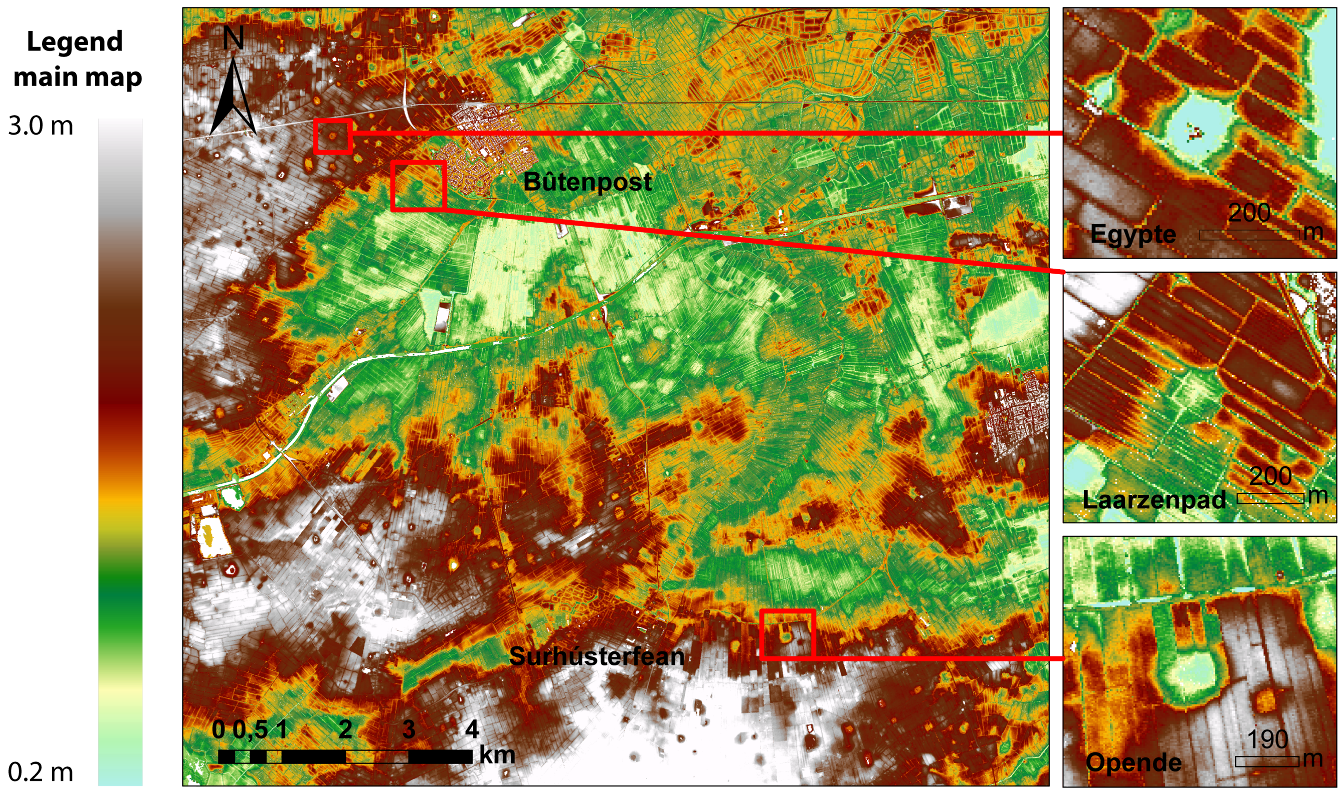

Figure 3.8: Digital elevation map of the Friesland study area and the three selected sites.

In the Drenthe area in the Netherlands, four sites have been studied (figure 3.9): Sleenerstroom I, Lammeer, Vlierendijk and Sleenerstroom II.

Four depressions have been selected in the area between Cloppenburg and Visbek based on previous work by H.J. Pierik MSc. These are Keller-Höhe, Rennplatz, Erlte, Emstekerfeld and Sevelte (figure 3.10).

The depressions that have been selected in Ost-Friesland, Germany are Timmelteich, Westerschoo, Brill and Wrokmoor. In the surroundings many similar depressions have been recognized, although many were filled with water. A map of these locations was not available.

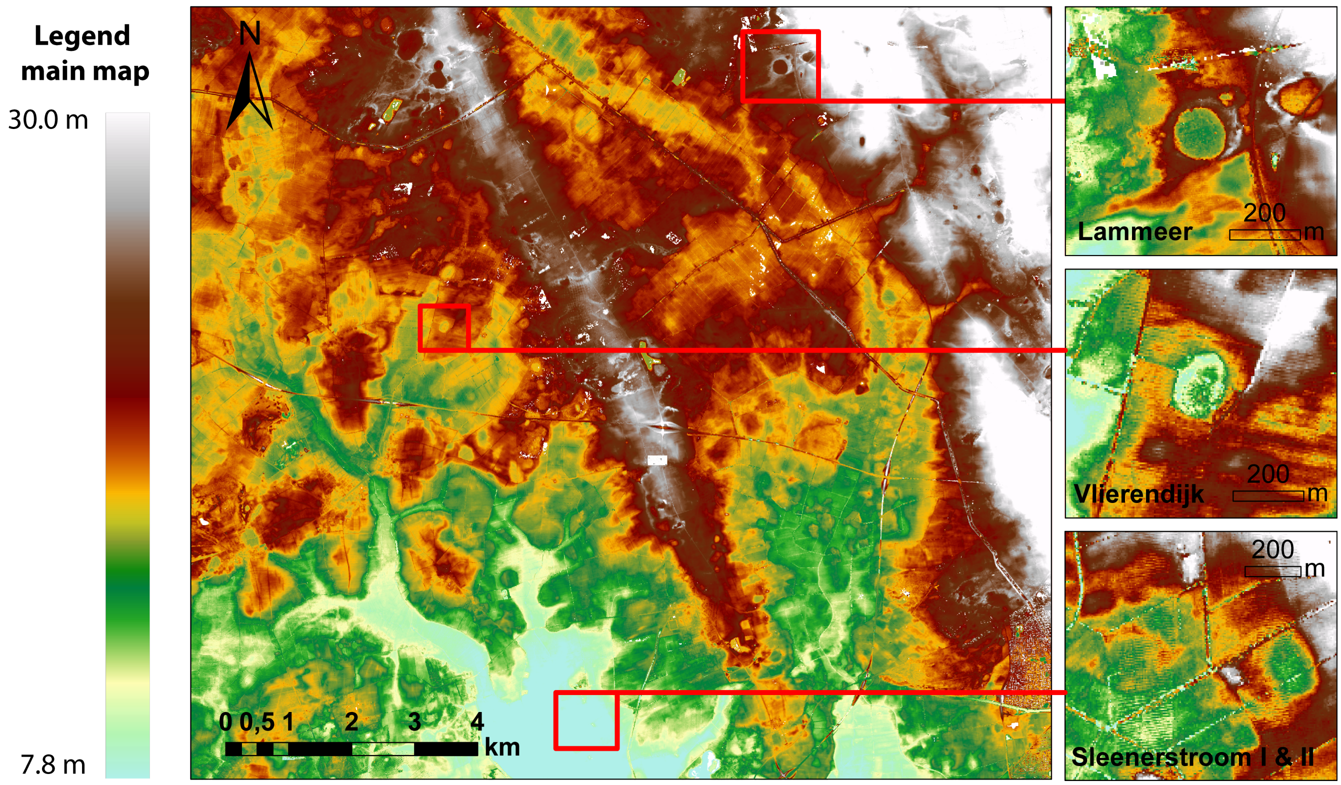

Figure 3.9: Digital elevation map of the Drenthe study area and the four selected sites.

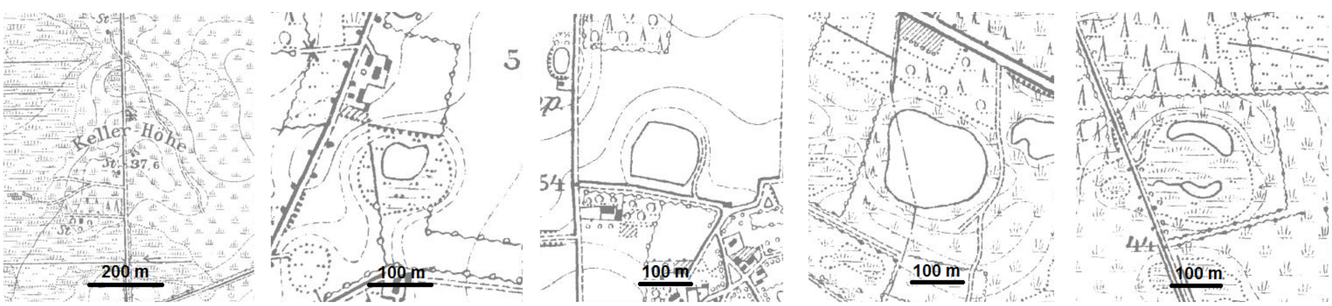

Figure 3.10: Historical map (1877 - 1912) of the study sites between Cloppenburg and Visbek. From left to right: Keller-Höhe, Rennplatz, Erlte, Emstekerfeld and Sevelte.

Chapter 4. Methods

This study has been based on data gathered during a four week field work in September and October of 2011. Prior to and during the field work, 17 possible pingo remnant depressions were selected and investigated upon dimensions and infill. The procedure of site selection is described in section 4.1.

In order to answer the research questions, the origin of these depressions needed to be clear, as only pingo remnant depressions can be included in the analysis. Therefore, all individual depressions have been investigated based on (1) geomorphology (dimensions) and lithology obtained from field results, and for most depressions, (2) the age and characteristics of earliest infill, obtained from lab research. Based on these properties, a conclusion on the depressions origin and age is drawn.

The methods which were used in the field are described in section 4.2. Several cores have been taken back to the laboratory, where measurements on Loss on Ignition were performed and pollen analysis was carried out. For two of these depressions, a pollen diagram has been constructed to provide an age model for the earliest infill. For several other depressions, age of earliest infill was constructed based on a pollen quickscan on loose samples that have been taken. Methodology on the laboratory analysis is described in section 4.3. For two of the cores that were brought back to the lab, an age model of the deepest infill has been constructed in order to determine the minimum age of the depression. Methods for this procedure are described in section 4.4.

4.1 Site selection

During preparation of the field work, four research areas were selected. Friesland and Drenthe were selected because previous studies (e.g. Kluiving et al., 2010; Bijlsma and de Lange, 1983; de Gans and Sohl, 1981) have demonstrated that pingo remnants are present in these areas. Previous research by dr. W.Z. Hoek and H.J. Pierik and examination of the topographical map (Topografische Karte 1:25.000, editions 1961 and 1975) led to selection of the area between Cloppenburg and Visbek. The area in Ost-Friesland was selected because of unpublished research on two presumed pingo remnants in the region by dr. W.Z. Hoek and J. van Dijk. Furthermore, local and amateur geologist A. Heinze (Niedersächsisches Internatsgymsasium Esens, NIGE) stated that many pingo remnants are present in this area.

Individual depressions within the areas were selected based on the criteria summarised in section 3.3. Preferably, the depressions should have a relatively wet centre, indicative for peat in the subsurface. For practical reasons the research was aimed at depressions with a diameter of 50 to 300 m, so a transect of sufficient resolution could be done in a single day.

For sites in the Netherlands, the high resolution digital elevation map 'Actueel Hoogtebestand Nederland' (AHN) was used to select circular depressions. Sites in the Cloppenburg/Visbek area have been selected based on examination of the topographical map, a recent map (DTK 50) and historical maps from 1877 to 1912. Depressions in Ost-Friesland were selected based on personal communication with A. Heinze. When possible, sites were examined based on air photos accessed through ©2011 Google Earth, in which images from different years are available. For all individual depressions, a first boring was done as near to the depression centre as possible, to establish whether this site should be further investigated.

From three out of four studied areas, a core has been taken for laboratory analysis. The sites from which these cores were taken were selected based on the following characteristics:

- deep depressions for a possibly high resolution record
- characteristics of infill; not all material can be cored easily (e.g. presence of cotton grass is not preferred)
- interesting lithology (e.g. well developed fine gyttja at the bottom, variations in sandiness)
- accessibility and permission for coring

4.2 Fieldwork methods

For most of the depressions, a set of borings from one edge of the depression towards the other side was made, preferably through the centre of the depression. When possible, the set included a reference boring placed some distance outside of the depression, in the substrate. The average distance between the borings is variable and ranges from 12.3 to 19.0 m, depending on the size and infill of the depression. The resolution in the depression itself is often slightly higher, as the reference boring is placed several meters from the depression edge. Distance between the borings is also variable within depression, because locally more borings were done to determine in more detail where a certain layer disappeared or how it continued. Cross sections were only drawn for depressions in which a transect of 5 or more borings was done. In the cross sections, the substrate has not been subdivided into different formations, as the emphasis in this report lies on depression infill. However, the reference boring outside of the depression and the couple of dm of material below the infill at the end of each boring gives a good impression of the substrate, which for each depression is described.

Sandy sections of the transect were augured with an Edelman hand auger, while for the peat a Dutch gouge (total diameter of 3 cm, inner diameter of 2.3 cm) was used. Cores that were taken back to the laboratory were taken with the 'Boncke-modified Livingstone Piston corer' (diameter 6 cm, Appendix B) and a Dutch gouge with a diameter of 4 cm (inner diameter 3.5 cm). For two depressions (Sleenerstroom I and Timmelteich) the complete depth was sampled, while for the third core (Emstekerfeld depression) only the deepest meter of the infill was taken back to the lab.

The presence of $CaCO_3$ was tested with a 10% HCl solution. Further, standard field equipment was used. Peat was classified according to the descriptions in Bos et al. (2012). Colour was described without a colour chart as correlation between borings was more important than the exact shade of the depression infill, and oxidation of the material resulted in quick alteration of colours so descriptions needed to be done fast.

4.3 Laboratory methods

Loss on Ignition measurements and pollen counting have been performed on the cores that were taken back to the lab. The LOI analysis was performed first, so the depths at which pollen samples should be taken could be based on lithological changes reflected in the LOI curves.

4.3.1 Lithological description

Cores that were taken from the field were transported in a PVC-pipe sealed with plastic thin foil and wrapped in a plastic bag to prevent oxidation. Cores are stored in a cold room. In the laboratory cores were cut open from the bottom up by a thin iron wire to avoid contamination with younger sediments. Loose material from the top of the cores was removed as this probably fell back into the borehole during coring practices, hence it is not part of the original record.

Lithological units have been distinguished based on sudden breaks in lithology or colour. Where gradual but clear transitions were present, an arbitrary boundary has been set. Colour of the cores was described directly after unpacking each core, without a colour chart, as rapid oxidation of the core did not allow extensive colour examination. Moreover, colour differences within the core were more important than the exact colour of the sediment (similar to the field methods). Resolution of the core description of the deepest section is approximately 0.5 cm, although distinct layers of 1-5 mm thickness have also been described. Higher up in the core, resolution is lower.

4.3.2 Loss on Ignition

To determine the organic matter content throughout the cores, Loss on Ignition (LOI) has been measured. Sampling resolution was variable depending on the homogeneity of the core: core sections with homogeneous lithology were sampled every 2 cm, while sections with varying lithology were sampled with a resolution of 1 cm. The deepest infill of the depression has always been sampled at a resolution of 1 cm.

Samples were prepared and measured by the method described by Heiri et al. (2001): samples with a volume of 1 to 2 cm^3 were dried at a temperature of 105 °C for at least 12 hours to remove moisture. For each sample, the dry weight was measured using a *Sartorius MC1 Laboratory LC 620P* scale. Subsequently, samples were put in an oven and ashed at 550 °C for 4 hours. After temperature has cooled to less than 100 °C, samples were weighted again. The fraction of organic matter was then calculated making use of the following formula;

$$LOI(\%) = \frac{Wg-Wb}{Wd-Wb} * 100\%$$

in which W_b represents the weight of the crucible, W_d is the weight of the crucible and the dry sample after it has been put in the stove and W_g stands for the weight of the crucible and the inorganic remains of the sample, after it has been put in the oven. Based on the results of carbonate measurements in the field, in the interpretation of the Loss on Ignition results the carbonate content in the samples has been regarded as insignificant.

4.3.3 Pollen analysis

For the cores that were taken back to the laboratory, pollen samples were taken every 10 cm and around visual lithological changes throughout the core. From this series, samples were selected based on lithological changes that were recognised after LOI analysis (Appendix F1). Furthermore, from several of the depressions a sample of the deepest infill was taken from the field.

Pollen samples were prepared according to the pollen preparation protocol of the Department of Physical

Geography, Utrecht University (Appendix C, in Dutch). For each sample, a total of at least 100 pollen have been counted. The pollen sum includes trees and shrubs (not thermophilous trees), upland herbs (including Graminae) and Ericaceae. Results of the pollen analysis are presented in pollen diagrams that were composed using the program TILIA (version 1.7.16, Grimm, 2011).

It should be noted that this amount of pollen per sample is sufficient for constructing an age model as trends can be recognised, however, for a detailed vegetation reconstruction a larger pollen sum is required. The pollen diagram can only provide a first impression on vegetation development and species diversity. The presence of indicator species can be informative, however, the absence does not show anything.

4.4 Age model

Vegetation development in the Netherlands and surroundings during the Late Glacial and Early Holocene are well-known (figure 3.6). Hoek (1997) constructed a chronological framework for pollen zone boundaries in the Netherlands through the calculation of the mean radiocarbon age of biozone boundaries at many different localities, resulting in well-established dates. Therefore, important transitions in pollen assemblage throughout the core can be used to construct an age model.

For the cores that were taken back to the laboratory, an age model was made based on the comparison of important transitions in pollen assemblages of the cores in this study to those in the reference site Uteringsveen (section 6.3.1 and Appendix F2). The Uteringsveen pingo remnant (Cleveringa et al., 1977) was selected because it is the most proximal pingo remnant for which a high resolution pollen record is available for which zone boundaries have been established. For one of the cores in this study, additional information from LOI results and a ^{14}C date is used to increase the coverage of the age model (see section 6.4).

Another method that has been considered to construct an age model, is the comparison of important transitions in the Loss on Ignition profiles to transitions in $\delta^{18}O$ of the GISP II ice core record, the graph of which at first sight looks very similar to the LOI curves obtained in this study. However, $\delta^{18}O$ is a temperature proxy, whereas LOI is a proxy for openness of the vegetation cover. Although vegetation is dependent on climate, many other factors play a role in openness of the vegetation cover, e.g. slow spreading due to low migration rates, (delayed) melting of the permafrost and soil formation and changes in abiotic landscape (Geel, 1996; Hoek, 2001). Therefore, a direct correlation of Loss on Ignition to $\delta^{18}O$ in GISP II is not legitimate.

Besides the cores that were taken, a pollen sample was taken from the (deepest) organic infill of several of the other depressions. This was used to estimate age based on a quickscan, in which the pollen assemblage was also compared to that of the Uteringsveen pingo remnant, yielding an age estimate of the initiation of pingo collapse.

Chapter 5. Fieldwork results

In this section the geomorphology and lithology of all individual study sites are described. When available, a lithological profile is presented. Locations of all study sites are given in the WGS 84 coordinate system. Additionally, for study sites located in the Netherlands, coordinates are given in the regional coordinate system Rijksdriehoekstelsel (RD). Elevation is given relative to Amsterdam Ordnance Datum (NAP) or N.N. (Normalnull) in Germany. At the end of each section, a conclusion on the depression will be drawn based on geomorphology and lithology. In this conclusion it is stated whether the depression is a possible pingo remnant. An overview of the results and conclusions on the investigated pingo remnant depressions is presented in table 5.1.

Research area	Study area	Diameter (m)	Depth (m)	Lithology	Minimum age	Pingo remnant?
Friesland	Egypte	170	3.4	organics	x	y
	Laarzenpad	150	2.6	organics	> Younger Dryas	y
	Opende	125	4.0	organics	Bølling	y
Drenthe	Sleenerstroom I	230	6.0	organics	Bølling	y
	Lammeer	230	?	sand	-	m
	Vlierendijk	170	7.3	organics	Bølling	y
	Sleenerstroom II	150	2.4	organics	-	n
Ost-Friesland	Timmelteich	200	5.6	organics	Bølling	y
	Westerschoo	>200	?	sand + organics	-	m
	Brill	>80	3.4	organics	-	y
	Wrokmoor	140	5.5	organics	Earlier Dryas	y
	Mamburg	130	2.9	organics	-	m
Cloppenburg/ Visbek	Keller-Höhe	>130	?	sand	-	n
	Rennplatz	100	2.4	organics	-	m
	Erlte	140	0.9	organics	-	m
	Emstekerfeld	170	>6.6	organics	Earlier Dryas	y
	Sevelte	150	>4.9	organics	Allerød	y

Table 5.1: Overview of the geomorphology and lithology of all 17 depressions and the consequent conclusion: (y) = probable pingo remnant depression, (m) = possible pingo remnant depression, (n) = not a pingo remnant depression.

5.1 The Netherlands, Friesland

5.1.1 Egypte

The Egypte depression (figure 5.1) is a circular depression located within an agricultural environment approximately 1.5 km west of Buitenpost (WGS 84: 53°15′ 08″ N - 6° 06′ 35″ E or RD: 203225-585303, at 2.0 m above N.A.P.). It has a diameter of about 170 m and the maximum height difference between the depression and surrounding land surface is approximately 1.2 m. Towards the centre of the depression, surface height slowly decreases. In the field, a rim can be recognised along the northern edge of the depression, although this does not show on the AHN. Both the depression and the surrounding land are divided into elongated fields that are used for cattle, as a meadow and for cultivation of trees. Fields are separated by ditches and rows of alders and elderberries. In the centre of the depression a small wet forest is present.

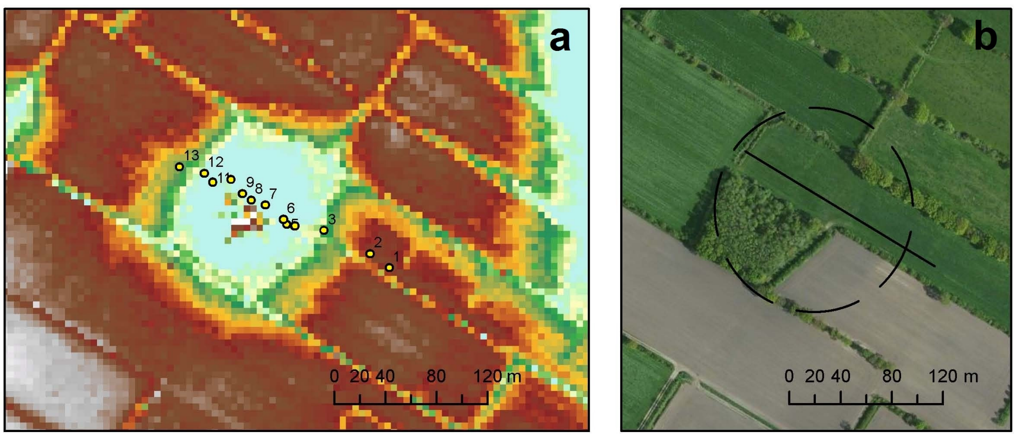

Figure 5.1: Digital elevation map and air photo of the Egypte depression.

Lithological description and interpretation

The cross section of the Egypt depression (figure 5.2) is based on 13 borings that were taken from the north-west towards the south-east. The cross section shows that the depression consists of a pit filled with organic material. The maximum depth of the depression infill found at this transect was 3.40 m. The shape is asymmetrical: the slope of the substrate at the north-western side of the depression is rather constant, while at the south-western side the slope is steeper towards the centre and shallower towards the edge.

Most borings end in loamy sand with a grain size of 150-210 μm. On the south-eastern side, the material is more humic and has a gravel fraction of up to 2%. At the north-western side the material contains up to 5% gravel, and contains lumps of loam. Few borings in the centre of the depression (005, 006 and 007) end in brown grey sand which does not contain gravel. The loamy sand with gravel is interpreted as till of the Drenthe Formatie and forms the substrate in which the pingo has developed.

In the deepest section of the depression (borings 005-011), the sand is covered by a very sandy gyttja with different shades of brown. It was described as very gummy-like and well-layered, so most likely it is a fine-detrital gyttja. The material contains a high amount of silt or very fine sand and in the deepest boring bands of sand have been recognised. The presence of this gyttja indicates that the depression must have hosted a lake during the time of earliest infill. In all borings, the gyttja gradually becomes lighter from the top down. This shift in colour of the gyttja that forms the deepest infill may be due either to soil formation or smaller environmental differences resulting in different organic precipitation or preservation. Formation of a soil directly on top of or in a (fine-detrital) gyttja indicates that ground water level would have dropped relatively rapidly, as no shallow water or marsh deposits have been found.

An orange brown peat layer, up to 150 cm thick and containing many plant remains, is found on top of the gyttja. Most of the plant remains consists of moss, although in the centre of the depression some sedge and cottongrass remains are present. In the shallowest section of the depression (borings 004 and 005) a 20 cm thick dark brown layer of peat containing wood remains is present. The peat indicates that water level was low, which may be due to either gradual infill of the lake or a drop in ground water level. In the top of boring 008 the peat even showed signs of soil formation. It seems that this can be correlated to soil indicators found in the sandy peat in boring 011 and in the substrate of the outermost borings.

The entire depression (boring 003 to 012) is covered by a layer of brown, very humic sand, that has a grain size of 150-210 μm. In this material, shards of bricks and flint stone are found, as well as wood remains and rootlets. This layer is oxidised and has been heavily disturbed through agricultural activities such as ploughing.

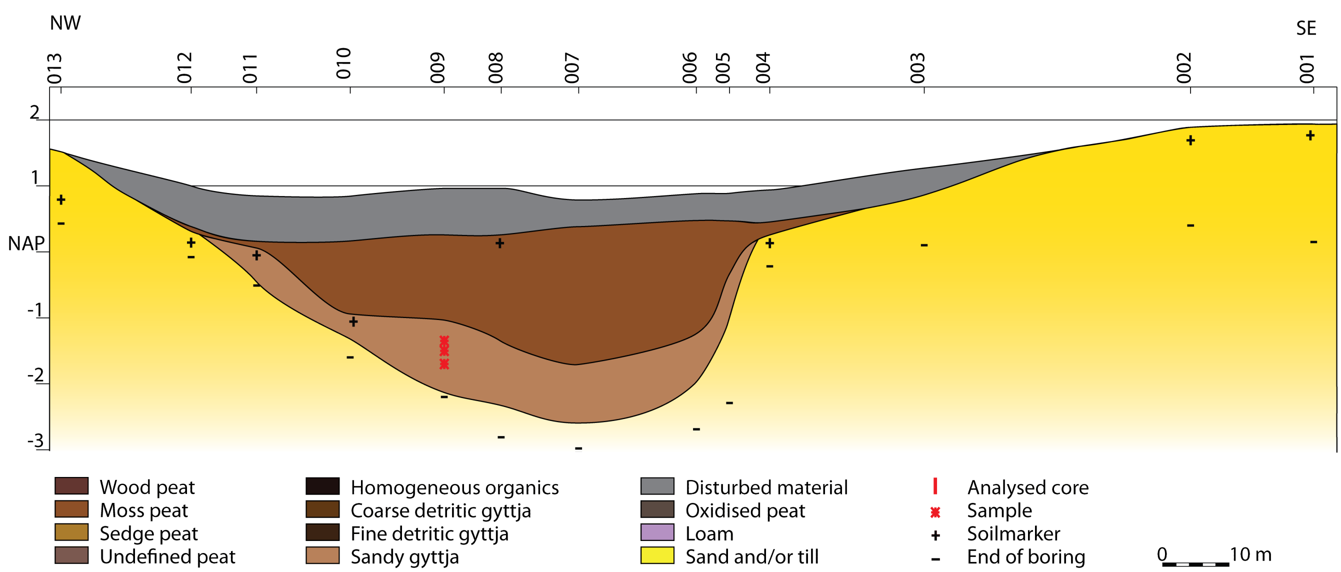

Figure 5.2: Lithological profile of the Egypte depression.

Conclusion

Dimensions and substrate in which the pit is found are similar to those of other acknowledged pingo remnants in the surroundings (e.g. Kluiving et al., 2010). Substrate and infill are also characteristic for pingo remnant depressions, hence this depression probably formed by the collapse of a pingo.

5.1.2 Laarzenpad

The Laarzenpad depression (figure 5.3) is located about 200 m south-west of Buitenpost (WGS 84: 53°014′ 42″ N - 6°07′ 52″ E or RD: 204571-584515, at 0.8 m above N.A.P.). It has a roughly circular shape with a diameter of about 150 m, although it seems elongated towards the south-west. The depression is not clearly recognisable in the field, but is clearly visible on the AHN. At the south-eastern edge a rim can be recognised. The maximum height difference between the depression and land on the northern side according to the AHN is up to 1.1 m, while at the southern side this is about 0.3 m. The land is separated into several fields that are used for cattle grazing.

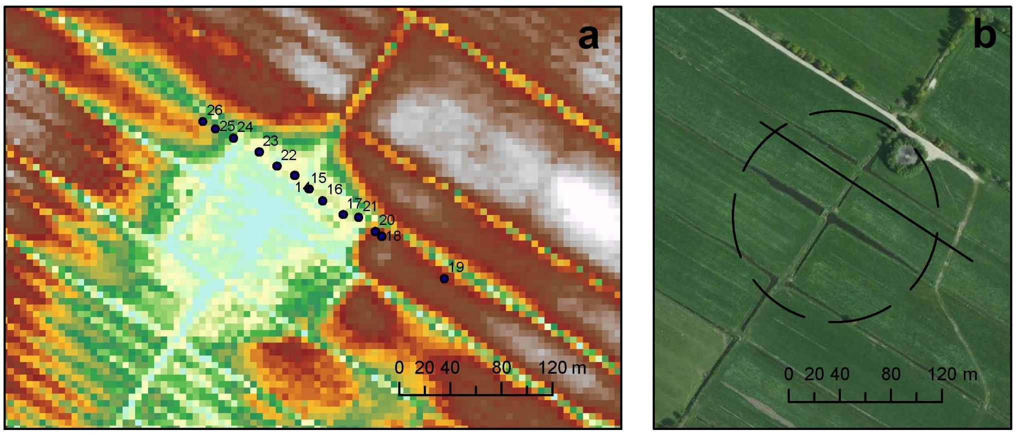

Figure 5.3: Digital elevation map and air photo of the Laarzenpad depression.

Lithological description and interpretation

The lithological transect (figure 5.4) has been constructed based on 13 borings along a line running from the north-west to the south-east, including one reference boring 50 m outside of the depression. It should be noted that this transect does not run through the depression centre, hence the deepest (oldest) infill has not been described. The shape of the depression is symmetrical and rather flat, although the latter is probably due to the location of the transect. Multiple steps can be recognised in the slope of the substrate. The maximum depth of the depression infill along the cross section is about 2.6 m.

All borings end in grey, loamy fine sand (150-210 μm), which is considered to form the substrate of the depression. This material has been found directly underneath the disturbed surface material in the reference boring (019) and in borings near the edges of the depression (018, 020, 026 and 027).

In the four deepest borings, the sand is overlain by a light brown sandy layered gyttja that contains some (unrecognisable) plant remains indicating that the depression used to be filled with water during times of active aeolian sedimentation. Superjacent to this layer, a slightly less sandy brown peat containing wood fragments is present. Signs of soil formation are present in boring 015. In the centre two borings (014 and 015) more distinct wood fragments have been found, and the peat is less deteriorated and less sandy. The presence of peat and wood fragments indicates that the depression no longer hosted a lake during this phase of deposition. The wood peat contains several signs of soil formation: in boring 014 there is a brown to black layer in the wood peat found at 180 cm depth. At a depth of 140 cm a soil layer seems to be present in boring 015. A brown to black soil has also been recognised in borings 020 and 025 at 80 cm depth and in boring 021 at 60 cm depth. Soil layers at similar depths that have been found in adjacent borings (e.g. 020, 021 and 025) probably originate from the same period of soil formation. The difference in depth of some of some of the soil indicators is too large to correlate them. Perhaps the infill of the depression reflects several episodes of peat oxidation soil formation. This may indicate a fluctuating water level.

In boring 023, a thin band of gravel was found on top of the wood peat with soil indicators. If the Laarzenpad depression is indeed a pingo remnant, the gravel may originate from the rampart and might be deposited during inward mass movements along the remnant rampart during or after pingo collapse.

Along the entire depression and beyond, the wood peat, gravel band or substrate is followed by a 10 to 50 cm thick layer of dark brown to black peat that does not contain recognisable plant remains. The peat shows signs of soil formation. Continuation beyond the depression edges indicates that peat growth continued after the depression had gotten completely filled. The dark brown layer gradually changes into a brown layer of very humic sand, covering both the depression and its direct surroundings. The top of this layer is heavily disturbed and contains bricks, gravel and lumps of clay.

The deepest infill that was found is very sandy and has probably been deposited during a period of increased aeolian sedimentation. Because there is no second sandy interval, this gyttja seems to be of Younger Dryas age. However, the deepest infill of the depression has not been described as the transect was not bored through the centre of the depression. Hence, the deepest infill will be older, originating from the Bølling/Allerød or before.

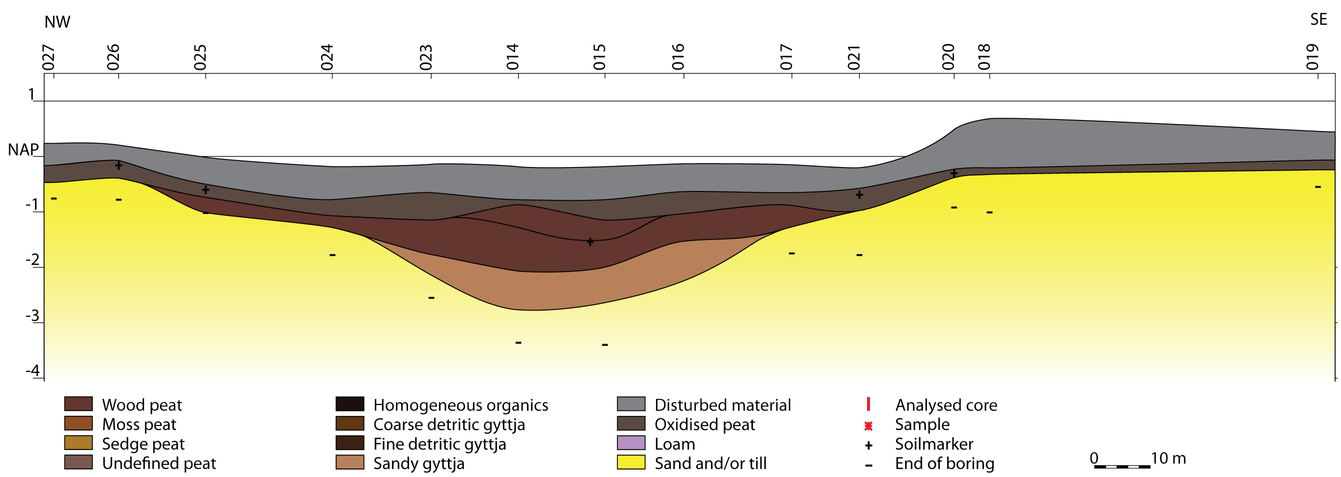

Figure 5.4: Lithological profile of the Laarzenpad depression.

Conclusion

The cross-section along the Laarzenpad depression reveals a relatively shallow profile for a pingo remnant in the Netherlands. The deepest infill that was found was interpreted as a Younger Dryas deposit, which is young for a pingo remnant depression (see Hoek, 1997, table 7.3). However, this cross-section was constructed along the depression edge, and a transect through the centre of the circular depression probably reveals a greater depth and older deposits. Furthermore, a thin band possibly originating from the collapse of a rampart was found. All together, there is a high probability that the Laarzenpad depression is a pingo remnant.

5.1.3 Opende

The Opende site (WGS 84: 53°10′ 52″ N - 6°′ 58″ E or RD: 210386-577409, at approximately 2.3 m above N.A.P.) consists of a circular depression with a diameter of approximately 125 m (figure 5.5). It stretches along several elongated agricultural fields that are used for cattle. The maximum height difference between the depression and the surrounding land ranges from 1.5 m at the western side to 2.7 m at the south-eastern side. Along the northern side of the depression, a strong decrease in surface elevation can be recognised in the field. The owner of the land stated that a ditch that used to run along the northern edge of the depression has recently been removed, and that a previous owner had attempted to level northern edge.

The southern side of the depression cannot be described in detail as sight was obstructed by corn, although it was clearly visible that land surface elevation increased in this direction. The centre of the depression was wet, with a ground water level up to 10 cm above surface elevation due to an extremely wet summer. The field along which the borings were taken was covered in long grasses as it was unsuitable for agricultural use. Borings have not been done at the most southern part of the depression, as this was covered with corn and it was located in the fields of another owner of whom permission was not granted. However, the AHN shows a clear, nearly circular depression.

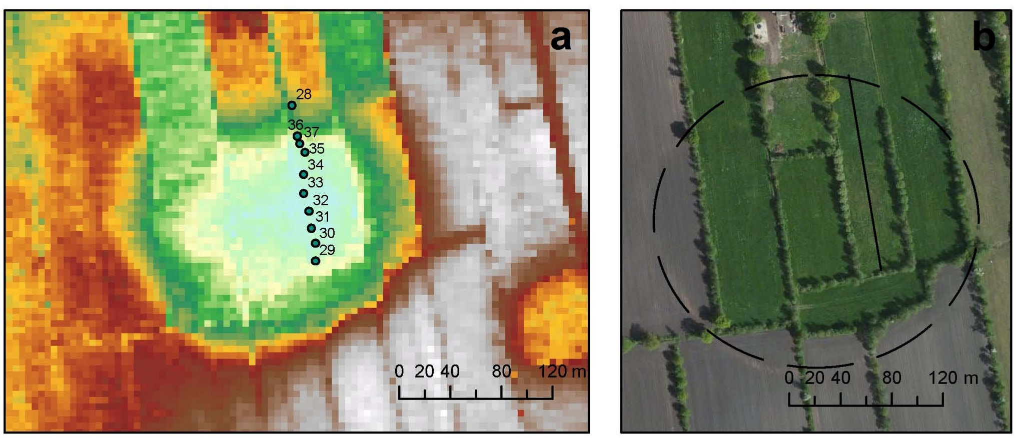

Figure 5.5: Digital elevation map and air photo of the Opende depression.

Lithological description and interpretation

The cross section of the Opende site (figure 5.6)is made based on 10 borings on a transect running from north to south. The cross section has a maximum depth of 4.0 m (boring 033). Although the deepest boring was taken slightly outside of the centre, the depression has a roughly symmetrical shape. The depression has a roughly flat bottom, and the slope of the substrate from the centre towards the edges is rather constant.

Most borings end in a grey sand of medium grain size (210-420 μm), except at the two most northern borings (028 and 036), which end in (slightly loamy) brownish fine sand (150-210 μm). About 2% of gravel was found in the sand of borings 031 and 037. The material looks similar to the till found at the bottom of the other depressions in the Friesland study area, but less loamy and contains little gravel. It seems that there is local variance in the composition of the glacial till.

Except in the two northernmost borings, the grey sand is overlain by a grey to light brown gyttja in which sedges and occasionally moss or cottongrass are present. At several locations (029, 030, 033 and 037) layering has been recognised. The presence of a coarse-detrital gyttja is an indicator for shallow water circumstances during the time of deposition of the earliest infill. In borings 032 and 033 the gyttja is covered by a distinct 5-10 cm thick layer of humic brown grey sand (105-150 μm) that seems slightly laminated. This layer is thought to be of aeolian origin. It cannot be followed along the sides of the depression, possibly because there aeolian sediment was trapped by (riparian) vegetation. Subsequently, there is a layer of (amorphous) homogeneous organic material covering both the peat and sand. Plant remains were beyond recognisable, except in boring 034, in which moss and sedges are found. This amorphous peat probably has deteriorated by oxidation during a period of low ground water level. In the northern part of the transect (boring 035 and 037) a 10 cm thick layer of grey brown very fine sand (105-150 μm) is found on top of the homogeneous organics. This well-sorted sand probably also has an aeolian origin. Perhaps it was found only locally because of the shape of the depression rampart (no longer present), vegetation distribution and/or the prevailing wind direction.

A 50 to 210 cm thick layer of dark brown peat covers the sand and homogeneous organics. This layer contains many remains of sedge and cotton grass. Sedges are mainly found in the peat covering the homogeneous material in the centre and northern part of the depression, while peat rich in cotton grass is covering the homogeneous material in the south and the cotton grass in the centre. In the northern section and the upper section of boring 033, less plant remains are found in the dark brown peat. The entire peat layer was formed when a lake was no longer present - perhaps because of a lowering of the ground water table or because of filling of the depression. Perhaps the peat in boring 033 was more deteriorated because of oxidation. The peat rich in sedge and cotton grass is covered by an almost black peat in all borings except 028, 036 and 037. The top layer of the depression infill consists of a 30 cm thick, brown, very humus layer of fine sand (150 - 210 μm) in which many rootlets are present. The peat has been oxidised.

The sequence of a sandy layer (centre), a deteriorated peat layer and again a sandy layer (north-western side) may reflect two periods of increased aeolian activity with a period of peat formation in between. These sediments may have been deposited in the Earlier Dryas - Allerød - Younger Dryas or Earliest Dryas - Bølling/Allerød - Younger Dryas (section 3.1 and 3.2). It is striking that apart from the two distinct sand layers, none of the peat found in this depression is described as sandy. This may be because of the lack of a local source of cover sands in the direct surroundings or a dense vegetation cover.

In boring 036, the only material that is found is sand, gradually changing in colour from orange brown to grey brown. Between 1.6 and 2.0 m below the surface, the sand contained gravel. Also, a flint stone was found at 1.4 m depth. This is probably where the ditch mentioned by the owner was located. In an attempt to level the property, it has been filled with sand.

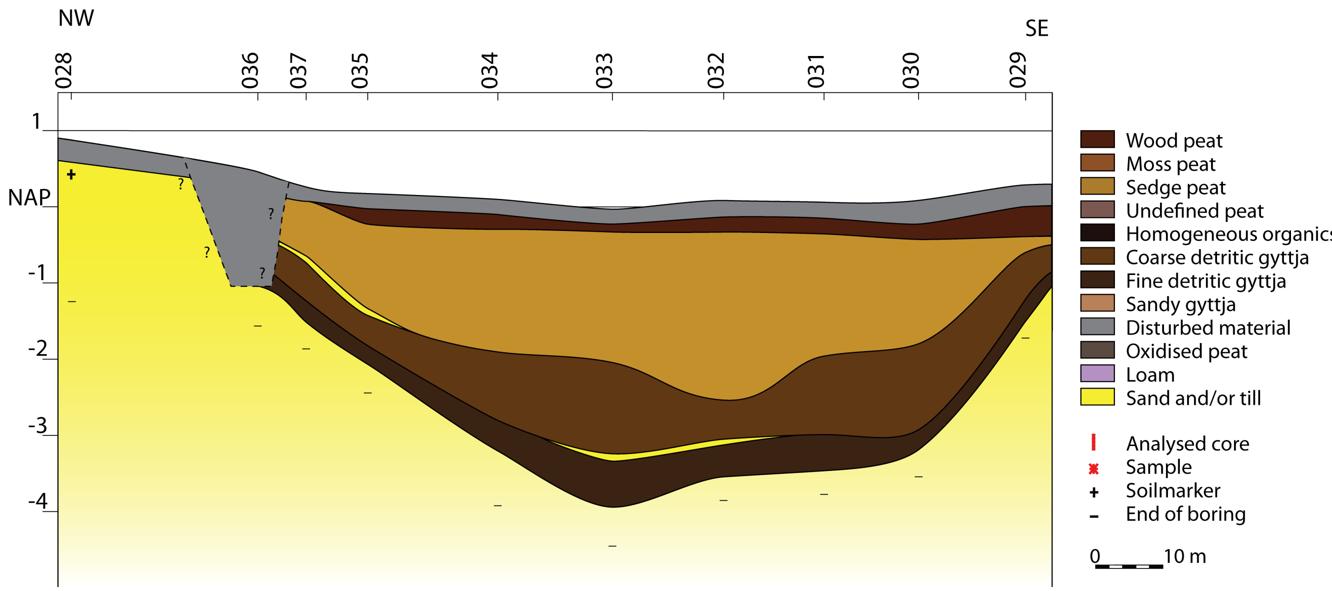

Figure 5.6: Lithological profile of the Opende depression.

Conclusion

The dimensions of the Opende depression match those of a pingo remnant. If sand layers were indeed deposited during separate episodes of increased aeolian sedimentation, the deepest infill of the depression probably is deposited during or prior to the Bølling. This is also suitable for a pingo remnant depression.

5.2 The Netherlands, Drenthe

5.2.1 Sleenerstroom I

The Sleenerstroom I depression (WGS 84: 52°45′ 24″ N - 6°46′ 50″ E or RD: 249056-530848, at 13.2 m above N.A.P.) is located 2 km southwest of Sleen, Drenthe, and has a diameter of 230 m (figure 5.7). Although clearly visible on the AHN, it cannot easily be recognised in the field: the maximum height difference with the surrounding land is about 0.9 m. The elevation difference is most clear at the eastern side of the depression, whereas at the western side no clear rim can be recognised. The depression lies within an agricultural environment consisting of hay land and corn fields, separated by ditches that contain water with a mottled, rusty red colour. A drainage system was constructed as land was previously too wet for agricultural use.

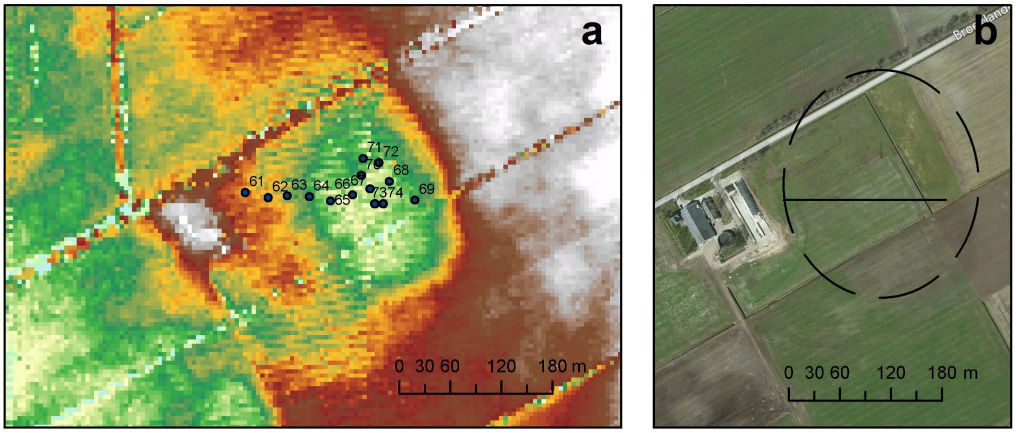

Figure 5.7: Digital elevation map and air photo of the Sleenerstroom I depression.

Lithological description and interpretation

The lithological profile of the Sleenerstroom I depression (figure 5.8) runs from west to east, and is based on 11 out of 14 borings that are performed at this site. The maximum depth of the depression infill along the transect is 6.0 m (boring 084). This is slightly deeper than expected based on extrapolation of adjacent borings 067 and 084. Borings have not been performed in the easternmost part of the depression. Therefore it is unclear whether the depression has a symmetrical outline.

In borings 061 and 062 the deepest material consists of a slightly sandy grey loam. On top of this lies light brown fine sand (150-210 μm). All other borings end in grey brown fine sand, except 066 and 068, which end in a grey and slightly loamy very fine sand (105-150 μm). In boring 065 and further west, the sand has a 2% gravel fraction. The loamy sand and loam found at the end of all borings is considered to be the substrate of the depression.

In the deepest part of the cross section (065 and further east) an about 20 cm thick layer grey brown, sandy fine-detrital gyttja that contains sedges is found. This changes into a fine-detrital gyttja with clear laminae that vary in colour from olive green to yellow brown with a maximum thickness of 60 cm. The presence of a fine-detrital gyttja indicates relatively high water depth during the time of earliest infill. Superjacent to this lies a brown, coarse-detrital gyttja containing sedges up to a depth of about 200 to 250 cm. Sand content of this layer is variable: the upper part is sandier than the lower part. The coarse-detrital gyttja indicates shallowing of the lake. This may be due either to a decrease in ground water level or shallowing of the lake because of sedimentation. In both the coarse and the fine-detrital gyttja white spots are present. The white spots found in the fine- and coarse-detrital gyttja have been interpreted in the field as siderite (lower end) and vivianite (upper end). Both the fine- and coarse-detrital gyttja are interpreted as a siderite gyttja. The precipitation of siderite and vivianite combined with the rusty colour of the water in the ditches in the depression indicates seepage conditions.

Superjacent to this is a grey brown or light brown very sandy coarse-detrital gyttja that contains sand layers. In this layer, seeds of Menyanthes were found. The Menyanthes seeds and the type of deposit prove that the depression still hosted water. The coarse-detrital sandy gyttja is covered by a dark coloured homogeneous layer of organics, which in borings 062, 063 and 065 consists of an amorphous, (bluish) black of 10 cm thick. The material contains some sedge and moss remains at the eastern side of the transect. The top layer of the depression consists of a dark brown, sandy oxidised peat. This indicates that water depth further decreases until the depression had run dry, resulting in soil formation of the top of the coarse-detrital gyttja, producing the amorphous peat and bluish black layer. The top material is oxidised and heavily disturbed by ploughing.

Based on the sandiness described along the transect, it is expected that the deepest material was deposited in the Earliest Dryas or Bølling as the described sand content is relatively high. This is followed by the less sandy lower part of coarse-detrital gyttja, which therefore may be deposited during the Allerød interstadial. In the coarse-detrital gyttja, vivianite was observed. Vivianite was also found in sediments of Allerød age in the Uteringsveen pingo remnant (Bohncke and Wijmstra, 2008), where vivianite precipitation is paired with an increase in lake level possibly caused by increased influx of drainage water (see also section 3.2). The upper part of the coarse-detrital unit gradually becomes sandier and is followed by a very sandy gyttja of about 1 m thick. Such an increase in aeolian sedimentation is expected during the Younger Dryas. The formation of soil and subsequent infill of the depression is expected in the Pre-Boreal and Holocene. The sand content of the Sleenerstroom I depression is also measured based on the core that was taken and is further discussed in section 6.2.3.

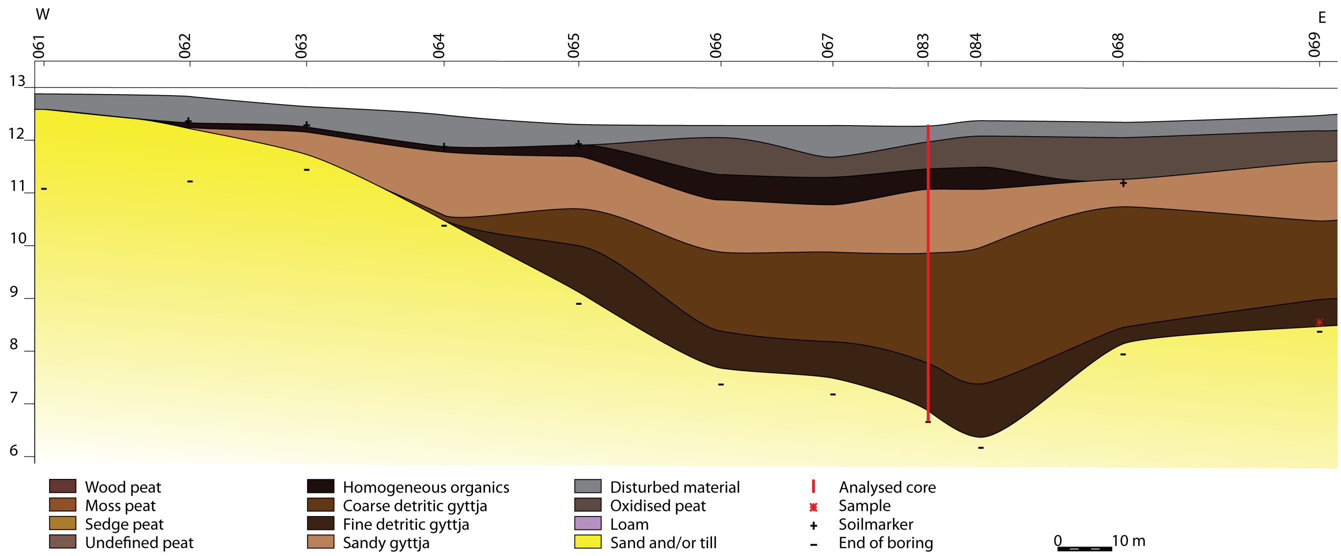

Figure 5.8: Lithological profile of the Sleenerstroom I depression.

Conclusion

The Sleenerstroom I depression has suitable dimensions and infill for a pingo remnant. Based on sandiness of the infill, an Earliest Dryas or Bølling age is expected. Both during the time of earliest infill as in the present, seepage occurs. This may have been a water source that fed the ice lens, perhaps at or near the location of the relatively deep boring (084).

5.2.2 Lammeer

The Lammeer site (WGS 84: 52°50′ 59″ N - 6°49′ 26″ E or RD: 251819-541257 at about 21.0 m above N.A.P.) is located in a pine forest approximately 2 km west of Odoorn. The depression has an almost perfect circular shape, with a diameter of 230 m (figure 5.9). The height difference between the depression centre and the surroundings locally exceeds 2 m, so it is well visible in the field. As can be seen on the AHN, a (broad) ridge is present along the sides of the depression. The vegetation cover in and around it consists of pine trees, brambles and nettles.

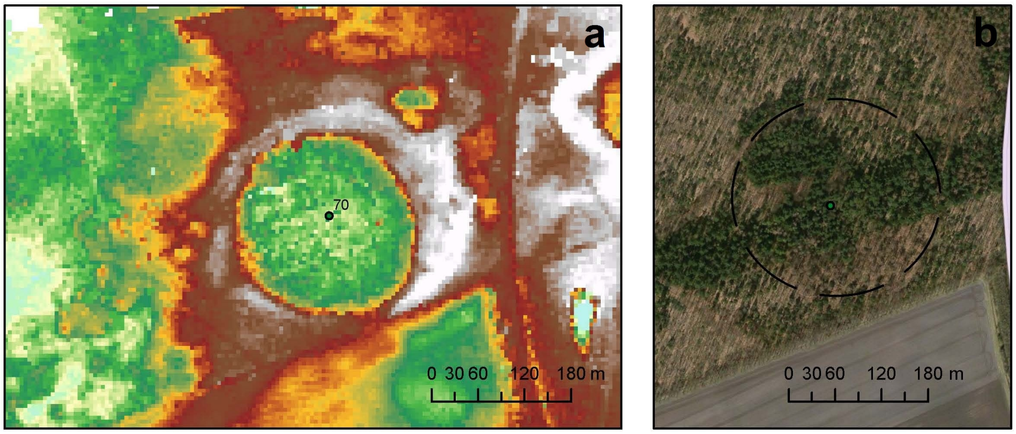

Figure 5.9: Digital elevation map and air photo of the Lammeer depression.

Lithological description and interpretation

A single coring to a depth of 370 cm was carried out at the centre of the Lammeer depression. The material that was found consists of only sand with a constant 2% gravel content below 50 cm depth. The colour of the sand gradually varies from dark grey in the upper 40 cm, to brown until 50 cm and light brown up to a depth of 200 cm. From 200 cm downward it changes further from light grey brown towards more greyish colours between 340 and 370 cm. The gradual change in colour and organic content from the surface down is a result of soil formation. Grain size in the sand varies from the bottom up: the lower part of the sediment consist of relatively coarse material. Between 370 and 340 cm, a slightly loamy sand with a grain size of 150-210 μm is present, followed by medium-sized sand (210-300 μm) up until 250 cm depth. The upper 200 cm consist of very fine sand (105-150 /mu m), except between 110 and 150 cm, where a fine sand (150-210 μm) is found. The uppermost 40 cm contain rootlets, and the sediment is humic to a depth of about 200 cm.

As opposed to the other sites, a separate substrate and infill have not been distinguished in the Lammeer depression. If present, the substrate and deepest infill may not have been reached because of the shallowness of the boring. However, even in a deep boring it may be very hard to distinguish the substrate if present. The sandy ground is very permeable and will only trap water if the ground water level is high enough. If ground water level decreased rapidly, the depression may have not hosted a lake in which organic sediments could precipitate or peat could form. Also, the sand is very poor in nutrients, withholding vegetation in a dry depression to develop. Therefore, if this is indeed a pingo remnant depression, the infill may be of the same material as the substrate in which it formed. The prerequisite that pingo remnant depressions should contain peat (section 2.4.1, Mackay, 1988; Wiegand, 1968) then does not apply.

Conclusion

The shape of the depression matches that of a pingo remnant. However, since surface dimensions are a criterion for site selection, these cannot be put forward as evidence. The depression is not filled with gyttja or peat and age has not been derived from the lithology. Results on the origin thus remain inconclusive.

5.2.3 Vlierendijk

A depression (WGS 84: 52°45′ 24″ N - 6°46′ 50″ E or RD: 251819-541257 at 17.6 m above N.A.P.) with a diameter of 210 m was found near the Vlierendijk, 1 km north of Zweeloo (5.10). The depression is not entirely circular; the short axis of the depression is about 170 m long. Height difference with the surroundings according to the AHN is about 0.6 m. Part of the depression is covered by a small wet forest, mainly consisting of birch trees. The northernmost part of the depression is inaccessible due to dense shrubs. The depression is relatively wet, especially at various small square patches from which peat was excavated. Water depth in these patches is estimated to be less than 1 m. The centre of the depression is slightly higher and dryer. The surrounding land consists mainly of hay land and corn fields.

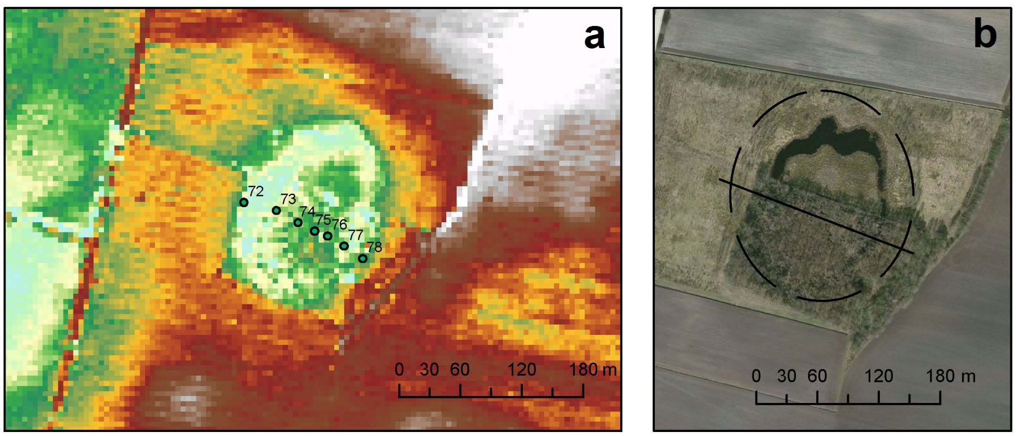

Figure 5.10: Digital elevation map and air photo of the Vlierendijk depression.

Lithological description and interpretation

The transect has a total length of 140 similar to that visible on the AHN, but does not reach the outer edges of the depression. The cross section is based on a set of 7 borings. The maximum depth of the depression is 730 cm. All borings end in a (loamy) grey sand with a grain size of 150-210 μm. In borings 71, 72 and 74 it contains 2% gravel and at the eastern side it is somewhat brownish. This material is considered the substrate of the depression.

The sand is followed by a loamy green or brown grey fine-detrital gyttja of 10 to 20 cm thick found in all borings except 071 and 077 at the edges. The loaminess of the gyttja indicates there must have been an influx of inorganic sediments. There is no evidence for fluvial activity, so the loam fraction must have an aeolian source. Over the entire transect, the brown grey fine-detrital gyttja is overlain by a very sandy fine-detrital green brown gyttja, which in boring 076 contains seeds of Menyanthes at the bottom. It seems that there is an increase in the grain size and the amount of aeolian influx. Both gyttja units indicate that the depression filled with water during the time of deposition of the earliest infill, directly after (or during) the formation of the depression.

In all borings, the gyttja is covered with a dark grey brown homogeneous layer of organics, that has a thickness of 40 cm at the edges up to 180 cm at the centre. This layer contains very little plant remains. The layer has probably become amorphous due to deterioration of the organics by oxidation because of a relative decrease in water level. This would also have caused the dark colour. The upper 350 cm of the infill consists of a brown to dark brown peat, with mainly sedge and cotton grass in the lower regions and moss or wood peat higher up in the profile. Part of this layer seems very loose. The presence of peat indicates a decrease in water depth. A coarse-detrital gyttja is missing in the shallowing sequence. Probably at least part of the homogeneous gyttja used to be a coarse-detrital gyttja, which now has lost its structure because of a period of oxidation after water level had dropped.

The loamy gyttja layer is expected to have been deposited in a time of aeolian sedimentation. A second, very sandy interval is found slightly higher up - this is expected to be of Younger Dryas age. This implies that the depression itself is of Earlier Dryas age or older.

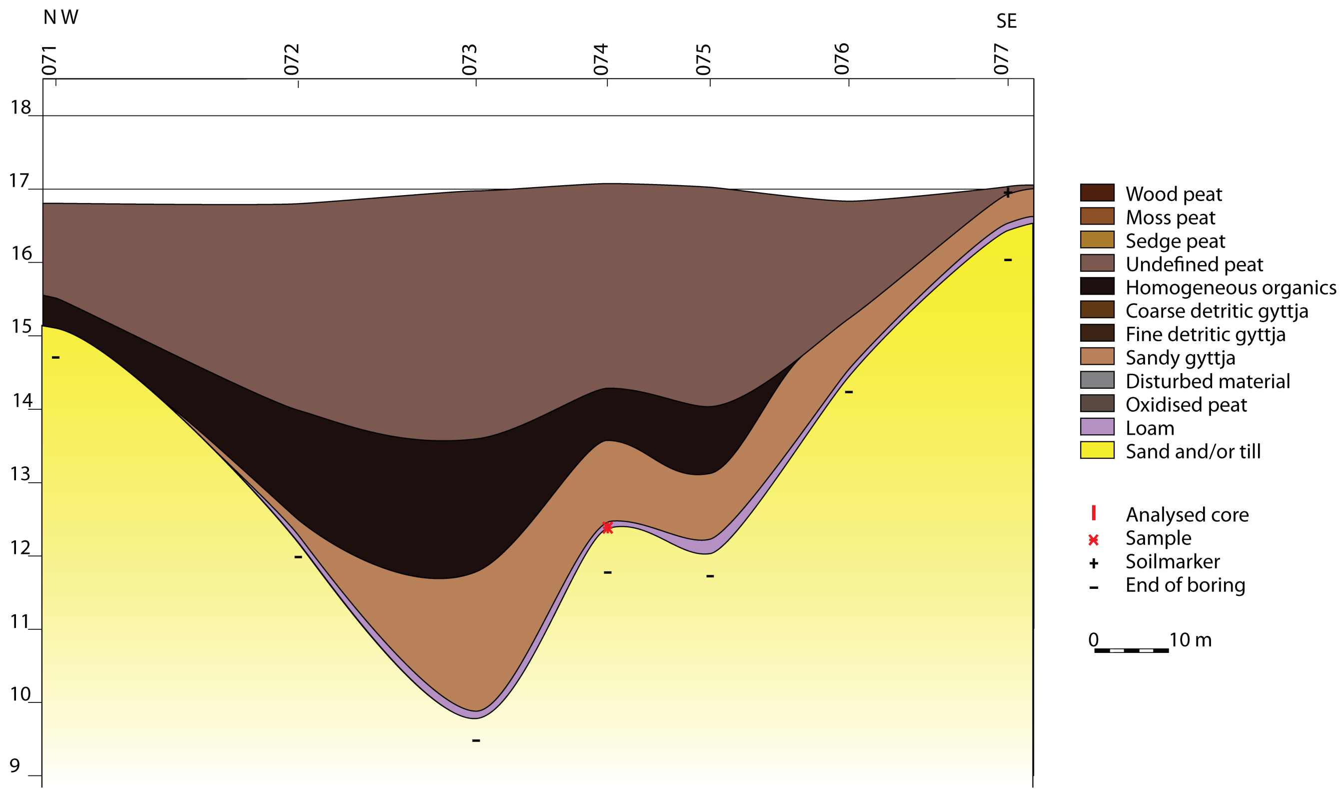

Figure 5.11: Lithological profile of the Vlierendijk depression.

Conclusion

The Vlierendijk depression has a dimensions that are suitable for a pingo remnant depression, even though it is deep compared to the other presumed pingo remnants in this study. The earliest infill is probably of Earlier Dryas age or older, as a second sandy interval is found higher up the sequence. Hence, the depression is probably a pingo remnant.

5.2.4 Sleenerstroom II

Approximately 200 m north-east of Sleenerstroom I another depression is located (WGS 84: 52°45′ 24″ N - 6°46′ 50″ E or RD: 248473-530867 at 12.5 m above N.A.P.). The depression has a diameter of 150 m, although it is not very well recognisable on the AHN (figure 5.12). It does show a discontinuous heightened rim, which can be recognised in the field. However, there is no clear height difference between the surrounding land and the area within the ring. The entire depression is covered with grass land with two ditches running through. The owner of the land stated that an additional ditch used to be present. Previously, the land was unusable due to its wetness and therefore it is currently being drained. Several drainage pipes were visible along the margins of the ditches.

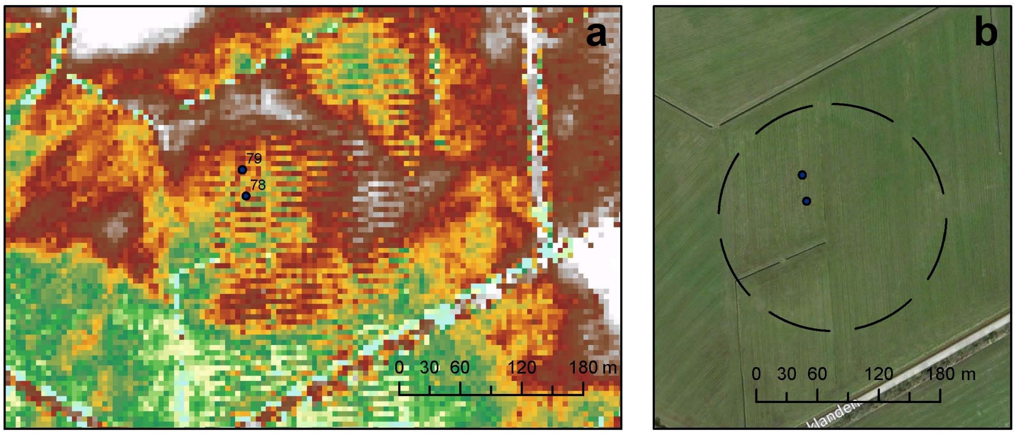

Figure 5.12: Digital elevation map and air photo of the Sleenerstroom II depression.

Lithological description and interpretation

Field observations do not provide clarity about whether the depression is a circular pit, as was expected based on examination of the AHN. The lithology of the Sleenerstroom II site has been examined based on two boreholes in the centre of the depression, that were taken approximately 15 m apart. Boring 078 and 079 reached a depth of 150 cm and 240 cm respectively, but show a very similar lithology. In both 078 and 079, the deepest material that was found is a grey loamy sand, with a grain size of 150-210 μm in boring 078 and of 210-300 μm in boring 079. This is overlain by a thick layer of brown or grey brown peat with a very high content of large pieces of wood to a depth of 50 cm, of which the uppermost 30 cm are sandy. The large amounts of wood does not match with the infill that was found in other depressions that were considered as pingo remnants. It seems that the peat in this area has a different origin. Therefore the depression has not been investigated any further, and it is unclear whether this peat continues beyond the depression rim and if these rims are natural phenomena. On top of the wood peat, a disturbed sandy oxidised peat containing rootlets and less wood remains is found.

Conclusion

Sleenerstroom II is a very shallow depression in a substrate that is suitable for pingo formation. Based on the shallowness of the depression and the deviant infill from that of other pingo remnants in the surroundings, it can be stated that the Sleenerstroom II depression is not a pingo remnant.

5.3 Germany, Ost-Friesland

5.3.1 Timmelteich

The Timmelteich depression (WGS 84: 53°22′ 01″ N - 7°31′ 34″ E at 0 m above N.N.) is located at the northern edge of the village Timmel (figure 5.13). It has a diameter of almost 200 m. The depression is circumvented by a road, and is currently used as a park. On the western side a church is located on top of a small artificial hill, houses are present in the south, and agricultural fields lie in the east and north. In the centre of the depression a pond with a bridge to an island is present. The island is covered with trees. According to a local, this pond and bridge have been artificially made. Previously, the land was too unstable for cattle, and was used to produce hay. When the pond was dredged during land consolidation, water came bubbling up from the bottom. Surface elevation decreases towards the pond, and at various locations surrounding the depression a higher rim can be recognised on which benches are built. The height difference between the rims and dry centre of the depression is estimated to be over 1 m.

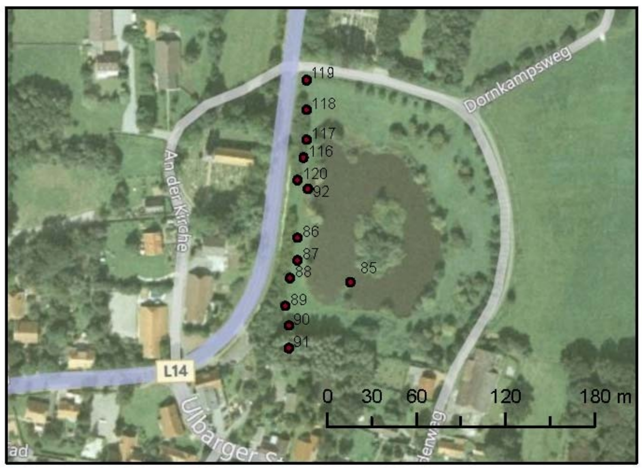

Figure 5.13: Air photo of the Timmelteich depression.

Lithological description and interpretation

The Timmelteich cross section (figure 5.14) is based on a set of 12 borings along a transect that runs from north to south. It consists of a subsurface depression with a maximum depth of 560 cm filled with organic material. The depression shallows towards the sides, except at the southern edge, where depth suddenly increases from (less than) 1.8 to 3.0 m.

All borings in the Timmelteich depression end in a light brown grey to grey sand with grain size varying from fine (150-210 μm) to medium (300-420 μm). Between borings as well as with depth, the slightly humic sand varies from regular to very loamy. The sand forms the substrate of the depression.

In most of the borings, a thin layer (1 cm) of organic macro-remains have been found on top of the grey sand. Remains found in boring 120 have been analysed by microscope by Hanneke Bos and seem to consist of leaves and twigs of *Salix polaris* or *Salix herbaceae*. *Salix polaris* is very well adapted to raw soils that are poor in humus but high in carbonate. It is well adjusted to lower summer temperatures compared to other wooden plants and can persist long lasting snow cover (Bennike et al., 2004). It is known to have occurred at various sites in Denmark around 14.2 ka BP (Korsager et al., 2003). *Salix herbacea* (dwarf willow), which occurred in the Netherlands between 22.0 and 14.0 ka BP, grows in wind-exposed fields and places with little protection from snow cover or snow beds (Alsos et al., 2009). Both species are shrubs that occur in a periglacial environments. If this depression is indeed a pingo remnant, the layer containing the organic remains could be a part of the pingo skin, that collapsed into the remnant depression during the melting of the ice core. The macro-remains have been dated to 12.470 $\pm$ 60 ^{14}C year BP, equivalent to approximately 14.650 cal yr BP.

Along most of the transect (except boring 086, 118 and 119) the grey sand or organic layer is covered by a light brown grey, very sandy fine-detrital gyttja. In several borings laminae can be recognised, and almost all contain remains of aquatic mosses. This gyttja is considered as the depressions earliest infill. It indicates that the depression must have hosted a relatively deep lake. In all borings that contain infill, the overlaying layer consists of a grey brown, coarse-detrital gyttja that sometimes contains remains of sedges. The gyttja has a thickness of up to 90 cm and sand content is highly variable. This variation in the described sand content may be partly due to the fact that borings along the transect were performed on different days, resulting in slightly different descriptions of the material. This coarse-detrital gyttja demonstrates a shallowing of the lake.

In the centremost borings (116, 120, 092 and 086) a layer that has been described as a sandy fine-detrital gyttja is found on top of the coarse-detrital gyttja. The appearance of a fine-detrital gyttja, reflecting relatively deep water conditions, on top of a coarse-detrital gyttja indicates that ground water level must have fluctuated. Descriptions of the coarse-detrital layer slightly vary per boring: in boring 086 a black brown, homogeneous organic material with some plant remains (sedges and wood) is described, and in boring 120 a gradual colour change from dark brown at the top to grey brown at the bottom have been observed. In the latter two borings, the layer seems to have been subject to oxidation. Borings 092 and 116 have a dark brown colour which also might be due to oxidation.

The layer superposing the fine-detrital gyttja at the northern side and in the centre of the depression, consists of a (dark) brown coarse-detrital gyttja containing sedges, twigs and seeds. The lower boundary of this coarse-detrital gyttja generally lies around 130 cm depth, although the in boring 092 is different than expected based on the adjacent borings: it lies 150 cm deeper. This could be due to the fact that borings were performed several days apart, which may have been of influence of interpretation of a boundary in gradually changing lithology. The coarse-detrital unit cannot be followed towards the southern side of the depression. However, part of the deteriorated peat in boring 086 may belong to this coarse-detrital gyttja unit.

The coarse-detrital gyttja gradually changes in to approximately 140 cm of brown peat of variable sand content, in which some sedges and wood remains have been found. The presence of peat indicates that water depth decreased to about zero. The top layer of the depression infill consists of a very sandy, dark brown oxidised peat containing rootlets, twigs and small pieces of brick. It is heavily disturbed.

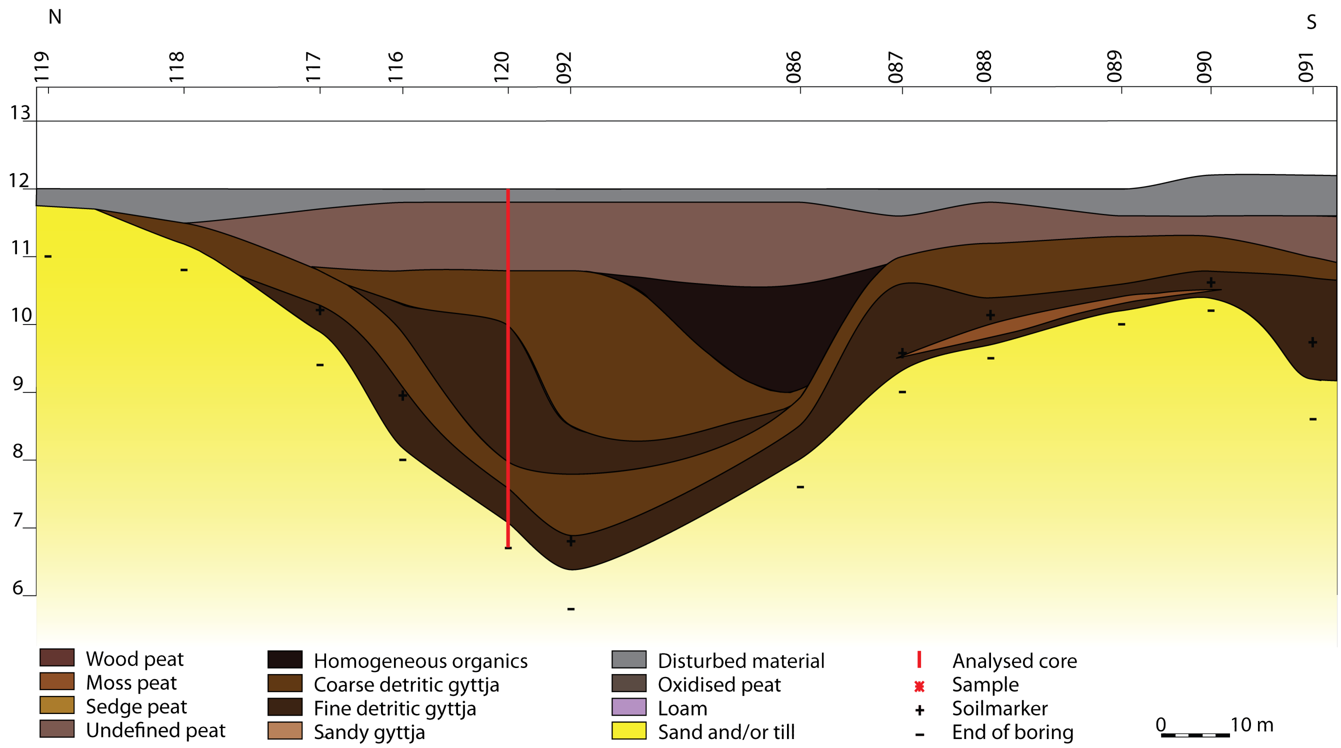

Figure 5.14: Lithological profile of the Timmelteich depression.

Conclusion

The Timmelteich depression dimensions match those of a pingo remnant. The southernmost coring of the transect forms an exception, showing a deepening of the infill. It is unclear why this is the case. More borings along the southern side of the profile are necessary to determine the origin of this increase in depth. Pollen analysis of the southernmost core may provide insight whether this deeper section has a similar age as the deepest lake infill.

Infill characteristics also match the expectations for a pingo remnant. Unlike other depressions, shallowing of the lake occurred in two phases. The great variation in sandiness reflects multiple periods of increased aeolian sedimentation. Difficult correlation of sandy intervals between cores prohibits an interpretation on which periods are reflected in the cores. Nevertheless, the *Salix* leafs indicate a periglacial environment, which is confirmed by the calibrated ^{14}C age of 14.7 kyr BP. In conclusion, the Timmelteich depression is a pingo remnant.

5.3.2 Westerschoo

Clearly visible on air photographs, the Westerschoo site (WGS 84: 53°35′ 18″ N â 7°32′ 34″ E at 12 m above N.N.) is located about 750 m northwest of Negenmeerten, on the south-western side of a pine forest (section 5.15). It lies over 1 m lower than the surrounding landscape and consists of a depression with a diameter of over 200 m, with vegetation strongly differing from that in the surroundings, which consists of pine trees. During a reforestation project in the area in 16th century, parallel ditches were constructed every 8 m meter (Axel Heinze, personal communication). Currently, birch trees and moss grow in the inner area with a diameter of approximately 160 m, with the highest birch density at the centre of the depression. Concentric differences in vegetation indicate differences in the subsurface, e.g. depth of a depression in the substrate. Vegetation may be either natural or was enabled or enhanced through construction of the drainage network. Despite the drainage, the depression is still very wet and thus inaccessible beyond the edges.

Figure 5.15: Air photo of the Westerschoo depression.

Lithological description and interpretation

Because of bad accessibility, a single coring was performed on the edge of the depression, with a maximum depth of 90 cm. Between 90 and 60 cm depth, a dark brown (above) to grey brown (below) humic loamy sand was found, which had a coarse grain size (210-300 μm) and a 2% gravel content with a single pebble of 3 cm in diameter. The sand forms the depressions substrate. The colour change in this substrate may be due to soil formation, which means it used to be at or near the surface.

Between 60 and 40 cm, a dark brown humic sand was found (150-210 μm). Although it is hard to distinguish this unit from the previous loamy sand, they have been separated based on the fact that this layer does not contain gravel or loam and wood remains. Lithology is deviant from that of the direct surroundings, which consists of dry sand directly at the surface. This unit is considered as the earliest infill of the depression. The dark brown sand is overlain by a dark brown, very sandy peat containing plant remains and wood fragments near the surface. The change from sand infill to peat infill can be explained by a rise in ground water level. Due to the wetness of the depression, peat formation is still continuing.

Conclusion

Dimensions of the Westerschoo depression are suitable for those of a pingo remnant depression. The presence of a peat infill would explain the deviant vegetation and wetness of the area. However, based on a single coring the results remain inconclusive. A profile or a coring in the centre of the depression and possibly a date of the deepest infill may provide further insight in the origin of the Westerschoo depression, but due too inaccessibility this is not possible, at least not during a wet summer season.

5.3.3 Brill

The Brill depression (WGS 84: 53°34′ 32″ N - 7°37′ 09″ E at 7 m above N.N.) is located 3 km north of Ogenbargen (figure 5.16). The edges of the depression cannot be distinguished on air photos. Based on the shape of the cross sections that were taken, the diameter of the depression seems at least twice the length the coring transects. The full diameter therefore is estimated to be at least 80 m. This is still very small for a pingo remnant. The difference in surface elevation with the surroundings is about 1 m. A circumventing rampart is lacking, but the presence of excavators showed that the land is heavily disturbed. From the centre towards the north surface elevation gradually increases, while at the western side, slope is slightly steeper. On the eastern and northern side of the depression lies ploughed agricultural land. The forest is bordering a horse paddock at the southern side. On the western side, excavators were busy working the land, revealing a reddish sand. The eastern part is covered by the provincial road running from Esens to Ogenbargen. The depression is covered with a small forest (70 m in diameter) of birch trees, underneath which brambles and nettles grow.

Figure 5.16: Air photo of the Brill depression.

Lithological description and interpretation

Two sets of borings have been made for construction of lithological cross sections in different directions (figure 5.17). The first stretches from north to south, the second perpendicular to this, from west to east. The lithological cross sections do not transect the entire depression, as part of it is inaccessible. A total of 10 borings was conducted. The deepest infill that was found lies at a depth of 340 cm. When taking the difference in depth of infill of both cross sections, the west-to-east transect probably has not been taken through the depression centre. In the north-to-south transect, an increase in depth towards the south is not observed, hence the maximum depth of the depression may exceed 340 cm.

Along the north-south transect, all borings end in a light brown grey, loamy sand. The same material is found in borings 094 and 095 in the wet-east transect. In boring 100, a red brown sand was found at a depth of 70 cm, gradually changing to orange brown with depth. This material is also present near the surface outside of the depression, as was visible at the excavation site. Hence, the substrate of this depression seems to consist of various sands cutting through several stratigraphic layers. The presumed substrate has not been reached in all borings, because of stiffness of the overlying material.

The deepest infill of the depression consists of the light brown grey, very stiff and compact material that is brown at the top and gradually becomes lighter towards the bottom of the depression. It has a very constant grain size of 105-150 μm does not contain plant remains or gravel. The layer is approximately 100 cm thick. The compact material found at the bottom of the depression is an inorganic deposit with a very uniform grain size, therefore it is probably of aeolian origin.

On top of this layer, a black brown (very sandy) layer of peat was found. Peat indicates that ground water level must have been around surface level. The black brown colour is probably due to soil formation, with a gradual colour change continues into the stiff sand layer below. This soil indicates that the depression must have run dry for a period of time long enough for pedogenesis to occur. Afterwards, the depression water level must have risen again, as a dark brown, coarse-detrital gyttja in which some sedge remains were present formed on top of the soil. The maximum thickness of this gyttja is 150 cm.

Between about 80 and 40 cm depth, an orange brown moss peat was found along the transect running from west to east. The top layer of both transects consists of 40 cm of brown, sandy oxidised peat in which wood fragments are found. This succession of moss and wood peat indicates a decrease in water depth. This does not necessarily require a drop in ground water level, as the lake also becomes shallower because of organic deposition.

Boring 097 strongly deviates from all others: it extends to a depth of 100 cm, of which the lower 30 cm consist of red to orange brown sand. This is covered with a 10 cm thick humic brown sand. Between 60 and 40 cm, a light brown grey, well-rounded (soft) fine sand is found (105-150 μm). This is covered with a dark brown grey humus sand of the same grain size. The top 20 cm consist of very sandy peat. Boring 097 has been discarded in construction of a lithological cross section, because in the field the material did not seem to be in situ.

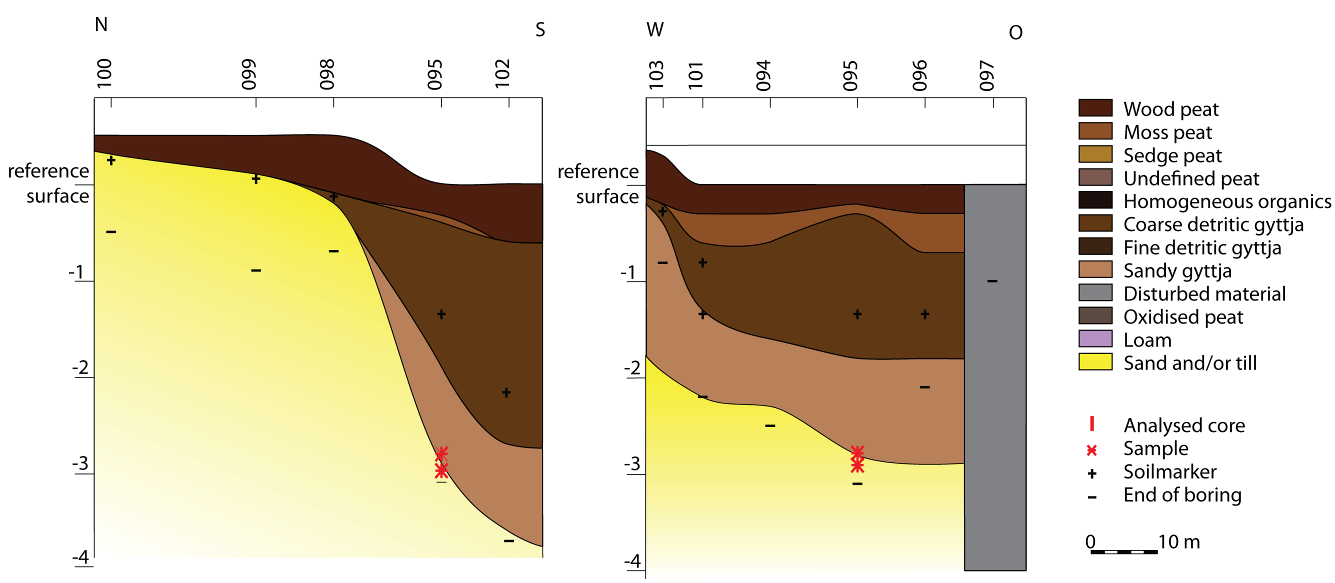

Figure 5.17: Lithological profile of the Brill depression.

Conclusion

The estimated diameter of the Brill depression (80 m) is on the small side for a pingo remnant. The deepest infill deviates from that of other depressions in this study, as the organic fraction seems to be very low or completely absent. Although it is not a perfect match, all prerequisites on shape and infill for a pingo remnant depression are met. The Brill depression therefore will be regarded as a possible pingo remnant.

5.3.4 Wrokmoor

Wrokmoor (WGS 84: 53°27′ 50″ N - 7°48′ 41″ E at 4 m above N.N.) is a depression that is located 425 m west of Amerika, near Friedburg (figure 5.18). From side to side it measures approximately 140 m and the height difference between the edge and centre of the depression is estimated at 1.5 m. It is situated in an agricultural field that is used for cattle. In the centre of the depression the ground is firm and small birches grow. Surrounding the centre is a wet area covered with moss plants, and consequently a concentric circle that is wet and contains high grasses. Further towards the sides of the depression muddy grassland is found. Higher up, the ground is dry and firm. The surrounding area is divided into agricultural fields used for cattle grazing, divided by wooden walls and trees.

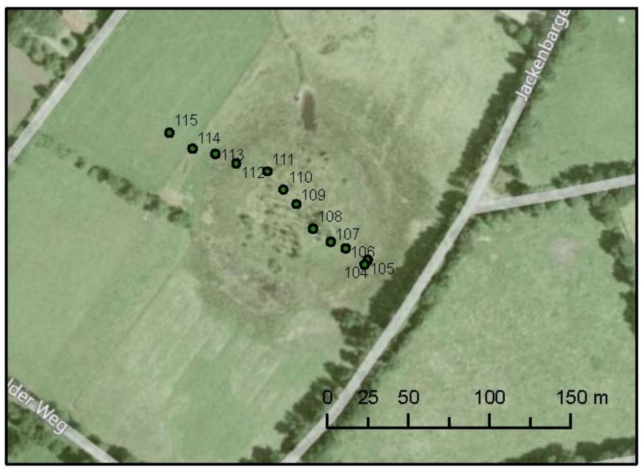

Figure 5.18: Air photo of the Wrokmoor depression.

Lithological description and interpretation

The cross section in figure 5.19 has been constructed based on a set of 12 borings along a transect running from the north-west to the south-east. The maximum depth reached is 550 cm. Except in boring 113, where further boring was not practical, all borings end in a slightly loamy fine sand (105-150 μm). In the centre borings, where a thick layer of peat is deposited on top of the sand, it has a grey (to blue-grey) colour, while at the edges where little or no peat covers the sand it is more humus and colour shifts from dark brown at the top to light grey brown as a result of soil formation. In boring 115 the upper 70 cm showed a mixture of grey and dark brown sand and was patchy. This material is probably disturbed.

In all borings in the infill except 106, the layer covering the substrate is a very sandy gyttja layer in different shades of brown, with a thickness varying from 35 to 160 cm. Colour of the gyttja varies from grey brown at the top to a lighter greenish grey at the bottom. The presence of a fine-detrital gyttja indicates that water depth in the depression during time of deposition must have been relatively high.

The sandy, fine-detrital gyttja is covered by a dark brown coarse-detrital gyttja in which some remains of sedge are present. This still has a high sand content, although it is lower than in the underlying layer. It is found in borings 107 to 112. Coarse-detrital gyttja generally forms closer to the lake shore (Bos et al., 2012), indicating that water depth had decreased during the time of deposition of this gyttja.

On top of the coarse-detrital gyttja is an homogeneous (amorphous) type of very sandy, dark grey brown gyttja (borings 109 to 113). homogeneous or amorphous gyttja may be formed by pedogenesis (Bos et al., 2012), and its presence indicates a further decrease in water depth.

In the centre of the depression (108 to 111) the amorphous material is overlain by a brown peat that is not sandy and contains a lot of moss (lower part of the centre borings) and sedge (upper part along the entire depression) remains. Superjacent to this, a very loose brown peat with some plant remains and wood fragments is found in borings 109 to 112. This might indicate that after a period of soil formation, water level may have slightly increased enabling peat formation. In boring 111, the material showed some white spots, possibly siderite. All borings from 107 to 112 contain a layer of dark brown peat between approximately 100 and 30 cm depth. In borings 108, 109 and 113 a black, sometimes somewhat granular layer of black organics is found. Apparently, the peat in these borings also became oxidised in a period of soil formation.

The uppermost layer of the depression consists of a moss peat with a thickness of about 30 cm. In boring 111, blue spots are found in the moss peat. They have been interpreted as vivianite. Moss peat formation is still continuing at the surface, although the centre of the depression is dry compared to the concentric ring. Ground water level has (for a longer period of time) been lower than the rims of the depression, resulting in soil formation in borings 004, 005 and 114. The material found in boring 115 may be unreliable because of agricultural acitivities and leveling of the adjacent field.

There are two phases of increased aeolian activity that can be recognised in the deepest depression infill: one during the time of deposition of the sandy fine-detrital gyttja followed by the deposition of a less sandy coarse-detrital gyttja, and the second very sandy, amorphous organics followed by brown peat that is not sandy. These sandy episodes may reflect the Pleniglacial / Bølling and the Younger Dryas. The amorphous layer would then have deteriorated during the early Holocene. Afterwards, aeolian activity had ceased sedge and moss peat were deposited. The loose peat is often of Holocene age (personal communication W.Z. Hoek). Along the transect there is some variability in sandiness; sand content seems to be somewhat higher in the south-east, but no clear trend can be discovered.

The white and blue spots that are found probably are (oxidized) vivianite. Precipitation of such minerals can be an indicator for seepage conditions.

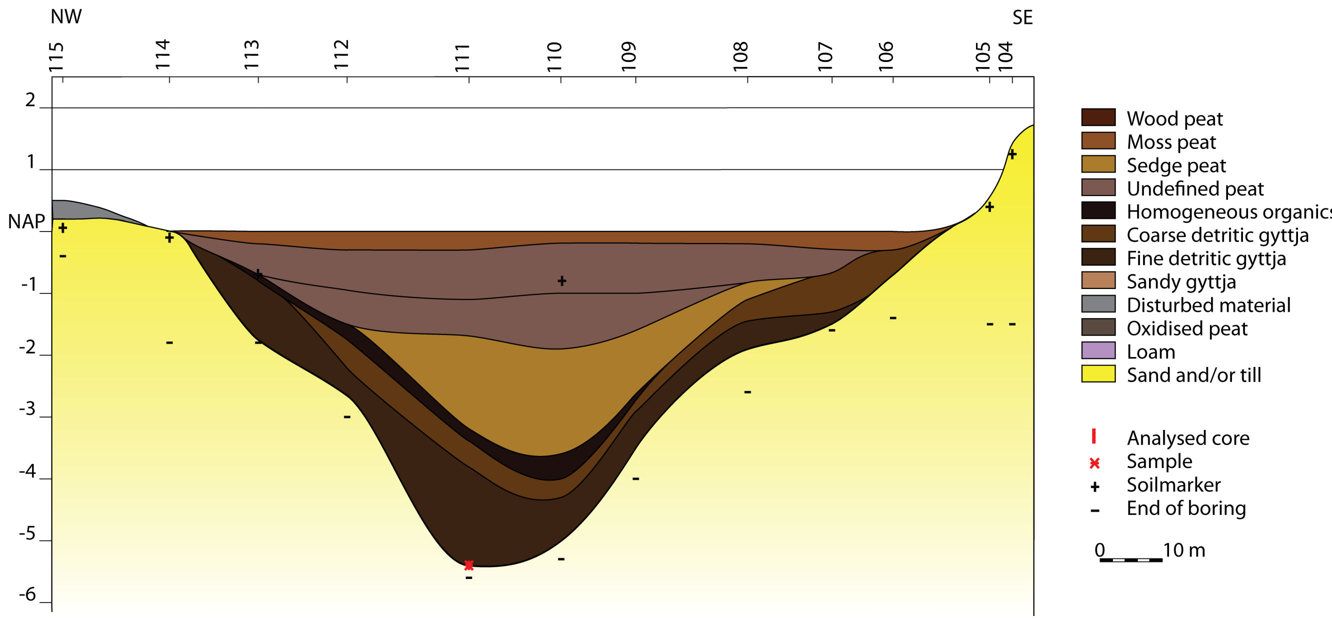

Figure 5.19: Lithological profile of the Wrokmoor depression.

Conclusion

The dimensions of the Wrokmoor depression are suitable for a pingo remnant depression. The deepest infill was probably deposited during the Pleniglacial or early in the Late Glacial, during the Bølling or Earlier Dryas. Seepage may have occurred during the period of infill. The sequence of infill of the depression shows a general decrease in water level, although it may have fluctuated as is indicated by the formation of peats after the development of a soil layer of amorphous peat. As the infill also shows a good match, this depression probably formed by pingo collapse.

5.3.5 Mamburg

The Mamburg depression (WGS 84: 53°37′ 32″ N - 7°38′ 20″ E at 1 m above N.N.) is situated in grass land that is surrounded by corn fields (figure 5.20). It has a diameter of 130 m and the centre of the depression is wet, while at the edges the ground is dry and firm. A ditch runs through the centre of the depression, parallel to the transect. Smaller channels run through the grass land for draining purposes. In the centre of the depression, about 10 cm of water stands, in which longer grasses are present.

The height difference of the depression centre with the surrounding land is more than 0.5 m. This site has been previously investigated by Axel Heinze, who constructed a profile running from west to east. During these activities, an archaeological find of pottery was done at the centre of the depression.

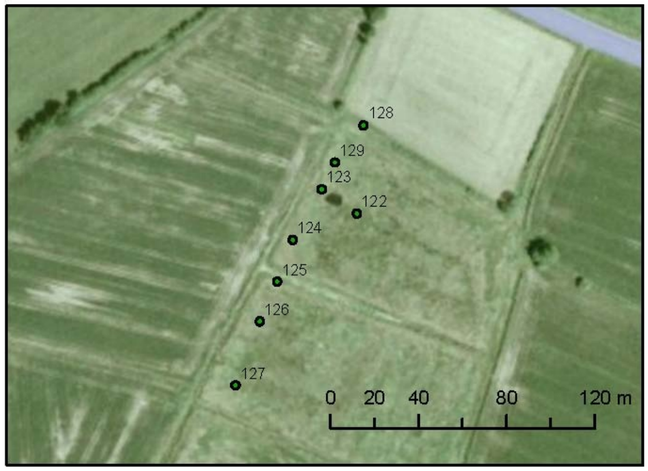

Figure 5.20: Air photo of the Mamburg depression.

Lithological description and interpretation

The cross section of the Mamburg depression figure 5.21 was constructed based on 7 borings along a transect running from north to south. It is a relatively shallow depression: the maximum depth found was 290 cm, which corresponds to the maximum depth found by A. Heinze.

The two south-westernmost borings (126 and 127) end in a grey, sandy loam that contains 2% gravel. Besides these, all borings end in a brown grey, ultra fine loamy sand (75-105 μm). This also is found superjacent to the loam in boring 126. The loamy material is considered as the substrate of the depression.

Material covering this sand in the deepest borings (123, 124, 125 and 129) consists of a grey brown fine-detrital gyttja layer of up to 90 cm thick. Superjacent to this, lies a coarse-detrital, brown gyttja that contains plant remains of mainly sedge, although moss and wood remains are also found. This layer is dark brown at the top and brown at the bottom and is found up to a depth of about 60 cm. In all borings except 127 follows a black brown peat, which contains heavily oxidated wood fragments in boring 123. The entire depression is covered with a grey brown, humic sand.

The lithological sequence that forms the infill of the depression indicates a decrease in water depth; coarse-detrital gyttja formed when the depression still hosted a (shallow) lake. A decrease in water depth led to peat formation. Further decrease resulted in exposure of the peat to the surface, resulting in soil formation. This also caused a gradual colour change in the coarse-detrital gyttja.

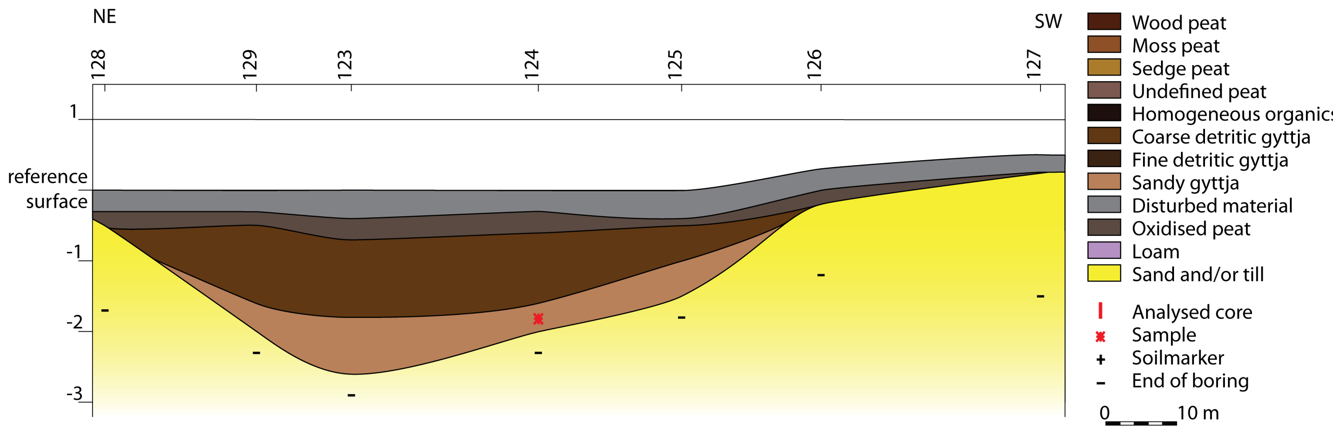

Figure 5.21: Lithological profile of the Mamburg depression.

Conclusion

The depression is relatively shallow and small compared to the other pingo remnants that are found in the region. Nevertheless, the size is suitable for a pingo remnant depression. Substrate and infill also are similar to that of pingo remnants in the area, although a sequence indicating decrease in water depth may be found in any depression. Based on dimensions and lithology, this depression may be a pingo remnant.

5.4 Germany, Cloppenburg/Visbek area

5.4.1 Keller-Höhe

The Keller-Höhe site (WGS 84: 52°53′ 33″ N â 8°05′ 45″ E at 40 m above N.N.) is located directly south of Keller-Höhe, in a ploughed wheat field in a rolling landscape (figure 5.22). It has not been preselected based on evaluation of the historical and topographical map, but was chosen in the field when height differences resembling a rim were observed. Along the eastern edge of the depression a rim of over 1 m high can be recognised. It cannot be followed along the entire depression, as part of it is covered with corn and a road is transecting the western side. Therefore the diameter of the depression was unclear, although it should exceed 130 m.

Figure 5.22: Topographic map and air photo of Keller-Höhe.

Lithological description and interpretation

At the Keller-Höhe site, three borings down to a depth of about 4 m were performed. The only material that was found was a very fine sand (105-150 μm), that gradually changed in colour from the top down from black brown to light brown over 70 cm. The change in colour that is observed is a result of a long period of soil formation. If this is indeed a pingo remnant, both the substrate and the infill would consist of sand.

When permafrost acts as the impermeable layer, pingos formation in a permeable substrate such as sand is very well possible. When water level drops below the maximum depth of the depression, it would eventually fill in with other material. Circumstances described in the interpretation of Lammeer (section 5.2.2) also apply in the Keller-Höhe setting. However, the historical map shows no indication of a depression at the Keller-Höhe site and post-field work evaluation of air photos show parallel rims in the landscape. It looks similar to sites in the surroundings were dune ridges were observed. In retrospect, the Keller-Höhe site does not meet the criteria that were set for site selection.

Conclusion

The Keller-Höhe site is not a pingo remnant, but a lower area between two dune ridges. The dune system must have been inactive for a longer period of time, because a soil layer has formed.

5.4.2 Rennplatz

The Rennplatz site (WGS 84: 52°49′ 10″ N â 8°18′ 01″ E at 52 m above N.N.), located 1.5 km south-southwest of the centre of Visbek (figure 5.23) was hard to recognise and difficult to reach. The diameter of the depression is approximately 100 m. The site consists of an elongated pond surrounded by trees, with a ploughed field at the southern side, and a corn field at the northern side. Based on air photographs, a roughly circular structure can be recognised when the land has been ploughed. A second pond is located on or just outside of the north-western edge of this circular shape.

Figure 5.23: Topographic map and air photo of the Rennplatz depression.

Lithological description and interpretation

Because of bad accessibility only a single boring has been performed at the site of the Rennplatz depression. Because no detailed DEM was available for this area, it is unclear whether this boring has been taken at the centre of the depression. Exact dimensions of the depression remain unclear.

Between 380 and 240 cm a grey loam was found, containing 2-5% of gravel and a lot of coarse (300-420 μm) sand. This material is interpreted as a glacial till, which presumably is the substrate of the depression. On top of this, between 240 and 180 cm a very loamy fine sand (105-150) of a light brown grey colour was present, followed by a loamy, light brown sand.

The sand is covered by a brown fine-detrital gyttja of 60 cm thick, which contained very fine sand. This material is considered as the depressions first infill. The organics may have caused the brown colour in the underlying sands. The very fine sand in the gyttja may be of local aeolian origin, as lithology of the surroundings is loess. The presence of a fine-detrital gyttja indicates that the depression must have hosted a relatively deep lake.

A 30 cm thick brown peat layer, dark brown at the top, overlays the gyttja, indicating a decrease of water depth. Possibly the slightly darker colour at the top of the peat is an effect of (initiation of) soil formation during a prolonged dry stand. The section above 60 cm consist of a sandy brown gyttja, of which the upper 40 cm contains rootlets. Apparently, a rise in lake level occurred. Currently, a small artificial pond is still present at the site.

Conclusion

The maximum depth of the presumed infill that is found at this depression is 180 cm, which is too shallow for a pingo remnant as it is less than the estimated thickness of the active layer of permafrost (section 3.3). However, it is unclear whether the boring was performed near the depression centre, and the maximum thickness of the infill may be much larger. Therefore, results on dimensions and infill of the Rennplatz depression remain inconclusive.

5.4.3 Erlte

About 200 m north-west of Erlte (WGS 84: 52°50′ 14″ N â 8°17′ 09″ E at 53 m above N.N.) a circular depression with a diameter of about 140 m is present (figure 5.24). It lies at the southern border of an agricultural field, which besides this feature is rectangular. A circumventing rim of about 20 cm high is present, although it is unclear whether this is natural or if it is formed through usage of machinery on the surrounding agricultural land. The northern half of the depression is filled with water, and the southern half is covered by a relatively open forest.

Figure 5.24: Topographic map and air photo of the Erlte depression.

Lithological description and interpretation

Three borings have been done, stretching from the centre of the depression towards the eastern edge. The deepest boring reaches a depth of 150 cm, of which 80 cm is considered as depression infill. A profile has not been constructed, because borings were very shallow and hard to correlate.

In all borings, the deepest material consists of a grey sandy loam with a gravel content of up to 10%. Gravel consists of many different types of stones (e.g. flint stone, quartz, possibly granite). It is found below a depth of 100 cm in the centre of the depression (boring 042), below 90 cm in the middle boring (043), and below 80 cm in the outermost boring (044). It is interpreted as a glacial till that presumably forms the substrate of the depression.

The material covering the glacial till in the different cores is hard to correlate, mostly due to differences in grain size. In the centremost boring (042), the till is covered with 40 cm of brown, humic and dry sandy clay, in which a pebble and some smaller pieces of gravel were found. Between 60 and 40 cm depth, a thin layer of dark brown, sandy peat is present. The uppermost 40 cm consists of dark brown, very humic sand (150-210 μm) or sandy peat. In the middle coring (043) the substrate is overlain by a brown (above) to light brown (below) coarse sand (210-300 μm) between 90 and 70 cm, with a 5% gravel content at the bottom. On top of this, a dark brown (above) to brown (below) medium sand (150-210μm) is found. The material covering the till in the outermost boring (044) is an 80 cm thick layer of sandy clay that is dark brown at the top and becomes lighter towards the bottom. The gradual shift in colour from dark brown to light brown that is observed in all borings is probably a result of a period of soil formation.

Although the substrate is suitable for pingo formation, the depression is rather shallow for a pingo remnant and does possibly not even exceed the presumed active layer thickness of permafrost that used to be present. Dimensions of the Erlte pingo remnant are relatively small, but still suitable for a pingo remnant. Possibly, this is a pingo remnant that could not develop to its full size because of climate changing towards unfavourable conditions (see section 2.3.2). The sandy material found on top of the glacial till in the centremost boring may be the pingo 'skin' that sunk or slumped back into the depression when the ice core melted (section 2.4.1). The material differs from that of the substrate, but this might be due to a removal of the fine fraction by water and wind erosion to which the pingo would be exposed. The principle is further explained in section ?? of the discussion chapter. If this indeed is a pingo that collapsed before development to its mechanical capacities, the age of deepest infill is expected to reflect a period of climatic warming.

Conclusion

The Erlte depression is too shallow to be a relict of a well-developed pingo. It might be a remnant of a pingo that collapsed in an early stage. If this type of pingo remnants does indeed exist in the area, the Rennplatz depression may have a similar history.

5.4.4 Emstekerfeld

The Emstekerfeld depression (WGS 84: 52°49′ 51″ N - 8°06′ 06″ E at 45 m a.s.l.f) consists of a circular low-lying forest area with a diameter of 170 m, that is located 3.8 km west of Emstek (figure 5.25). Most of the land surrounding the depression consists of corn fields and hay land. The maximum height difference between the surrounding land and the depression centre is estimated to be more than 1 m. Although surface elevation changes rapidly along the south-eastern side of the depression, a circular rim cannot be recognised. In general, surface elevation slowly decreases towards the centre of the depression.

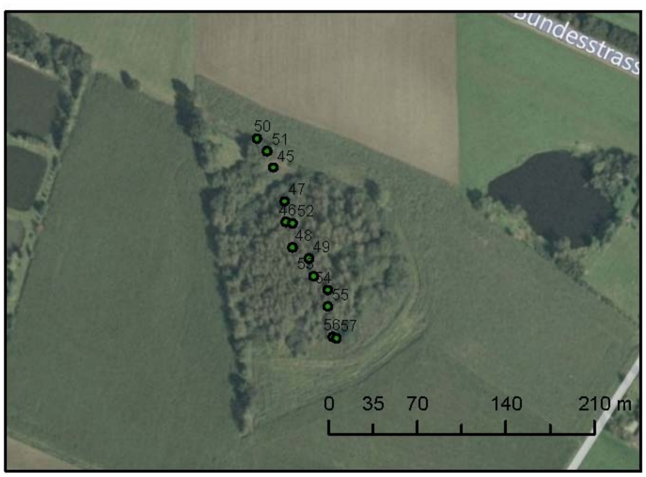

Figure 5.25: Topographic map and air photo of the Emstekerfeld depression.

Lithological description and interpretation

The cross section of the Emstekerfeld depression (figure 5.26) was made based on a transect of 13 borings, stretching from the north-west to the south-east. The maximum depth that was reached is 660 cm. Except for boring 048, 049 and 053, all borings end in a grey or brown loamy coarse sand, and gravel was felt. This material is considered as the depressions substrate. The presumed substrate has not been reached in the centremost borings because the maximum depth reachable with the hand augur was reached (660 cm).

In most borings, the presumed substrate is overlain by a (light brown) grey, silty or sandy loam. In the north-western part of the depression, this material is over 50 cm thick and contains about 2% of gravel, while in the south-eastern part this thickness is thinner and gravel was not observed. In two of the north-westernmost borings (050 and 051), this loam contains black stalk remains of reed or sedges. The loam shows laminae in boring 054, on the south-eastern side of the depression. Strikingly, boring 052 does not contain a loam layer at all. Because of the presence of remains of reed or sedges, it can be stated that the loam is part of the infill of the depression. The sterns derive from riparian vegetation bordering a lake or marsh.

The loam is expected to be of aeolian origin. Because it directly covers the substrate, it must have been deposited directly after the depression was formed. The colour of the loam is the same as that of the substrate. Possibly, this is the fine fraction that is blown out of the surrounding surface (perhaps during formation of a desert pavement) and deposited in the depression. The slightly brown colour found in some of the borings may be caused by a small fraction of organics, or by alternation of the original colour by the overlying organic material. Laminae that were found in boring 054 may have a seasonal origin, due to variable amounts of wind transport during seasons or because of periodical deposition due to presence of ice covering the lake in winter. This is further discussed upon in section 7.5 of the discussion chapter. Deposition of the loam has probably occurred over a short period of time, otherwise a mixture of loess with (organic) lake deposits would be expected. The gravel that was found in the loess deposits may originate from a rampart. The loam is not expected to continue into the deepest part of the depression, because it was not found in boring 052.

In the deepest part of the depression and overlaying the loam, a dark to light green brown, fine-detrital gyttja of up to 150 cm thick is found, which at the bottom is described as sandy in the northern part of the depression. Seeds of *Potamogeton* are found in this layer. It is covered by a coarse-detrital, dark grey brown sandy gyttja containing remains of sedges that has a thickness of up to 200 cm. Part of the gyttja (in boring 046, 047 and 052) is covered by a homogeneous gyttja (or amorphous peat) of a grey brown colour. Subsequently, a brown peat containing sedges, cotton grass and moss is found, which in the north-western part contains red rootlets and has a more orange colour. In borings 045 to 054, a very loose orange brown peat overlies the brown sedge peat. This 200 cm thick layer contains a lot of plant remains: sedges, wood, cotton grass, heather and, predominantly, moss. In boring 054 along the south-eastern side of the depression, moss peat is not horizontally layered, but dips about 20°towards the depression.

The uppermost layer consists of a peat in different shades of brown, in which cotton grass is found. On the north-western and south-eastern side of the depression, an up to 50 cm thick layer of oxidised peat is found at the surface.

Overall, the infill shows a decrease in water depth in the depression; fine-detrital gyttja changes into a coarse-detrital gyttja. The amorphous gyttja found on top of the fine- and coarse-detrital gyttja may originate from decay of original material (gyttja) because of availability of oxygen due to changed water level, resulting in soil formation. Afterwards, water level has slightly risen, resulting in the development of a sedge peat (shallow water), a moss peat and consequently oxidation of the uppermost layer of peat because of a renewed period of soil formation.

Field descriptions on sand content along the complete transect do not allow a precise interpretation on the age of this depression, although it seems as if the bottom of the fine-detrital gyttja and the coarse-detrital gyttja reflect two periods of increased aeolian sedimentation. At the south-eastern side of the depression, two episodes of increased aeolian sedimentation were recognised from the lithology, indicating that the earliest infill was deposited prior to the Allerød. The deepest infill at the centre of the depression was not reached and may provide an even older age. Loose peat in the depression likely is of Holocene age (as is the case in the Wrokmoor depression).

Both the sand and loam of the depression infill seems to be of aeolian origin. Generally, the sand content of the peat is not very high. According to field descriptions, the most sandy deposits are found in the peat at the south-eastern side of the depression. This is striking, as the thickest loam deposits are found in the north-west. Furthermore, both the loess (deepest layer of infill) and sand deposits (within the peats) are aeolian, a change in grain size of aeolian deposits must have occurred. The precise grain size of the material in the peat has not been further examined in the field, and thus the sand and loess might be the same material. The distribution of aeolian sand in the infill of a depression is also further discussed in section 7.5 of the discussion.

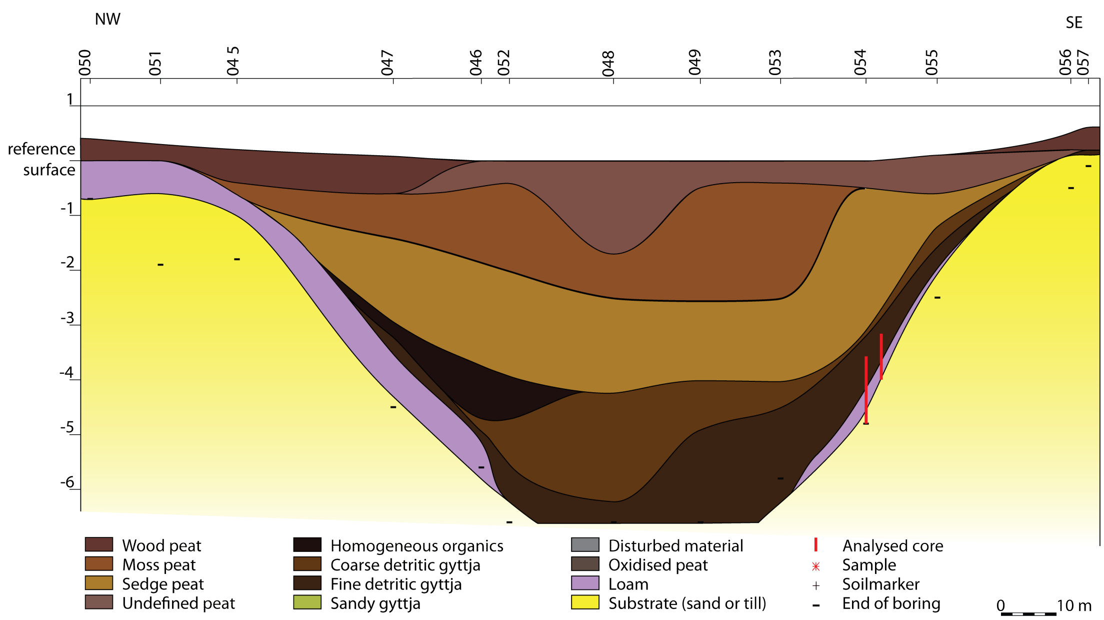

Figure 5.26: Lithological profile of the Emstekerfeld depression.

Conclusion

The dimensions of the Emstekerfeld depression meet the prerequisites for a pingo remnant. Sand content of two of the borings provide a pre-Allerød age for the earliest organic infill. Together, this indicates that the Emstekerfeld depression is caused by the collapse of a pingo.

5.4.5 Sevelte

The Sevelte site (WGS 84: 52°49′ 18″ N - 8°03′ 18″ E at 44 m above N.N.) is located in between hay lands about 650 m north of Sevelte (figure 5.27). The diameter of the depression is estimated at 150 m. It consists of a small forest of 100 m diameter in the centre, which has a pond at the northern side and a surrounding ditch. In the field surrounding the forest, a rim of approximately 1.5 m high can be recognised, although it is not completely circumventing the depression. The depression is surrounded by grass land in the north and east and a horse paddock in the south. Directly west of the forest lies a provincial road. Borings have been done along the northern side in the depression, and outside of and at the northern rim.

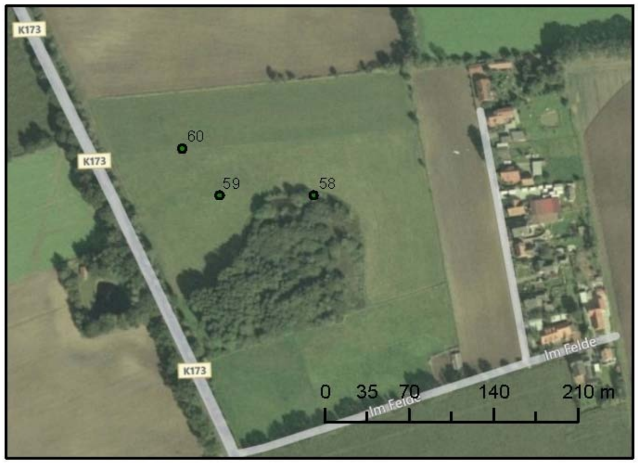

Figure 5.27: Topographic map and air photo of the Sevelte depression.

Lithological description and interpretation

The lithology and alongside the Sevelte depression has been determined based on three borings. The deepest of these borings (058) was carried out as close to the estimated centre as possible and extends to 490 cm below the surface. The second boring (059) was done at the rim partially surrounding the depression, and the third was performed well outside of the rim. Because of the limited amount of boring data, a lithological profile has not been constructed.

In the boring near the centre of the depression (058) a possible substrate has not been reached. The material found in the deepest section (490-400 cm) is a fine-detrital gyttja, which is slightly sandy at the top and gradually changes in colour from the top down, from brown grey towards green grey and subsequently dark green grey at the bottom. Between 400 and 350 cm a coarse-detrital dark brown green gyttja is found, followed by a homogeneous (amorphous) dark brown green sandy gyttja between 350 and 250 cm depth. On top of this lies a 90 cm thick layer of dark brown peat, that contains remains of cotton grass, sedges and wooden sprigs. Between 160 and 90 cm, an orange brown moss peat was found, which besides moss contained sedge and cotton grass. This is followed by 10 cm of dark brown sandy peat that contains cotton grass. The upper 80 cm consist of sandy oxidised peat changing in colour from dark brown at the surface to light brown further down. The peat contains medium (150-210 μm) sand and seems disturbed. The sequence illustrates that the depression must have hosted water, the level of which gradually decreased. The amorphous dark brown gyttja may have formed as a result of soil formation in a period during which the depression was completely dry. Afterwards, water level must have been high enough for peat growth. More recently, a renewed period of soil formation occurred leading to the gradual colour change in the uppermost material.

The second boring (059) was done at the rim partially surrounding the depression, to a depth of 365 cm at which sand was felt. The material in this boring can be divided in two intervals: one of gyttja and peat between 365 and 210 cm depth, and a second of heavily disturbed loam and sand between 210 cm depth and the surface.

The peat underneath the rim was over 2.5 m thick, hence the boring has not been done at the edge of the depression. Between 365 and 355 cm, a laminated grey brown fine sand was found (105-150 μm). Laminations may have a seasonal origin caused by freezing of a lake in the depression. Similar observations have been done in the proximal Emstekerfeld depression (section 5.4.4).

The sand is covered by a fine-detrital gyttja up to a depth of 290 cm. The gyttja is sandy to a depth of 300 cm and not sandy below, with several changes in colour from the top of the layer to the bottom: dark brown, grey brown, green grey, brown, yellow brown. A 5 cm thick wood sample was found between 320 and 325 cm depth. The fine-detrital gyttja is followed by a brown sandy coarse-detrital gyttja between 290 and 260 cm depth. Between 260 and 210 cm, a dark brown, sandy peat containing sedge was found.

The upper interval is the rim itself. From 210 to 200 m a grey brown loamy sand (150-210 μm) was present, followed by a sandy grey loam and sand mixture (105-150 μm) up to a depth of 170 cm. Then, a yellow brown, medium sized clean sand is found. Between 140 and 120 cm depth, a very sandy oxidised peat containing very coarse sand (420-600 μm) followed. Above this, between 120 and 10 cm depth, a yellow brown sand of varying grain size and a gravel fraction of up to 5% is present. In this sand, dark grey and brown to orange (gley) lumbs of loam were found. The upper 10 cm consist of dark brown, mixed humic sand with a grain size of 210-300 μm. The entire interval seems to be heavily disturbed. It seems that this material has been artificially deposited here. Possibly, a remnant rampart was present and then was shoved into the depression, over the peat, in an attempt to level the property and make it more accessible for agricultural machinery. This resulted in mixed lithology of sand and loam. The yellow brown sand is not found elsewhere and is probably put here artificially for the same purpose.

The last boring (060), taken behind the rim, extends to a depth of 130 cm, of which the lowest 60 cm consist of grey sandy loam with a low gravel content, although a piece of gravel of 1.5 cm in diameter is found. Between 60 and 10 cm of depth, a grey loamy sand with variable gravel content is found. Some pieces of gravel consist of a 'lumb' of gravel shards of the same material. These lumbs look like pebbles that have been crushed. Therefore, the material is interpreted as a glacial till. Part of the rim material in boring 059 strongly resembles that of this substrate. The upper 10 cm consist of brown, humic sand and is probably disturbed.

In both borings 058 and 059, there is a relatively sandy interval above the deepest part of the infill, followed by less sandy material. This indicates that in the time of depression infill, an interval of high aeolian activity occurred. This is thought to correspond to the Younger Dryas. The gyttja below then would be of Allerød age, and since the deepest infill of the depression was not reached, the depression is probably older.

Conclusion

The diameter of the Sevelte depression is larger than the 100 m that was estimated based on air photos and the circumventing rim. Therefore, all prerequisites in terms of dimensions, substrate and infill material and age in determination of pingo remnants are met in the case of the Sevelte depression. Therefore, the Sevelte depression is considered to be a pingo remnant of Allerød age or older, circumvented by an artificial rim that consists of substrate and rampart material mixed with artificial sands.

Chapter 6. Laboratory results

6.1 Core descriptions

In the laboratory, cores were taken from three different sites have been further investigated: Timmelteich (Ost-Friesland), Emstekerfeld (Cloppenburg/Visbek) and Sleenerstroom (Drenthe). Detailed core descriptions from the lab and photographs of the cores can be found in Appendices E1a-b, E2a-b and E3a-b. Core descriptions from the lab strongly resemble those done in the field, although sandiness of the infill does not always correspond.

Both the Timmelteich and Sleenerstroom I cores contain several hiatuses. The Emstekerfeld cores are continuous as these are short sections that were taken with a single boring using the gouge. The Timmelteich and Sleenerstroom cores, however, contain hiatuses; an interval of several centimetres is missing between successive cores. The hiatuses may be explained by either (1) compression of the peat during coring, (2) material being pushed aside by the piston corer during coring, or (3) removal of material in the lab. Since only loose material has been removed in the lab, the hiatus is thought to be caused by the coring activities. Most probably the hiatuses exist because of material pushed aside during coring after the piston corer was completely filled.

Besides hiatuses, several of the cores show some slight overlap. This is probably caused by material falling back into the borehole from higher up after removal of the piston corer. This material should have been removed in the lab. A slight overestimation of core length may also be due to the presence of cracks in the core.

6.2 Loss on ignition

The Loss on ignition of the infill directly covering the substrate has been measured for all three pingo remnants (figure 6.1). For the depressions Timmelteich and Sleenerstroom I, a Loss on Ignition profile was constructed for the entire infill (figure 6.2). Loss on Ignition has also been measured on samples from other presumed pingo remnant depressions, that were extracted in order to perform pollen quickscans. Results are shown in table 6.1. Pingo remnants in the study area are expected to be of Late Glacial age. An LOI-based interpretation of the age of the deepest infill can be made by comparison to changes in the vegetation cover.

The organic fraction is dependent on the influx of both organic and inorganic material. Because fluvial input is not expected in a pingo remnant depression, the inorganic influx is regarded to originate mainly from aeolian activity and chemical precipitation because of seepage. The latter is assumed to be of minor influence. Another source of inorganic input in a pingo remnant depression may be inward transport of sediment from the depression rampart. However, these are regarded as single, local events that do not continuously influence LOI values. The organic fraction originates from deposition of both terrestrial and aquatic plant material and algae.

The rate of organic influx is not constant. Peat growth and other organic deposition is dependent of various factors, such as topography and the hydrological regime (Balyae and Clymo, 2001). Deposition of organics is also expected to be slower during cold and dry periods and faster during warm and wet periods. However, in this report this effect will be neglected. The main emphasis in the explanation of variation in LOI values will be on changes in aeolian activity.

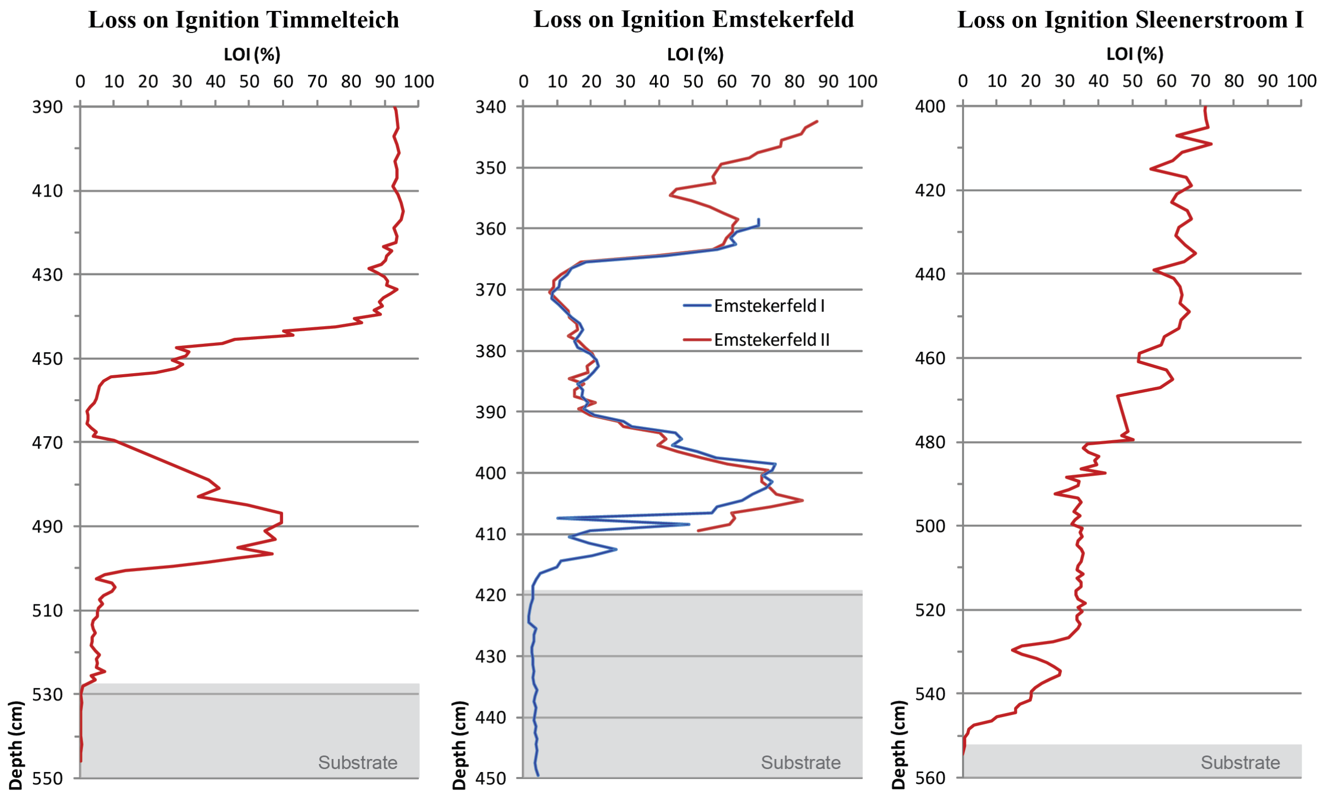

Figure 6.1: Loss On Ignition profile of the deepest meter of the Sleenerstroom I, Timmelteich and Emstekerfeld pingo remnant depressions.

6.2.1 Timmelteich

All lithological descriptions mentioned in this text are derived from section 5.3.1 and Appendix E1a. The section of the core below 527 cm consists of the glacial till that forms the substrate of the depression. The glacial till does not contain organic matter, except for the upper 2 cm, which may contain some because of contamination with the overlying organic material.

The Loss On Ignition curve of the deepest meter of infill for the Timmelteich is divided into four intervals and transitions between those intervals. Directly covering the substrate between 527 and 526 cm depth a small peak in organic fraction can be observed. This peak corresponds to the layer of organic macro-remains found at the bottom of the depression.

The thin layer is followed by the first interval (526-502.5 cm). It has an organic matter content of approximately 5%, with a short excursion to a percentage of 10.3% at a depth of 504.5 cm. This is followed by a small minimum (4.9%) at 502.5 cm depth. This part of the core corresponds to a very sandy fine-detrital gyttja. The low organic matter content (<10%) indicates high aeolian activity during the time of deposition. An open landscape in which sediment is available for transport is expected. This section may be correlated to the B olling interstadial, when aeolian activity was high because the vegetation cover had not been able to get in equilibrium with the warmer

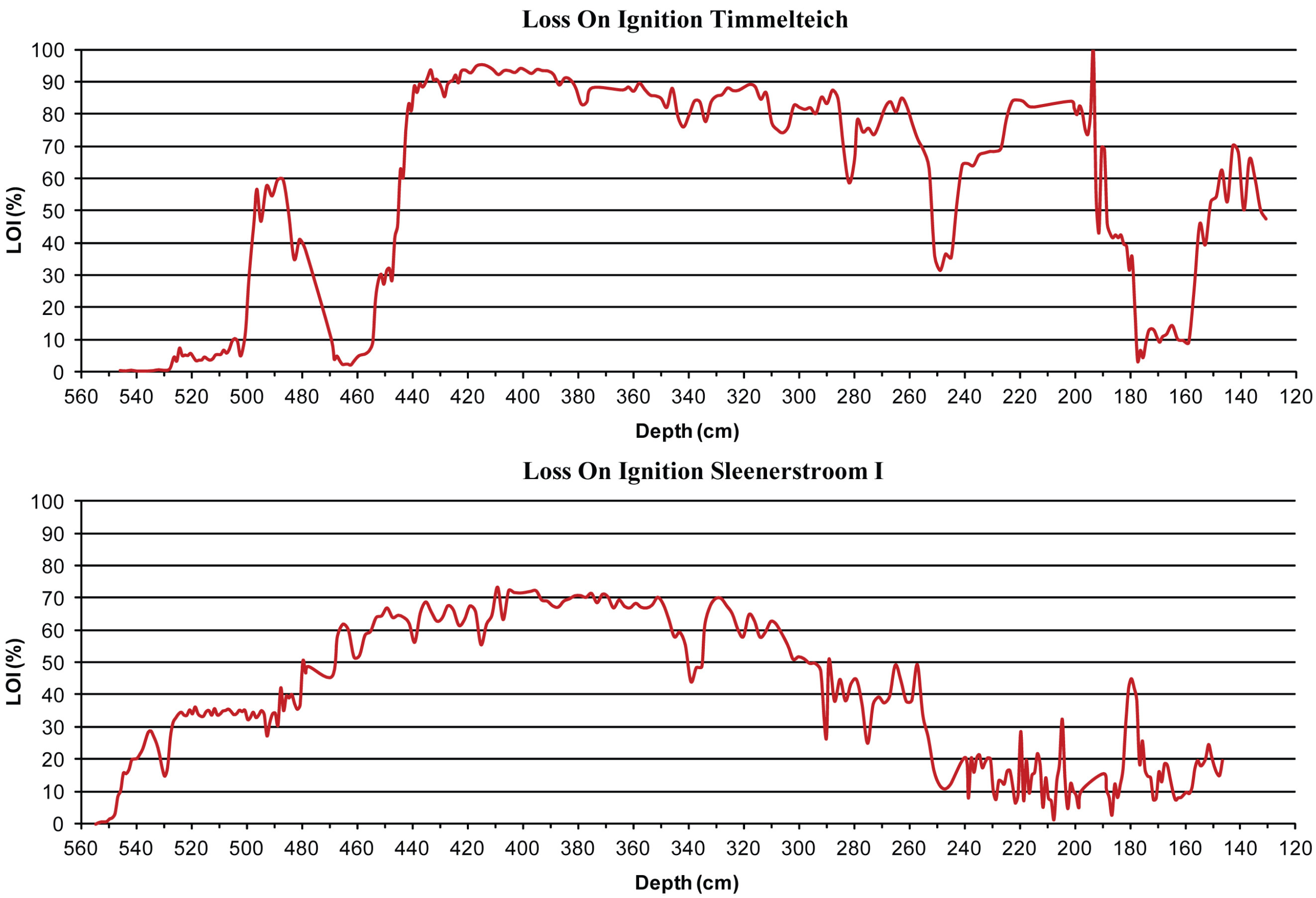

Figure 6.2: Complete Loss On Ignition profile of the Sleenerstroom I and Timmelteich pingo remnant depressions.

climate conditions (section 3.2). The small minimum in organic matter content at 502.5 cm depth coincides with a 0.5 cm thick sand layer that may be correlated to an event, but could also be deposited during the Earlier Dryas.

After the first interval a rapid increase in organic matter can be observed between 502.5 and 496.5 cm. The transition reflects a decrease in openness of the landscape. The following 10 cm (496.5 - 486.5 cm) show a high but variable organic matter content (47 - 60%). This fine-detrital gyttja has also been described as less sandy. It indicates a period of decreased aeolian sedimentation and possibly increased peat growth. Sediments of this interval have probably been deposited during the Allerød.

Consequently, LOI values decrease from 60 to 5% between 487 and 467 cm depth. The decreasing trend in this transition is interspersed with a small and short increase in organic matter around 460 cm of depth. LOI values from the second part of the decrease are not available, because of a hiatus is between 479 and 470 cm depth. Results from below and above the hiatus have been interpolated. The transition reflects a rapid change in the vegetation cover in the surroundings of the depression: vegetation opened up again, enabling aeolian sediment transport.

After the hiatus a third interval is recognised, consisting of 10 cm of sediment with a very low LOI content (469.5 - 455 cm depth). Aeolian activity must have experienced a maximum during deposition of this very sandy fine-detrital gyttja. The interval might be split in two phases: a first section between 469.5 and 461.5 cm with very low values of under 5%, and a second section up to a depth of 455 cm, in which LOI values are slightly higher. This difference may be due to either slightly decreased aeolian sedimentation, or increased organic deposition. Again, an open landscape and availability of sediments for aeolian transport is expected. This was the case during the Younger Dryas. Although the low LOI interval can be split in two sections, it is not clear whether these correspond to phases in the Younger Dryas, especially because data below 469.5 cm depth is lacking.

The interval of very low organic matter content is followed by a sharp increase to LOI values of almost 30%, which persist for 5 cm. Then the graph shows a very rapid increase to values of over 90%. A small setback in the curve is shown in a 5 cm thick interval around 430 cm of depth. After this, the LOI values remain rather constant at high values. The transition to values of over 90% of organic matter indicate a rapid closure of the vegetation and possibly increased rates of peat growth. This reflects the transition towards the Holocene. The plateau at about 450 cm depth may be due to either a break in vegetation development, or a change in local circumstances. The small minimum observed at 428.5 cm depth may be due to a small climatic setback resulting in increased aeolian sedimentation or local changes resulting in reduced organic production.

After the rise of organic matter content to over 90% it remains at high values up to a depth of 389 cm. Afterwards, several intervals show an increased organic matter content and an overall decreasing trend in LOI is observed (figure 6.2). The higher up in the core, the longer the intervals and the lower the organic matter content. These intervals of increased aeolian sedimentation do not correspond to large climatic shifts, as the deposits most likely are of Holocene age. Possibly, the intervals reflect episodes of human occupation, during which the vegetation cover is lower because of anthropogenic disturbance. This hypothesis should be tested by determining the timing of these intervals and correlation to known human occupation in the area. In this report, the topic will not be further discussed, as the focus is on the Late Glacial and early Holocene.

6.2.2 Emstekerfeld

For the Emstekerfeld depression, two cores were taken approximately 2 m apart to cover the transition between depression infill and the substrate. Although small variations in organic matter content occur, the cores show a very similar LOI profile and thus will be discussed simultaneously. The lithological descriptions in this text can also be found in section 5.4.4 and Appendix E2a.

The deepest 31 cm of the core (450 - 419) consists of the substrate of glacial till, which has an organic matter content of about 5%. The earliest infill (419 cm depth) has a similar low organic matter content, indicating that during and/or directly after pingo collapse, vegetation was open and aeolian activity was high.

Consequently, a rapid increase in organic matter content of approximately 80% is recorded within 15 cm of sediment, reflecting a fast closing of the vegetation cover. This probably corresponds to the transition towards the Allerød. There is strong variation in sandiness during this transition towards more organic rich material. If the transition towards more organic sediments because of increased vegetation cover occurs because of (rapid) climate change, a decrease in slope stability of the depression rampart may have lead to mass movements along the slope, for example through repeated freeze-thaw conditions (Kolstrup, 2007). The Emstekerfeld cores are taken relatively close to the edge of the depression, hence they are likely to be covered by rampart sediments. The strong maximum in sand content at around 407 cm depth is only reflected in one of the cores, indicating a very local event. However, the maxima in sand content cannot be related to observations of sand bands in the field or laboratory.

Above 398 cm depth, LOI values start to decrease to 20% at a depth of 390 cm, indicating increasing aeolian activity (and perhaps decreasing rates of peat growth). A small wiggle in the decrease in organic matter content shows around 395 cm depth. Such an incursion is also observed in the Timmelteich depression. A 25 cm thick interval (390-395 cm) of low organic matter content follows, indicating a period of strongly increased aeolian activity. Hence, during the time of deposition, landscape must have been relatively open. This section of the core is probably of Younger Dryas age. The interval can be split into a first phase with an organic matter content of 20%, and a second phase with an organic matter content of 5-15%. A similar interval was split up in the Timmelteich depression, although there the lower interval was sandier than the upper interval. The intervals may reflect different phases of the Younger Dryas.

A rapid increase in LOI values to over 60% occurs between 364.5 to at a depth of 358.5 cm, but does not continue to increase towards higher values yet. Vegetation (forest) density seems to recover. A rapid change which is also reflected as a sharp transition in lithology as was observed in the laboratory. Consequently, another sharp transition marks the decrease in LOI values to a minimum of under 45 at 354.5 cm at depth. This indicates a setback in vegetation development around this time, or a strong decrease in peat growth rate due to local factors. Another explanation may be increased inwash of inorganic material due to slope instability of the rampart. However, the latter should reflect in for example unexpected excursions in the pollen diagram, which have not been observed (see section 6.3.3). The increase in organic matter content resumes at a depth of 354.5 to values well over 80%. Vegetation development continues and the vegetation cover becomes more dense, prohibiting aeolian erosion and deposition. Perhaps this is accompanied by an increase in the rate of peat growth. The transitions towards higher LOI values mark the onset of the Holocene.

6.2.3 Sleenerstroom I

The substrate consists of a glacial till that does not contain any organic material. The Loss on Ignition profile of the depression infill can be divided in five intervals. The first interval shows an increase in LOI values from 0 to 30% between 447 and 435.5 cm depth. This is followed by the second interval, which consists of a 5 cm thick minimum in the organic matter content, where LOI falls back to a value of 15% and then recovers. An interval of rather constant LOI values of about 35% follows between 424.5 and 393.5 cm depth. The fourth interval consists of an increasing trend in organic matter contant, which is heavily overprinted by variations on scale of 5 cm. Above 457 cm, the Loss on Ignition profile remains fairly constant with variation around a value of 65%.

The LOI curve of the Sleenerstroom I depression is not as well interpretable as those of Timmelteich and Emstekerfeld. As the amplitude of fluctuation in LOI values is much smaller than in the previously described depressions, it is hard to distinguish whether they are due to local or regional factors.

If the Sleenerstroom I depression is a pingo remnant, the earliest infill is expected to be of Late Glacial age. Based on this, the core is expected to contain an interval reflecting the increased aeolian sedimentation that is known to have occurred during the Younger Dryas. The only (strong) minimum observed in Loss on Ignition is that between 535 and 525 cm depth. However, considering the increased aeolian sedimentation, a much thicker Younger Dryas interval would be expected. The LOI curve also does not reflect a strong transition from an interval dominated by aeolian sediments to an interval dominated by deposition of organic materials, which is expected for the onset of the Holocene. Part of these problems can probably be explained by problems that were encountered when the core was taken. Therefore, it shall not further be interpreted.

6.3 Pollen analysis

This section presents the pollen results and the zone boundaries that were assigned to the Timmelteich and Emstekerfeld cores, including an interpretation on vegetation development, and the pollen results of individual samples from other depressions. Firstly, a reference pollen diagram of the Uteringsveen pingo remnant in Drenthe is presented (section 6.3.1), to which Timmelteich and Emstekerfeld have been compared. The pollen results of Timmelteich and Emstekerfeld are presented in sections 6.3.2 and 6.3.3. This comparison has been used for the construction of a pollen based age model in section 6.4. Finally, the results of pollen quickscans on the deepest samples of organic matter in several other depressions are presented (section 6.3.4). An overview of the results of pollen analysis is presented in table 6.1.

Research area	Study site	LOI (%)	Pollen zone	Sample age
Friesland	Egypte	-	1c	Earlier Dryas
Drenthe	Sleenerstroom I	12.88	1b	Bølling
	Vlierendijk	3.36	0	Pleniglacial
Ost-Friesland	Timmelteich	section 6.2.1	1a/b	Bølling
	Brill	2.72 and 4.43	0 or 1a/b	Pleniglacial or Bølling
	Wrokmoor	1.74	0	Pleniglacial
	Mamburg	19.61	0	Pleniglacial
Cloppenburg/Visbek	Emstekerfeld	section 6.2.2	1a/b	Bølling
	Sevelte	40.61	2b	Allerød (*Pinus* phase)

Table 6.1: Overview of the laboratory results on the deepest infill. In the pollen zone column, the Pleniglacial is indicated by a 0.

6.3.1 Reference site Uteringsveen

The Uteringsveen pingo remnant 6.3 is an originally 5 m deep depression of approximately 350 m in diameter. The substrate in which it has formed consists of a unit of fine and coarse sands from the Eindhoven and Peelo Formation, covered with glacial tills from the Drenthe Formation. It has a ring wall of about 0.5 m high that partly consists of sandy till (Dutch: 'keizand'). The deepest part of the depression is filled with a gyttja layer of over 2 m thick, superposed by a 2 m thick peat layer (Cleveringa et al., 1977).

A detailed pollen diagram of the Uteringsveen pingo remnant can be found in Appendix F2. Pollen zones that have been defined are described in Appendix A, which provides a schematic overview of the main occurrences and changes in assemblage per zone for both the Uteringsveen II core and the generalised vegetation development in the Netherlands.

6.3.2 Pollen analysis Timmelteich

The pollen diagram of the Timmelteich site was constructed based on a set of 28 samples (Appendix F1). The complete diagram and a table with pollen results can be found in Appendices F3a and F4a. A simplified pollen

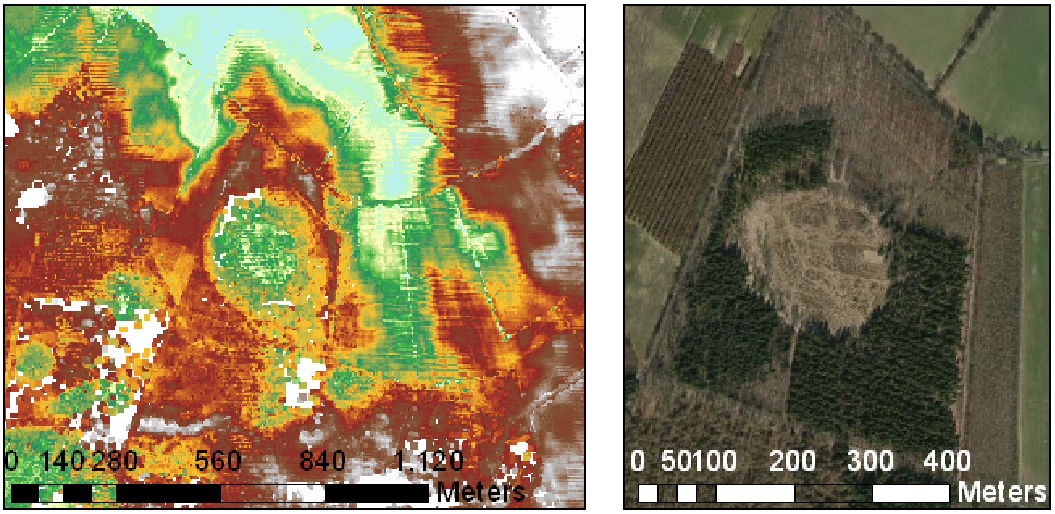

Figure 6.3: Digital elevation map and air photo of the Uteringsveen depression.

diagram is depicted in figure 6.5.

Pollen zone 1 is characterised by relatively low percentages of arboreal pollen. The landscape is very open and Gramineae are an important constituent of the vegetation. Vegetation consists of a lot of different species of herbs that occur in relatively high percentages. The lowest part of the core, between 525 and 507 cm depth, has been interpreted as pollen zone 1b, which is equivalent to the Bølling zone (van Geel et al., 1989). At the time of the Bølling interstadial, vegetation did not come in equilibrium with climate and still reflected that of a glacial period. Aeolian sedimentation in pollen zone 1b is therefore high. The interval deviates from zone 1c (507-495.5 cm), equivalent to the Earlier Dryas (van Geel et al., 1989), in the sense that in the latter, arboreal pollen decreased to a minimum and percentages of grasses increased to over 50%. In zone 1c, a peak in *Salix* pollen appears. The observations of a relatively open landscape during the Bølling correspond to the period of increased aeolian activity reflected by very low LOI values. The local signal in aquatic and riparian species in zone 1 shows that wet conditions prevailed: high percentage of algae (highest in zone 1b) and Cyperaceae (highest in zone 1c) occur. This succession may indicate that the water became less deep. This section of the core consists of a fine-detrital, very sandy gyttja that sometimes contains sand layers. The deepest sample in the Timmelteich pollen diagram should be neglected, as it was taken in very sandy material. This results in an overrepresentation of pollen grains that are relatively resistive to erosion, causing anomalously high values of the Gramineae and *Salix* pollen. During the Earlier Dryas, vegetation shifts towards that of a glacial period, resulting in slightly increased aeolian sedimentation.

The transition to pollen zone 2 is characterised by a strong increase in the amount of arboreal pollen. A small peak of *Salix* pollen is present at the transition, but in particular *Betula* strongly increases to over 70% of the pollen sum. At the transition, a small peak in *Juniperus* pollen is present. *Juniperus* is a species that is thought to form a shrub belt preceding the *Betula* immigration (Van der Hammen, 1951). Meanwhile, a decrease in the amount of upland herbs pollen is observed. This coincides with a decrease of species diversity in this group. It indicates

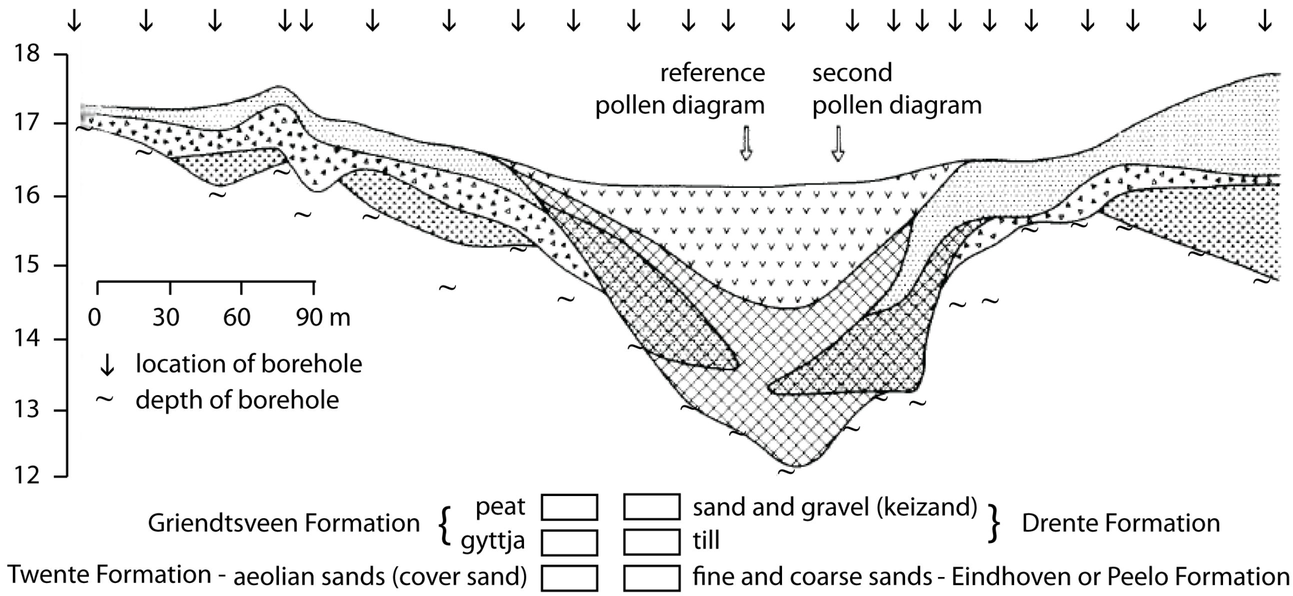

Figure 6.4: Lithological profile of the Uteringsveen pingo remnant (modified after Cleveringa et al., 1977.

forest expansion and closing of the vegetation cover during this period. The shift in vegetation demonstrates a climate transition; pollen zone 2 is equivalent to the Allerød (van Geel et al., 1989). Due to a more rapid vegetation response compared to the Bølling, aeolian sedimentation in this period ceased.

In the Uteringsveen II pollen diagram zone 2 can be split in zone 2a, *Betula* phase and zone 2b, the *Pinus* phase. However, a *Pinus* phase is lacking in the Timmelteich pollen diagram. An onset of increasing values is observed at 480 cm depth, followed by the hiatus between 479 and 470 cm depth. In the core description (section 6.1) a coring hiatus is mentioned: this part of the core falls exactly in between two samples taken with the piston corer. However, signs of soil formation have been found approximately this level in various other borings along the transect (see figure 5.14). Furthermore, a minimum of algae and riparian and aquatic pollen is present directly above and below the interval, indicating that relatively dry conditions prevailed. This may indicate a temporal dry-stand. A lake level low-stand and soil formation is described in the literature for north-western Germany (section 3.2). On the other hand, lithology directly above the interval is a fine-detrital, sandy gyttja indicating deep water conditions, and a hiatus in deposition is not required to explain the missing interval. It would be valuable to resample this particular interval to obtain a complete record. This is important in construction of the age model, especially because the interval might contain the Laachersee ash, which can be used as a chronological marker providing an absolute date.

The start of pollen zone 3, which is equivalent to the Younger Dryas (van Geel et al., 1989) has been identified based on the low percentage of *Pinus* pollen after the hiatus (in pollen zone 2b, a higher percentage of *Pinus* would be present). The interval covers the section between 469.5 and 455 cm depth. The amount of arboreal pollen decreases and an increase in herbs with respect to zone 2 (the Allerød) is observed. Combined with the low LOI values, this reflects an opening of the vegetation cover. The zone is split in two sections, of which the upper zone

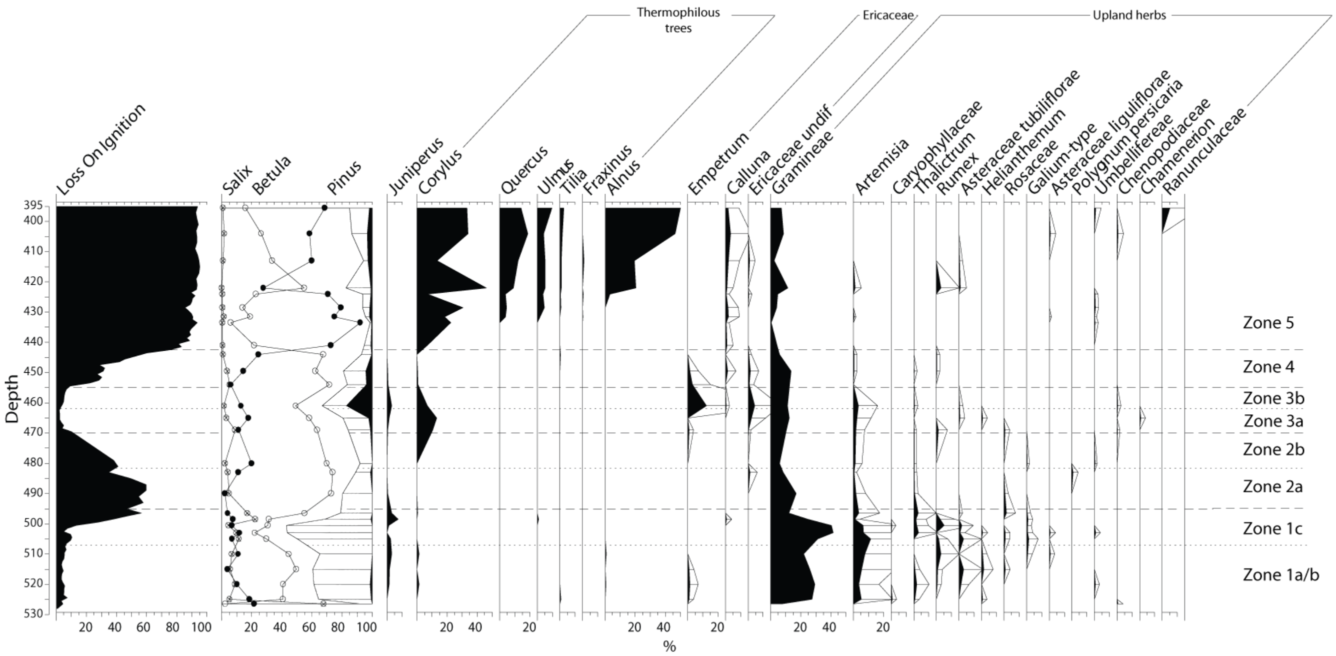

Figure 6.5: Simplified pollen diagram of Timmelteich.

3b is characterised by a peak in Ericales, particularly *Empetrum* pollen.

Despite an subtle increase in algae, which suggest that the depression held water in zone 3a, pollen of aquatic and riparian species are not very abundant in the Younger Dryas. Nevertheless, the lithology at this interval is a fine-detrital gyttja, implying relatively deep water conditions. Perhaps when the openness of the vegetation cover increases, less macro-remains may be available for deposition, resulting in the formation of a relatively fine-detrital gyttja even though water level is not very high. A low pollen production of aquatic and riparian species during cold climate conditions may also be a factor. However, this is all speculative.

The peak in the thermophilous *Corylus* pollen in zone 3 can be explained by an increase in (mineral) inwash (section 3.2; Walker et al., 1994). At the end of zone 3b, again, a *Juniperus* peak is observed in advance to an increase in percentage of *Betula*, that marks the onset of pollen zone 4, equivalent to the Preboreal (Behre, 1966) or the Late Preboreal van Geel et al. (1981).

In pollen zone 4 (455-442.5 cm depth), an increase in arboreal pollen is recognised, at the expense of upland herbs and Ericaceae. A decrease in *Corylus* pollen indicates that the inwash of reworked material ceased. A strong increase in riparian and aquatic pollen suggests a shift towards wetter conditions. Diversity and amount of pollen of herbal species decreases and vegetation cover becomes less open. Water level seems to decrease towards the end of the zone.

Pollen zone 5 (above 442.5 cm) is marked by a further increase in arboreal pollen, predominantly by a strong increase in *Pinus*. Thermophilous species successively migrate towards the area:*Corylus*, *Quercus*, *Ulmus*, *Tilia*, *Fraxinus* and *Alnus*. A *Pinus* forest developed and vegetation cover became very dense, which is reflected in high

LOI values. At a depth of 428.5 cm, a LOI minimum is present. This short increase in aeolian sedimentation occurred after the immigration of *Corylus* and *Quercus*, approximately simultaneously with the first appearance of (Berendsen, 2001b), this seems to correspond to the 8.2 event.

6.3.3 Pollen analysis Emstekerfeld

For the pollen analysis of the Emstekerfeld cores, a compiled Loss on Ignition diagram has been constructed (Appendix F1). Pollen samples were extracted from ESF I up until 370 cm depth. Above this, they originate from ESF II to extend the record of vegetation changes in this depression. A table of results and a complete pollen diagram can be found in Appendices F3b and F4b. The resolution of the Emstekerfeld pollen diagram is somewhat lower than that of the Timmelteich pollen diagram. Nevertheless, a clear trend in vegetation development can be recognized, because pollen samples were taken at depths of lithological (and thus environmental) change. Overall, the regional signal of the Emstekerfeld pollen diagram is very similar to that of Timmelteich, therefore, only striking differences and the local signal reflected by riparian and aquatic species shall be discussed here.

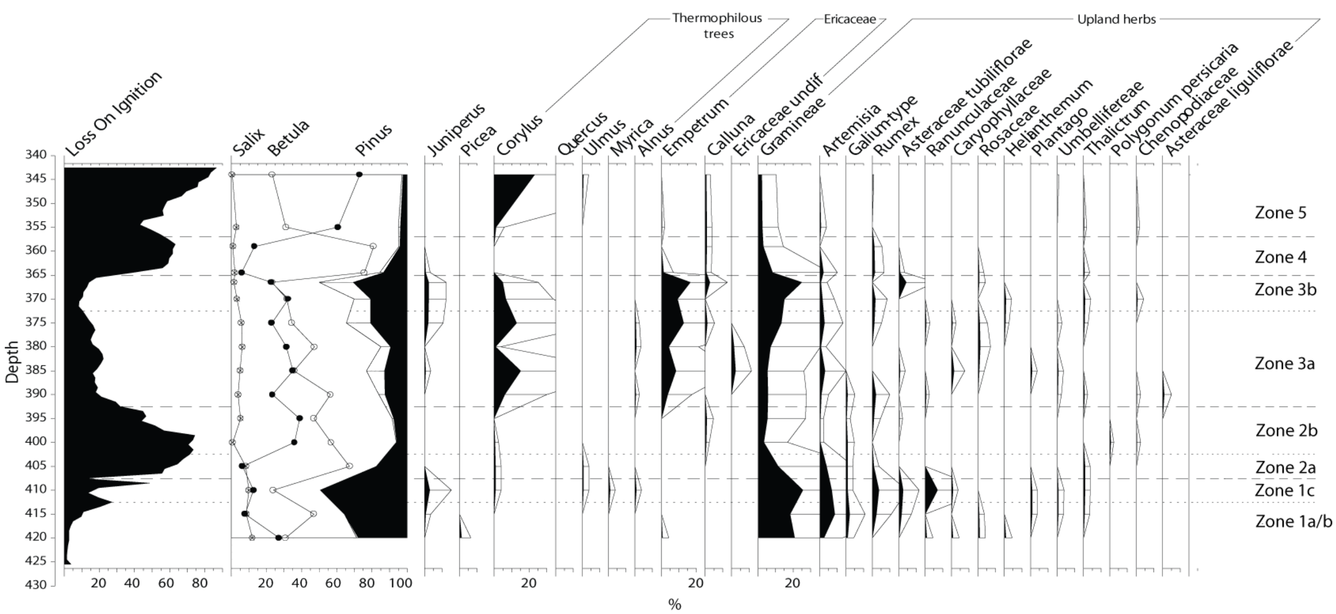

Figure 6.6: Simplified pollen diagram of Emstekerfeld.

Pollen zone 1 (below 407.5 cm depth) again reflects a high percentage of upland herbs and grasses, hence vegetation cover was relatively open during the time of deposition. The main arboreal species is *Betula*, although in the deepest sample *Pinus* is also very important. Various different type of herbs occur in small quantities. Abundant riparian species and algae indicate that the depression was wet at the time. Again, the zone can be split up in zone 1b (equivalent to the Bølling, van Geel et al., 1989) zone 1c (equivalent to the Earlier Dryas, van Geel et al., 1989), the latter of which is characterised by a more open landscape in which Gramineae are highly abundant.

A peak in *Juniperus* pollen is followed by a strong rise in *Betula* in the transition to zone 2 (equivalent to the

Allerød, van Geel et al., 1989), during which the vegetation cover was more dense. The increase in forest density led to a decrease in aeolian sedimentation. In this core, the both the *Betula* (zone 2a, 407.5 - 402.5 cm) and *Pinus* phase (zone 2b, 402.5 - 392.5 cm) of zone 2 can be recognised. Also, *Ulmus*, *Myrica* indicate that climate conditions were warmer. *Alnus* pollen are observed, but these may be reworked. There is a clear decrease in the amount and diversity of pollen from herbs and shrubs. The diagram does show a minimum in algae and riparian pollen. Although this indicates a relatively dry period, pollen of several aquatic species are still observed which means the depression still hosted water.

The pollen assemblage in pollen zone 3 (392.5-364.5 cm depth, equivalent to the Younger Dryas, van Geel et al., 1989) *Pinus* and *Betula* seem almost equally important. Reworked pollen from thermophilous trees occur in the samples, including reworked *Alnus* pollen. This is probably due to increased mineral inwash during the Younger Dryas (section 3.2). Zone 3 contains two *Corylus* peaks. In the sample at 375 cm depth, zero *Corylus* pollen were counted, and a minimum in *Betula* pollen is present. This is probably an error in the counting of this sample, where *Corylus* pollen have been counted as *Betula*. A similar situation occurs at 385 cm depth, at which *Pteridium* spores have been counted as trilete spores without further determination. Graminae, herbs and Ericacaea were an important constituent of the vegetation (approximately 15 - 50% of the pollen assemblage). Vegetation cover during the time of deposition was relatively open. In pollen zone 3b (387.5-364.5 cm depth), the *Empetrum* peak is even more pronounced than in the Timmelteich pollen diagram, representing over 10% of all pollen in multiple samples. Lithologically, the interval consists of a fine-detrital gyttja, indicating a relatively high water level that is also implied by the abundance of aquatic and riparian species and algae compared to zone 2.

In pollen zone 4 (364.5-356.5 cm depth, Preboreal zone Behre, 1966 or Early Preboreal and first part of the Late Preboreal van Geel et al., 1981), characterised by the renewed rise in *Betula*, the amount of aquatic and riparian pollen and algae decreases (as opposed to zone 4 in Timmelteich, where maxima are recorded) indicating a decrease in wetness. The openness of the vegetation cover decreases, as can be derived from the strong decrease in pollen percentage of herbs, Graminae and Ericacaea. In this period, water level had dropped, as all species indicating the presence of water strongly decrease.

At the onset of zone 5 (above 356.5 cm depth, first part of the Boreal zone Behre, 1966, or the latter part of the Late Preboreal zone van Geel et al., 1981) is marked by an increase in *Pinus* forests taking over the dominant role from *Betula*. Furthermore, *Corylus* starts to occur in the vegetation composition. The pollen diagram does not illustrate the successive immigration of other thermophilous species, which is due to the fact that the Emstekerfeld core compilation is shorter than that of Timmelteich and does not include this period.

6.3.4 Pollen quickscans: Egypte, Sleenerstroom I, Vlierendijk, Brill, Wrokmoor, Mamburg, Sevelte

A table containing the results of the pollen quick scans performed on the deepest infill of seven of the depressions can be found in Appendix F5. This section describes the results and provides an interpretation with respect to the age of the presumed pingo remnant depression.

Egypte

The deepest organic sample at the Egypte depression was taken at 270 cm below the surface. The predominant arboreal pollen type that was found is *Betula* (39.4%) while *Pinus* pollen is much less abundant (5.5%). A small percentage of the assemblage consists of *Juniperus* (3.7%). *Alnus* and *Corylus* have also been observed (4.6 and 2.8%, respectively) but these seem to be reworked. An important part of the pollen sample is made up of Gramineae (31.2%). There is a high amount of *Artemisia* pollen (15.6%); other herbs or shrubs represented in the assemblage are *Thalictrum* (1.8%) and *Galium*-type (1.8%). The depression clearly hosted water during deposition of the sampled material, as is demonstrated by the aquatic species *Myriophyllum alterniflorum* (4.6%) and *Sparganium* (1.8%). *Botryococcus* algae have not been observed, but *Pediastrum* is clearly present. The riparian Cyperaceae are also highly abundant (46.8%).

The high percentages of grasses and *Artemisia* indicate a rather open vegetation cover, which is often the case in cold climate conditions. The scan resembles the pollen assemblage of pollen zone 1c in the Uteringsveen pingo remnant. This is equivalent to the Earlier Dryas (van Geel et al., 1989). An quick scan of pollen samples higher up in the sequence was done (without counting) to verify this age. As the pollen samples have been taken approximately 0.5 m above the substrate, the deepest infill will be slightly older.

Sleenerstroom I

A pollen sample of the Sleenerstroom I depression was taken in boring 068 at 546 cm depth. The predominant pollen type is *Betula* (63.5%), where *Pinus* (2.7%) and *Salix* pollen (3.1%) seldomly occur. Gramineaea are an important constituent of the pollen assemblage (18.0%). Other pollen types that occur in the sample are *Artemisia* (5.5%), *Compositae tubiliflorae*, *Rumex*, *Thalictrum* and *Galium*-type, (1.6%) and a single pollen grain of *Rosaceae* was present. Of the riparian and aquatic species, Cyperaceae are very abundant (55.7%) and the aquatic species *Equisetum* (3.1%) and *Myriophyllum alterniflorum* (0.8%) are also present. Other evidence for the presence of water is the high abundance of both *Pediastrum* (149.5%) and *Botryococcus* (39.2%). LOI at the depth at which the sample was taken is 12.88%.

The very low concentration of *Pinus* pollen and high percentage of *Betula* pollen suggest that the sediment from which the pollen was extracted was deposited during the *Betula* phase of the Allerød (Zone 2a) or during the Bølling. Based on the abundance of Cyperaceae and *Artemisia*, the sample most probably can be assigned to Zone 1a/b, which is equivalent to the Bølling (van Geel et al., 1989).

Vlierendijk

A pollen sample of the Vlierendijk depression was taken in boring 074 at a depth of 465 cm at the base of the homogeneous organics. It has an LOI value of 3.36%. A relatively low amount of pollen from trees and shrubs was counted: 4.8% of pollen originates from *Betula*, and respectively 13.0 and 6.8% of *Pinus* and *Salix* pollen are present. Gramineae are very well represented (67.6%). *Corylus* pollen has been counted (1.9%) but is possibly reworked. Other species that have been observed are *Artemisia* (3.9%), *Galium*-type (1.9%), *Empetrum* and *Plantago* (1.0%) and the aquatic species *Typha latifolia* (1.0%). Riparian pollen has also been found: 45.5% of Cyperaceae and 1.9% of *Equisetum*, indicating that the depression hosted a lake. The presence of water is also indicated by extremely high amounts of *Pediastrum* and Botryococcus algae (423.2 and 83.1%, respectively) and a dinoflagellate (1.0%).

A very high percentage of grasses is associated with glacial conditions. However, it may also be due to the high resistance of the pollen grain in a reworked sample, resulting in a disturbed pollen diagram. The anomalously high percentage in the Vlierendijk pollen diagram suggests the latter. *Empetrum* is a species indicative for the Younger Dryas, although in the Uteringsveen pingo remnant percentages of 1% have also been observed prior and post this period (Cleveringa et al., 1977; Hoek, 1997). Relatively high percentages of *Artemisia* may indicate an older age of the samples, as this is not observed in the Uteringsveen pingo remnant.

Based on the pollen diagram, a Younger Dryas or Pleniglacial age is expected for this sample, although it is unclear whether the pollen assemblage is disturbed because of reworking of the sediment. Considering the age of known pingo remnants in the Netherlands, the deepest depression infill is likely of Pleniglacial age.

Brill

The pollen assemblage of two samples has been analysed. The first sample is taken at a depth of 291 cm and has an LOI content of 2.72%. The main constituents in this sample are 26.9% of *Pinus*, 34.4% of *Betula*, 5.4% of *Salix* and 17.2% of Gramineae pollen. Pollen of thermophilous trees have also been found: *Alnus* (20.4%), *Corylus* (12.9%), *Ulmus* and *Tilia* (2.2%). Cyperaceae were also abundant (33.3%). Part of the thermophilous pollen seems reworked, another part seems very well intact. Other species that are present are *Calluna* (4.3%) and *Empetrum* (1.1%), *Artemisia* (4.3%), *Chenopodiaceae* (2.2%), *Galium*-type (1.1%) and *Rumex* (3.2%).

The second sample with a LOI of 4.43% was taken at a depth of 288 cm. The pollen assemblage of this sample is as follows: *Betula* (8.5%), *Pinus* (36.2%), *Salix* (3.1%), *Gramineae* (42.3%), *Corylus* (2.3%) and *Alnus* (0.8%). Also, 1.5% of the pollen are derived from *Picea*. Pollen of *Artemisia* (1.5%), *Lysimachia* (0.8%), *Plantago* (1.5%), *Rosaceae* (0.8%) and *Rumex* (3.1%)

Both samples contain pollen of riparian and aquatic plants: Cyperaceae, *Equisetum* and *Myriophyllum alterniflorum* in both samples, and *Nuphar* and *Sparganium* in the sample at 291 cm depth. In the sample of 288 cm depth *Filipendula* pollen is present and a dinoflaggelate is observed. Both sample contain *Botryococcus* and *Pediastrum*. This indicates that the depression was filled with water of considerable depth during the time of deposition.

The deepest pollen sample was taken in loamy sand which was interpreted as the substrate section **??**, whereas the second pollen sample was taken in stiff sand of the infill. In the substrate, aquatic pollen are not expected. Therefore, either the lithology of the deepest sample has been misinterpreted or there has been contamination of the material either during sampling or by natural processes such as bioturbation. The low LOI value of both sample indicates that the samples are from a period of increased aeolian vegetation. The presence of *Picea* in the 291 cm sample indicates that the sample is very old, as *Picea* did not occur in this region in the Late-Glacial and beginning of the Holocene (Latalowa and van der Knaap, 2006). The thermophilous pollen that were found thus originate from a time prior to Zone 1, in the Pleniglacial. The second pollen sample also contains several thermophilous tree pollen, but these have a weathered look and are considered as secondary deposits. This sample also originates from the Pleniglacial or pollen zone 1.

Wrokmoor

A pollen quickscan of the deepest infill of the depression shows an extraordinarily high percentages of Gramineae (46%), 22.7% of *Pinus*, 11.8% of *Betula* and 12.7% of *Salix*. The thermophilous species *Corylus* (1.8%), *Tilia* (0.9%), *Alnus* (2.7%) and *Ulmus* are also present, although the latter two sometimes seem reworked. Species of shrubs and herbs that are present are *Compositae tubiliflorae*, *Thalictrum* and *Galium*-type pollen (1.8, 0.9 and 0.9%, respectively). The presence of water is indicated by an abundance of *Pediastrum* and *Botryococcus* algae and the riparian Cyperaceae (27.3%) and *Equisetum* (16.4%). The aquatic *Nympheae* is also represented in the pollen sample (1.8%). Loss on Ignition of the sample is 1.74%.

It seems that the high percentages of Gramineae and *Salix* could be due to the fact that the sample was very sandy, and these pollen stay preserved relatively well. The low LOI value of the sample suggests deposition during a cold phase, although thermophilous tree pollen is also present - these may be reworked. The absence of species typical to the Younger Dryas indicates that the depression is older than the Allerød. The pollen assemblage is roughly similar to that of Uterinsveen II in Zone 1, however, the dominance of *Pinus* over *Betula* is not present here. When consulting the generalised Late Glacial and Early Holocene pollen diagram for the Netherlands (Hoek, 1997) it seems that prior to zone 1, *Pinus* was the most important. Therefore, the Wrokmoor depression infill is thought to be of Pleniglacial age. During zone 1 (the Bølling and Earlier Dryas, van Geel et al., 1989) *Salix* and *Graminae* were also an important vegetation component.

Mamburg

The pollen sample of the Mamburg depression was taken at a depth of 208 cm in boring 124 has an LOI value of 19.61%. The dominant species in the pollen assemblage is *Pinus* (64.5%) with *Betula* being much less abundant (5.1%) and *Salix* attaining values of 4.3%. Of thermophilous tree species, *Corylus* is present in the sample (4.3%) and *Alnus* and *Abies* pollen have also been counted (5.8 and 0.7%, respectively). Part of the *Corylus* pollen seem reworked. A relatively high amount of Gramineae pollen (17.4%) is present. Other species that were encountered are *Artemisia* (4.3%) and *Compositae liguliflorae*, *Polygonum* and *Rumex* (0.7%). At the time of deposition, the depression clearly hosted water, as is indicated by the abundance of riparian species (Cyperaceae, 60.1%; *Equisetum*, 13.0%; *Filipendula*, 0.7%), aquatic species (*Myriophyllum alterniflorum*, 1.4%; *Typha latifolia*, 0.7%), algae (*Botryococcus*, 26.1%; *Pediastrum*, 20.3%) and even dinoflaggelates (2.2%).

This pollen assemblage is not very similar to vegetation composition reflected in the Uteringsveen pingo remnant, which does neither attain such low values of *Betula* nor such high values of *Pinus*, especially not in combination with a relatively high percentage of Graminae. The presence of thermophilous species indicate deposition during a warm stage, however, part of the *Corylus* pollen seem reworked. Usually if *Alnus* is not reworked, it is very abundant (personal communication W.Z. Hoek) whereas here, only a small amount of *Alnus* pollen was counted. High *Pinus* values do imply deposition during an Interstadial (or Interglacial). Since there seems to be no equivalent to this vegetation composition in Uteringsveen during the Late Glacial, it is possible that the depression infill was deposited in the Pleniglacial. This is supported by the presence of the grain of *Abies*, which is not known to have occurred here during the Late Glacial.

Sevelte

A pollen quickscan was performed on a sample at 482 cm depth in core 058, with an LOI of 40.61%. In this sample, 25.5% of *Pinus*, 57.6% of *Betula* and 3.0% of *Salix* pollen was counted. The Gramineae and Cyperaceae percentages are 9.6 and 4.4, respectively. Graminae constituted 9.6% of the pollen sum. The herbs that are recognised in the pollen sample are *Plantago* (0.7%) *Ranunculaceae* (0.7%) and *Umbellifereae* (0.7%) are also observed. Riparian species in the sample are Cyperaceae (4.4%), *Filipendula* (2.2%). A single grain (0.7%) of *Equisetum* is present.

The high organic content indicated by the high LOI value indicates that this pollen sample stems from a warm period. The amount of *Pinus* pollen is extraordinarily high compared to those in the Late Glacial in Uteringsveen, where *Betula* is still the dominant species even during the *Pinus* phase of the Allerød. The percentage of Gramineae pollen is comparable to that of Uteringsveenin pollen zone 2b and above, or minima in pollen zone 2a, and the relatively low percentage of riparian species also indicates an age younger than the Earlier Dryas (zone 1c). The high LOI value of the pollen sample (6.1) indicate deposition in an Interstadial or Holocene setting. All in all, the sample reflects a pollen composition most similar to that of pollen zone 2b in Uteringsveen, which is equivalent to the *Pinus* phase of the Allerød (van Geel et al., 1989). It should be noted that the substrate of the depression was not reached (section **??**), so the deepest infill must be older.

6.4 Age model

The pollen based age model for the Timmelteich depression has been constructed based on the established pollen zone boundaries (section 6.3.2), the ^{14}C date of macro-remains that forms the depressions first infill at 526.5 cm depth (dated to 12.470 ^{14}C yr or 14.650 cal yr BP) and the 8.2 event that was recognised in the Loss on Ignition graph. Verification of the 8.2 event in the LOI curve occurred through comparison to the pollen diagram: immigration of several species of thermophilous trees during the early Holocene matches that around the 8.2 event 6.3.2. For the Emstekerfeld depression, an age model could only be constructed for the section of the part between the uppermost and lowermost pollen zone boundary that is identified, as a higher zone boundary or other marker like the 8.2 event has not been recognised. Because less pollen samples have been counted, pollen transition zones could be located less precisely and larger and age has been interpolated over larger sections Therefore, this age model is less precise. The age models are presented in figure 6.7.

As can be seen in the pollen diagrams of Timmelteich and Emstekerfeld, vegetation response to climate change is very different for the Bølling and Allerød interstadial and the transition towards the Holocene. For the Bølling interstadial, or the GI-1e interstadial in the GISP-II ice core record, vegetation remained very open, reflected by upland herb pollen percentages of >30% in Uteringsveen II, Timmelteich and Emstekerfeld. For the generalised pollen diagram of the entire Netherlands 3.6 this percentage is even higher (>60%). The percentage of upland herbs (including grasses) increased further during the Earlier Dryas.

During the second warmer phase of the Lateglacial, the Allerød or the GI-1c interstadial in the ice core record, vegetation did respond to the warming climate much faster, perhaps because species had already partially migrated towards the research area during the previous interstadial.

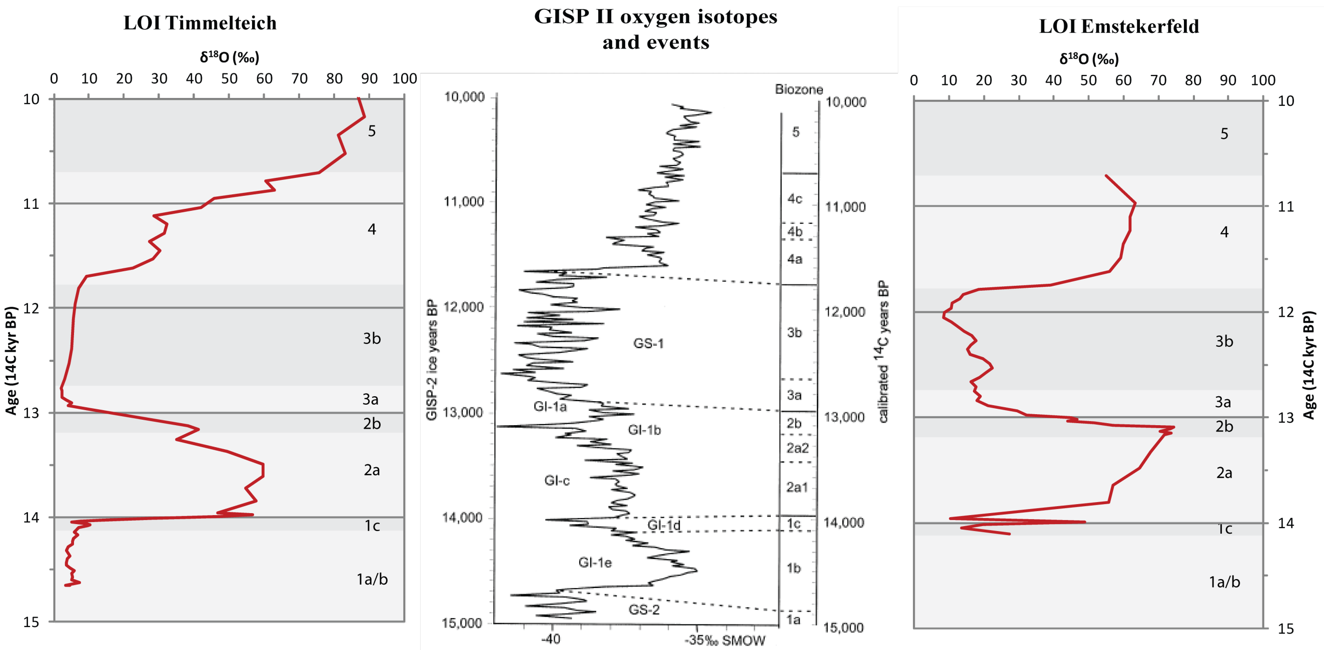

Figure 6.7: Compiled graph of GISP-II oxygen isotope record and event stratigraphy (centre) and pollen biozones after Hoek (2001) with LOI and pollen zones of Timmelteich (left) and Emstekerfeld (right).

A significant delay in vegetation development due to climate is not or hardly observed for the warming during the transition towards the Holocene. The Younger Dryas (GS-1) cold period is relatively short compared to the cold period in the Pleniglacial preceding the Bølling interstadial. Therefore, species would not have migrated as far to warmer climate zones. Possibly, prior to or during the Bølling interstadial, species may even have migrated behind a geographical barrier such as the Alps, that was not reached during the shorter Younger Dryas cold phase.

The main difference that appears from the age models of both depression is that in the LOI graph during the transition towards the Holocene. For the Timmelteich depression, a plateau in Loss on Ignition values is observed, while for the Emstekerfeld depression the transition is more abrupt. This is probably due to regional differences - the Timmelteich and Emstekerfeld pingo remnant depressions lie approximately 70 km apart.

Chapter 7. Discussion

7.1 Dimensions and geographic trends

Pingo remnant depressions in this study have a diameter ranging from 125 to 250 m and depth ranging from 2.6 to over 7.3 m (table 5.1). Because of absence of a clear pingo rampart, diameters are often an estimation based on the DEM or in the field. Depth is likely to be underestimated, as borings are not always done in the deepest part of the depression. Depressions that were visited in this study were subdivided in five different types (figure 7.1):

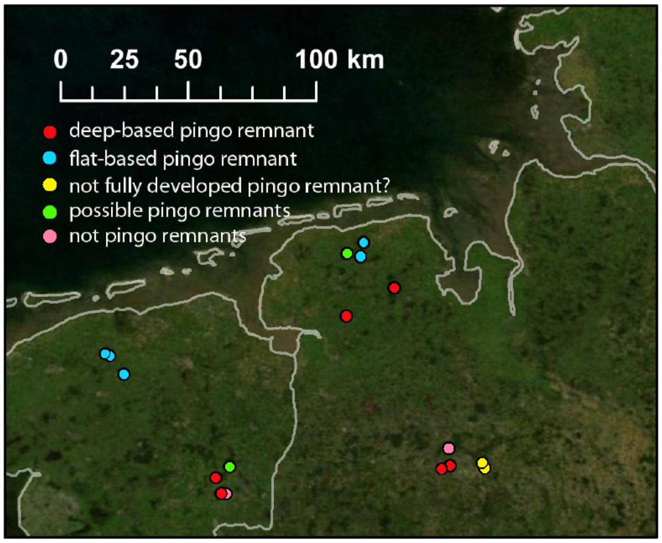

Figure 7.1: Locations of all investigated depressions that are subdivided into five types.

1. sites that are pingo remnants with a deep base: Vlierendijk (D, Netherlands), Sleenerstroom I (D, Netherlands), Timmelteich (OF, Germany), Wrokmoor (C/V, Germany), Emstekerfeld (C/V, Germany), Sevelte (C/V, Germany);

2. sites that are pingo remnants with a flat base: Egypte (F, Netherlands), Laarzenpad (F, Netherlands), Opende (F, Netherlands), Brill (OF, Germany), Mamburg (OF, Germany);

3. sites that may be pingo remnants that have not been fully developed: Rennplatz (C/V, Germany), Erlte (C/V, Germany);

4. sites that may be pingo remnants, but could not further be investigated: Lammeer (D, Netherlands), Westerschoo (C/V, Germany);

5. sites that are not pingo remnants: Keller-Höhe (C/V, Germany), Sleenerstroom II (D, Netherlands).

There seems to be no clear correlation to the type of pingo and its diameter, although the supposed underdeveloped pingo remnants have a diameter that is in the small end of the range. The largest pingo remnant depressions either have a deep base, or could not further be investigated. The deep pingo remnants have a diameter in the middle or upper end of the range and both sand depressions are in the higher end of diameters. The flat-based pingos generally have an intermediate diameter.

The different pingo remnant types are about equally spread among the four study areas. The only remarkable outcome is that all five flat-based pingo remnants that were found are located in the northern region of the research area. The depth of the flat-based pingo remnants in this study is approximately 3.0 m, which is shallow compared to the cone-shaped pingo remnant depressions. With three to five pingo remnants in each study area, sampling size is too small to draw firm conclusions on a geographical trend. However, out of 30 pingos that have been recognised by Kluiving et al. (2010) in the surroundings of Buitenpost, Friesland, thickness of infill in only four pingo remnants exceeded a depth of 3.4 m depth, which is the maximum thickness of infill of flat-based pingo remnants in this study. Therefore, the presence of flat-based pingos in the north seems significant. Although depth of a pingo remnant can be an indicator for permafrost thickness, thin permafrost is probably not the reason for these relatively shallow depressions, as the deepest depression found in the area has an infill of 7.6 m (Kluiving and Verbers). Perhaps the abundance of flat-based pingo remnants can be related to the substrate in which the depressions are formed. This is further discussed in section 7.2.

The thickness of the infill of a pingo remnant depression does not necessarily reflect the maximum depth of the ice core. The ice core can consist of every possible gradation from pure ice to icy sediment. Therefore, the depth of infill in pingo remnants is an approximation rather than a reflection of the actual depth of the former ice core (Mackay, 1979). It seems likely that icy sediment forms when the pingo is growing because of segregation rather than by water supply from a point source. These different types of growth may be reflected in the shape of the ice core and later on in the pingo remnant depression. The grouping of flat-based type pingos in Friesland and Ost-Friesland may be related to a different type of growth, which in turn could be due to other factors such as substrate and hydrological circumstances.

Except at the site of Keller-Höhe, all pingo remnants that were investigated consist of a circular depression in the landscape. Very little of these depressions showed signs of an (in situ) surrounding rampart. Height differences that were observed along the edges of the depression seemed to originate from incomplete filling of the remnant depression. Ramparts that were present (e.g. Egypte and Sevelte) are heavily disturbed by anthropogenic activities. Furthermore, ever since pingo collapse, formed ramparts will have been subject to both fluvial and aeolian erosion. For example, increased aeolian erosion at the time of formation of the Beuningen gravel bed (14.8 to 14.3 ka cal BP, Hoek and Bohncke, 2002) may have led to severe erosion. Depressions of Younger Dryas age which were not subject to this erosional phase often have maintained a rampart (de Gans, 1988). For this reason, the presence of a rampart should not be used as an important criterion in site selection when investigating pingo remnant depressions.

7.2 Pingo substrate and geographic variation

The substrate in which pingo remnants are found in the Netherlands and Germany is very similar, consisting of Saalien glacial tills (loamy sand, sandy loam) of the Drenthe Formation covered by Saalian and/or Weichselian coversands of the Boxtel Formation. In some of the pingo remnants, a glacial till has not been reached, though it is expected to be present deeper in the subsurface. Although the tills are present in all study sites, its characteristics are not necessarily uniform throughout the areas; thickness and composition of the till regionally varies. The substrate in this study is similar to that of other pingo remnants described in the literature, where pingo remnants are found in glacial tills (e.g. Kluiving et al., 2010; Bijlsma and de Lange, 1983; Paris et al., 1979), sands (e.g. Kluiving and Verbers; de Gans, 1982) and even clay (Kluiving and Verbers).

It should be noted that this result may be biased because of differences in preservation potential in different substrates. Hypothetically, if a pingo formed in for example clean (cover)sand with the permafrost acting as an impermeable layer, after thawing of the pingo ice the remnant depression may not remain intact as well as a pingo remnant in a glacial till would, as pure sand is probably less resistive against erosion than a till. Also, pingos in different substrate may lead to different shape of the remnant depression. A surrounding rampart composed predominantly of sand would be easier to erode and might also collapse. If a pingo forms in clay, compaction of clay may also lead to a different relief.

7.3 Pingo infill and geographic variation

The infill of our presumed pingo remnants has been investigated both in the field and in the laboratory. It was used to determine the timing of pingo collapse based on both lithology and pollen analysis. An integration of the results is summed up in table 7.1. It should be noted that the deposition of the earliest infill is a mere indication and does not necessarily coincide with the timing of pingo collapse. As mentioned in chapter 2, pingo collapse does not necessarily occur at once but can take place in multiple phases, which means a summit crater in which sediments are deposited can be present when the pingo is still active. When dating these sediments, the age of a pingo remnant may be overestimated. On the other hand, sediment deposition does not necessarily start during or immediately after pingo collapse. This can result in an underestimation of the timing of pingo collapse.

Almost all pingos in this study showed a sequence of infill demonstrating a long-term shallowing of the lake, i.e. a hydroseral succession. This decrease in water depth may be either caused by drier climate conditions or accumulation of sediment and organics at the bottom of the lake. The deepest material generally is a fine-detrital gyttja. In the case of the Timmelteich depression, a thin soil seems to be present in the top of this fine-detrital gyttja. The second lithological unit consists of a coarse-detrital gyttja that often contains sedge and sometimes other plant remains. In some cases these gyttjas have been described as sandy gyttja rather than fine or coarse detrital, due to their exceptionally high sand content.

In several pingos (Egypte, Laarzenpad, Sleenerstroom I), the top of the gyttja shows a gradual change in colour reflecting a period of soil formation. In others (Opende, Vlierendijk, Wrokmoor, Emstekerfeld, Sevelte), the coarse-detrital gyttja does not occur at all and is replaced or followed by an amorphous peat layer containing very little plant remains. This probably is a (coarse-detrital) gyttja layer that partly decayed when oxygen became available during a dry stand. Overall, it seems that a dramatic change in climate may have occurred resulting in regional soil formation. Considering the depth and lithology associated with the soil layer and comparing this to the thickness of Late Glacial infill in the Timmelteich and Emstekerfeld pingo remnants, the soil is probably not of Allerød age. Furthermore, the amorphous layers are relatively thick, so a long period of soil formation is expected. Therefore, these soils probably developed in the Holocene (section 3.2).

After the period of soil formation, lake level generally increased resulting in most cases in the formation of sedge peat or moss peat with often a very loose structure, and eventually wood peat. A similar succession is

Research area	Study site	Dimensions diameter/depth (m)	Pollen and lithology based (minimum) age	Pingo remnant?
Friesland	Egypte	170 / 3.4	Earlier Dryas	y
	Laarzenpad	150 / 2.6	pre-Younger Dryas	y
	Opende	125 / 4.0	Bølling	y
Drenthe	Sleenerstroom I	230 / 6.0	Bølling	y
	Lammeer	230 / ?	-	m
	Vlierendijk	170 / 7.3	Pleniglacial	y
	Sleenerstroom II	150 / 2.4	-	n
Ost-Friesland	Timmelteich	200 / 5.6	14.7 kyr BP	y
	Westerschoo	>200 / ?	-	m
	Brill	>80 / 3.4	Pleniglacial	y
	Wrokmoor	140 / 5.5	Pleniglacial	y
	Mamburg	130 / 2.9	Pleniglacial	y
Cloppenburg/ Visbek	Keller-Höhe	>130 / ?	-	n
	Rennplatz	100 / 2.4	-	m
	Erlte	140 / 0.9	-	m
	Emstekerfeld	170 / >6.6	Bølling	y
	Sevelte	150 / >4.9	Allerød, *Pinus* phase	y

Table 7.1: Overview of the field and lab results of all 17 depressions.

observed in the concentric vegetation circles at the surface of the Wrokmoor depression. It is striking that in several cases (Vlierendijk, Wrokmoor), the centre of the depression seems somewhat higher and dryer than the area around it.

There are three sites that deviate from the succession described above. The Timmelteich depression (section 5.3.1) is the only site where the deep coarse-detrital gyttja is covered by a fine-detrital gyttja before: here, a return towards wetter climate conditions probably occurred. The pingo remnants Vlierendijk and Emstekerfeld (sections 5.2.3 and 5.4.4) contain a layer of loam directly covering the substrate. It seems to be of aeolian origin. Characteristics of these loam layers are very different: whereas the Vlierendijk depression contains a loam layer of equal thickness throughout the depression, the layer at the site of Emstekerfeld is very asymmetric. This will be further discussed in section 7.5.

There also is a clear trend in sandiness of the infill through time. Changes in aeolian activity in the Late Glacial (section 3.2) are well-reflected in the Loss on Ignition curves of both Emstekerfeld and Timmelteich. Two phases of increased aeolian sedimentation are correlated to the period prior to the Allerød and to the Younger Dryas. These phases can also be recognised in the lithological descriptions of several other sites (Laarzenpad, Opende, Vlierendijk, Sevelte). The similarity of the LOI profiles of Emstekerfeld cores shows that Loss on Ignition can be reproducable.

The Loss on ignition pattern that is found in the Timmelteich and Emstekerfeld depressions, show similarities to LOI curves of other pingos of the same age in the Netherlands (e.g. Heiri et al., 2001; Davies et al., 2005; Nijhuis, 2006). The inorganic influx in pingo remnant depression thus is a regional. The Sleenerstroom I site forms an exception; the LOI profile is much less distinct and may be overprinted by a strong local signal.

7.4 Notes on pollen assemblages

In the construction of pollen diagrams in this study, cores was taken near the centre of the Timmelteich depression and from the south-eastern side of the Emstekerfeld depression. However, the pollen assemblage can be influenced by the exact location of the coring.

For the Uteringsveen pingo remnant, two separate pollen diagrams have been reconstructed by Cleveringa et al. (1977). Both pollen diagrams show slightly different pollen assemblages, demonstrating that the position of the core has implications on vegetation and/or climatological reconstruction based on pollen assemblages. Although both cores are expected to reflect the same vegetation development, there are some differences between their pollen diagrams. Cleveringa et al. (1977) summarise a few possible explanations:

- Not all plants are good pollen dispersers. *Salix* for example is an entomophile (Blamey and Grey-Wilson, 1989): pollen dispersal occurs by insects, whereas most other trees in the record are wind-pollinated. This leads to a relative under-representation in the centre of the depression.
- Some types of pollen, such as those of *Pinus*, can float on water for a period of time. These pollen may be driven to one side of the lake by wind, leading to a very low pollen concentration at the wind direction side, and a high pollen concentration at the opposite side.
- The vegetation along the banks of the depression may catch pollen from the air and thereby withhold some of the pollen from deposition along the shores.
- Pollen deposition in the lake is influenced by species proximity to the water.

Pollen composition may also be influenced by the size of the lake, even when the core is taken in the centre. For example, the third argument will have a relatively large influence in smaller lakes. For all these reasons, it seems best to extract a pollen diagram as close to the centre of the former lake as possible.

Due to the location of the cores that were taken, the Timmelteich and the Emstekerfeld pollen diagrams may be influenced by one or more of the above factors. Large deviations are not expected, as the pollen assemblages in both cores shows a very good correlation to the Uteringsveen pingo remnant. However, the samples from the other depressions that were used for pollen quickscans are more susceptible for errors, as a single slide does not provide an overall image and deviations may go unnoticed. This could lead to misinterpretation of sample age due to a skewed pollen assemblage.

The pollen samples that were taken in this study were mainly used for construction of an age model or to pinpoint a single age by a sample quickscan, hence, the resolution of the records is relatively low. The continuous record of the Emstekerfeld depression is a good candidate for high resolution vegetation reconstruction in north-western Germany during the Lateglacial. Timmelteich also is a good candidate, provided that the hiatus at the Allerød - Younger Dryas transition is only a coring hiatus.

7.5 Notes on aeolian influx

Inorganic deposits in pingo remnant depressions consist mainly of aeolian material, chemical precipitation and inward movement of material from the rampart. In this study, aeolian influx seems the main contributor to the inorganic fraction. Just like the pollen record, the aeolian influx is likely to vary within the depression. The distribution of aeolian material in a depression is dependent of the dominant wind direction, the shape of the depression and (riparian) vegetation. Less material may be deposited at the leeward side of a rampart and vegetation may capture aeolian sands preventing them to be deposited near the depression edges. The inorganic fraction along the depression edges is also influenced by inward transport from rampart material. Hence, the position of a core in the depression is of influence on the LOI record that is retrieved.

Two cores have been taken by Cleveringa et al. (1977) in the pingo remnant Uteringsveen. Both cores were taken relatively close to the centre of the depression. Although the overall LOI pattern is roughly the same, there are some differences in the peaks between both cores. Furthermore, the lithological profile of the Uteringsveen pingo remnant (figure 6.4) does show a higher content of inorganic sediments in the north-east. The effect of the location of the core would be larger if they were taken further apart.

In this study, the different rates of aeolian influx along a depression is best demonstrated in the Emstekerfeld depression (section 5.4.4). There, a thick layer of loam covers the substrate in the north-west, while the loam layer in the south-east is much thinner. In the centre of the depression, the loam is not found or not reached. The peat that fills the depression, however, contains more sand in the south-eastern part of the depression. Below follows an explanation based on aeolian material found in the Emstekerfeld depression, however, similar processes can explain asymmetrical deposition in other depressions. The described processes are illustrated in figure 7.2.

The sandier infill at the south-eastern part of the depression is likely due to the dominant wind direction during times of increased aeolian deposition. In the Late-Pleniglacial, the predominant wind direction indicated by proxy data is westerly to north-westerly. Model experiments suggest domination by south-westerly to west-northwesterly winds (Renssen et al., 2007). In the Younger Dryas, depositional winds came from the south-west to west (Isarin et al., 1997). The south-western part of the depression lies on the leeward side of the surrounding rampart (if present), hence aeolian sedimentation is reduced. In the north-west the rampart is at the luff side and sediments are being deposited. Furthermore, riparian vegetation will capture aeolian material at the side where the wind comes from.

The loam layer covering the substrate, however, shows an opposite distribution, where laminated loess deposits are thicker in the north-west. This may be explained by the presence of an seasonal ice cover. If sediments are deposited on top of the ice, most material at the windward site of the depression would be blown out before the ice cover melted. Sediments at the lee side of a rampart would be protected and remain inside. The thin layer of loam in the south-east consists of material that was not completely blown out of the depression, because it was blown up against the rampart at the south-eastern side. Melting of the ice results in deposition in of aeolian sediments laminae. After complete disappearance of the seasonal ice cover, aeolian sediments would be deposited on the other side, as is described above.

In lithological cross sections other than that of the Emstekerfeld pingo remnant, differences in sand content along the profile are less clear. Field descriptions indicate that in Friesland, depressions seemed to contain slightly more inorganic material along the northern side of the depression. This is not expected based on the dominant wind direction. Aeolian deposition is not always as strongly variable, as measurements on the Emstekerfeld cores show that Loss on Ignition can be reproducible.

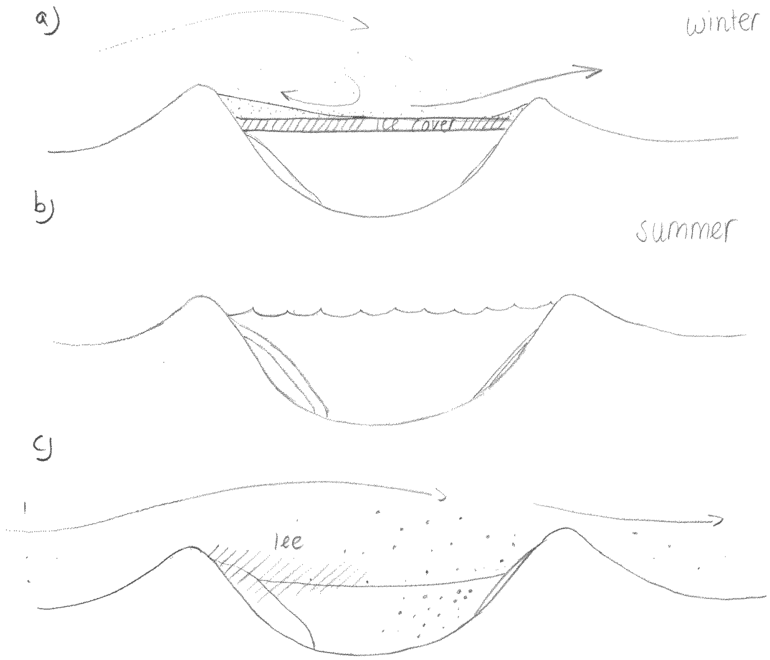

Figure 7.2: Schematic cross section of asymmetrical deposition of aeolian material.

The distribution of aeolian sediments along a depression is of importance when reconstructing climate based on an extracted core. It may be interesting to see whether this distribution is variable through time, as it may be a proxy for prevailing wind direction. Furthermore, climate reconstruction is often based on a single core. As results are influenced by the position of the core, it is important to select the location that is most representative and least influenced by local effects, such as the proximity of a protecting rampart. Therefore, the centre of the depression is the best place to obtain a core from. Sediment accumulation by mass movement or slope wash into the central part of the depression is the least likely in the centre of the depression (Kolstrup, 2007). To further investigate the distribution of inorganic sediments in a pingo remnant depression, multiple transects in different directions should be taken to evaluate the range of spatial differences. To minimize local effects, this should be done for multiple depressions.

7.6 Improvement of the age models

The primary goal of the age models in this study is to determine the age and possible temporal trends in the earliest infill of the depression. High resolution sampling is necessary to distinguish as many biozones as possible with good accuracy and construct a reliable age-depth model.

Although the Uteringsveen II pingo remnant that was used as a reference site is the most proximal high-resolution record in the surroundings, no ^{14}C datings have been performed on this core. Its age model is thus based on an average for the Netherlands. Nevertheless, the regional difference in immigration of new species is probably negligible, especially in the Emstekerfeld pingo remnant where resolution is low.

The age models could be further improved by adding the very precise ages of the Vedde ash and the Laachersee tephra. The Vedde ash is a widely dispersed volcanic ash (Lower et al., 2008) that originates from the eruption of Katla in southern Iceland (Jennings et al., 2000). The eruption has been dated to 12.1 kyr BP (Rasmussen et al., 2006) and ashes have been found extending from Ireland in the west to Saint-Petersburg in the east, and from Norway southward into and Switzerland (Lower et al., 2008). In the Netherlands, it has been found in the pingo remnant Kostverloren Veen in Drenthe Davies et al. (2005). The Laachersee tephra orginates from the eruption of the Laacher See volcano in the Eiffel, Germany, of 11.0 kyr BP (van de Bogaard and Schmincke, 1985). Laacher See Tephra is possibly also present in Kostverloren Veen (Davies et al., 2005).

If the Vedde Ash and Laacher See tephra are present, this provides valuable information for fine-tuning the age model. Unfortunately, for the Timmelteich depression the Laachersee tephra is expected at the depth of the hiatus that encompasses the *Pinus* phase of the Allerød and the transition from the Allerød to the Younger Dryas. In order to find the Laacher See Tephra, a new core should be taken in which this interval is recorded. The Allerød sediment of the Emstekerfeld core shows sign of soil formation around this interval.

To improve ages that are derived from pollen quickscans, samples should be taken at multiple lithological transitions, as was done for the Egypte site. This way, the interpreted age can be verified based on pollen composition higher up in the core without having to construct a complete age model. This can be required as a single pollen slide may leave multiple options on the samples age. A combination of pollen and lithology based age also overcomes part of this problem.

7.7 Pingo formation in the research area: hydraulic vs. hydrostatic

The type of permafrost and pingo formation in the Netherlands (and north-western Germany) is subject to debate. In order to contain ground water that is expelled in front of a freezing front in the formation of a hydrostatic pingo, a permeable substrate would be necessary. Although cover sands are permeable, for most pingos a glacial till has been found in the substrate. There are no indications of the presence of a former lake in the substrate directly surrounding the pingo remnants, whereas for hydrostatic pingos, a talik underneath a lake is required 2.1).

Usually, hydraulic pingos form in areas with elevation difference, where water is forced up through a weak spot because of a pressure gradient (section 2.2). In a glacial till, ground water may penetrate the weak spots in the substrate when ground water pressure is large enough. Hydraulic pingos can only form in a permeable substrate if there is an impermeable layer (e.g. permafrost or glacial till) forcing the water source up at a single point. Elevation differences in the study area are relatively small, hence, ground water pressure must be caused by another mechanism. According to a theory proposed by dr. W.Z. Hoek, the presence of a forebulge may have caused increased groundwater pressure in the study area (personal communication dr. W.Z. Hoek; Ruiter, 2012).

The majority of pingo remnants in this study (6 out of 11) has a deep, cone-shaped base. This may indicate where the water source was. Indicators for seepage have been found in several of the pingo remnants in this study. Precipitation of siderite has been observed in the depressions of Egypte (flat-based), Sleenerstroom I and maybe Timmelteich and Wrokmoor. Vivianite was found in Sleenerstroom I. Current seepage situations are indicated by the rusty iron rich water in the ditches at the Sleenerstroom I depression, and by an observation of a local of

Timmel, who saw water bubbling up during dredging activities in the Timmelteich depression. These phenomena point to a ground water source which may also have fed a pingo ice core during the time of pingo activity. The flat-based shape of pingo remnants in the north of the research area (figure 7.1) is thought to be caused by regional differences in the substrate influencing regional hydrology and pingo formation and shape.

7.8 Pingo collapse in the research area: mechanical vs. climatic failure

Pingo collapse can occur either because of mechanical failure or because climate circumstances are no longer suitable. While mechanical collapse can occur in stadial conditions, the onset of climatic collapse is only expected in a period of transition to a warmer climate. Therefore, the timing of pingo collapse is essential in determining its cause. The estimated timing of pingo collapse based on lithology and pollen analysis is shown in table 7.1.

The age of earliest infill in this study ranges from Pleniglacial and Bølling for most pingo remnants, to the second phase of the Allerød in the case of Sevelte. The latter, however, has been based on a sample that was not taken directly above the pingo substrate. Such a variable age of earliest infill is also found in other studies. Most pingo remnants have an earliest infill of Earliest Dryas/Bølling age (Hoek, 1997, table 7.3). The transition towards the Bølling is characterised with a warming climate, which is likely to induce or enhance pingo collapse. The most recent presumed pingo remnant depressions found in the literature are Scheemda A and Maartensdobbe 906, with an earliest infill dating to the Younger Dryas cold stage (Hoek, 1997) when discontinuous permafrost was present in the Netherlands (section 3.3). These depressions are relatively small for pingo remnants (personal communication dr W.Z. Hoek), though this can be expected from pingo remnants that collapsed before developing to their maximum size (section 2.3.2).

Depressions in which a Pleniglacial infill was found (Vlierendijk, Wrokmoor and Mamburg) must have started to collapse prior to climate warming, hence, they collapsed because of mechanical instability. For the other depressions of which the deepest infill was dated, there may be additional prove for collapse induced by climate change besides the age of the depressions infill. A review of a depressions dimensions and the type of material in the depression may throw new light on the reason for collapse of pingo remnants in the study area.

Possible indications for mechanical collapse (e.g. radial dilation cracks that change into ice wedges outside of the depression rampart) have not been observed in the field for any of the remnant depressions. However, the lithology of the depression may provide some indications for climate-induced collapse.

In periglacial conditions, the pingo skin is exposed to erosional processes. Material is radially transported downslope, forming a rampart. If a pingo collapsed due to changing climate conditions, less material of the pingo skin would be transported along the slopes to form a rampart. During thawing of the ice core, the covering pingo skin would sink back into the depression. This sunken back material should look like a layer of partially eroded or weathered substrate. The process is illustrated in figure 7.3. Because the pingo remnant would not have attained its potential size, it may have a smaller diameter or depth than usual. It seems this process might have taken place at the Erlte depression (section 5.4.3). However, the deepest infill of this depression has not been dated. The same accounts for the Rennplatz depression. Both depressions are in the small end of the range of pingo dimensions in this study. To understand the nature of these possibly underdeveloped pingo remnant depressions, a transect and date of the deepest infill is required.

It is evident that pingo remnants occurred in the Netherlands and Germany during the Middle and Late Weichselian. Not all of these pingo remnants will have collapsed synchronously. Some will have become unstable and collapsed mechanically prior to climate warming. These pingos have a Pleniglacial infill. The warming during the Late Glacial, however, put an end to existence of all other pingo remnants in the region that were still active.

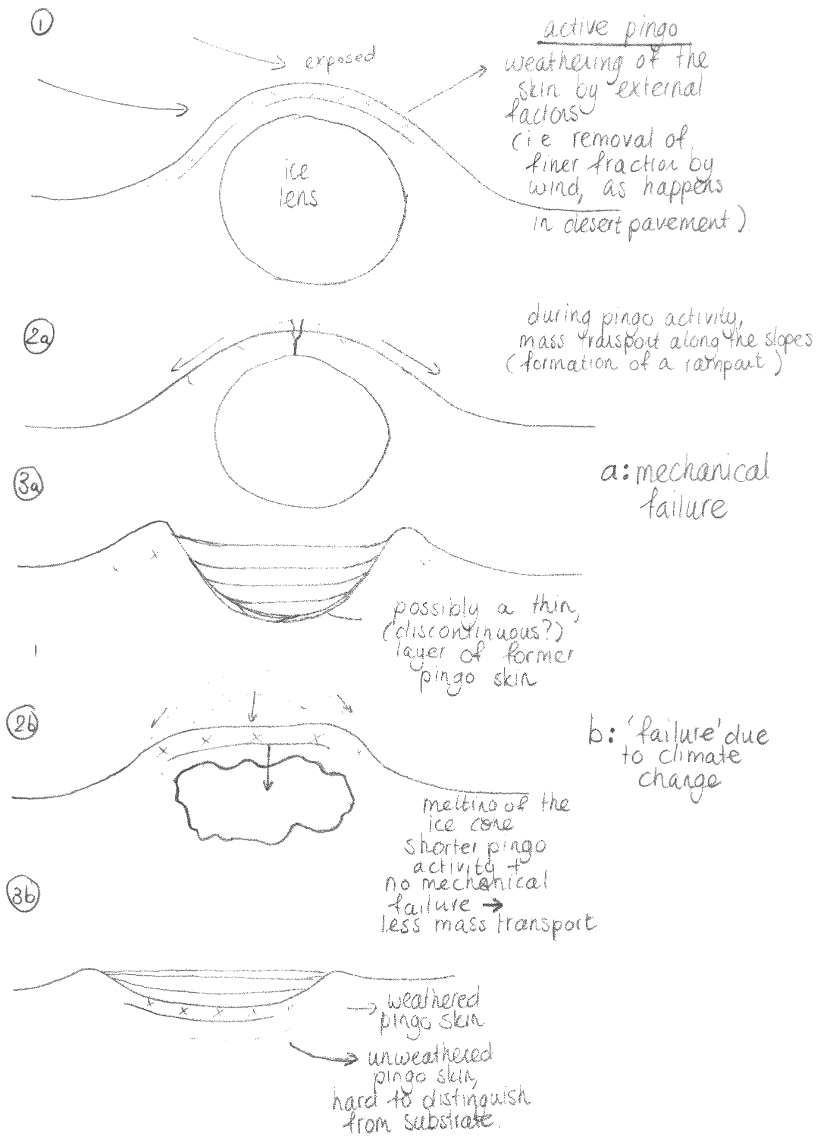

Figure 7.3: Pingo collapse because of climate warming.

Chapter 8. Conclusion

Are pingo remnants in north-western Germany similar to those in the Netherlands in terms of dimensions, infill and substrate, and which geographic and temporal trends can be recognised? Overall, pingo remnants in the northern Netherlands and north-western Germany are very similar. There are spatial differences in terms of dimensions of the pingo remnants, however, these are differences between the north and south rather than west and east. They are likely to be caused by differences in the substrate in which the pingos have formed. Regional differences in pingo infill have not been recognised. Answers to the subquestions below provide more detailed information on the results obtained in this study.

- *Are pingo remnants in Germany of similar dimensions as those in the Netherlands?*

  Yes. In this study, three different types of pingo remnants have been distinguished in the Netherlands: (1) flat-based pingo remnants, (2) cone-shaped pingo remnants and (3) depressions that may be pingo remnants but could not be further investigated, because with the methods used presumed infill could not be distinguished from the substrate. In Germany, an additional category of possibly underdeveloped pingo remnant depressions has been distinguished. All pingo remnants in Germany and the Netherlands range in diameter from 125 to 200 m, with no significant deviation in a certain study area. However, this cannot be regarded as a true result, as depression diameter was a criterion for site selection. Depth is strongly variable, ranging from 2.6 to over 7.3 m in all depressions that are considered as pingo remnants.

- *When were active pingos present in the study areas and when did they collapse?*

  Periglacial climate conditions and permafrost are required to maintain the inner ice core of a pingo. In the study area such conditions prevailed in the Middle and Late Weichselian. The latest indicators for permafrost date from the Younger Dryas. The earliest infill of pingo remnants provides a minimum age for the onset of pingo collapse. In this study, it most often dates to the Pleniglacial or Bølling. Results of ^{14}C-dating of the former skin of the Timmelteich pingo remnant provided an age of 14.650 cal kyr BP. Younger dates obtained in this study are based on samples that were not taken directly above the substrate. It should be noted that there may be a lag between initiation of collapse and deposition of the earliest organic infill. It cannot be stated that the youngest pingo remnant in the area was found due to the small sampling size.

  The range in dates suggests that pingo collapse did not occur isochronously. Pingos with a Pleniglacial infill must have collapsed because of mechanical instability as climate still allowed the presence of ice (cores) in the subsurface. However, many pingos have an infill dating to the Bølling. Probably, these pingos collapsed because of climate changing to interstadial conditions, which were no longer suitable for the persistence of a pingos inner ice core. In the Cloppenburg/Visbek area, two sites have been studied that are depressions that may be underdeveloped pingo remnants, originating from pingos of which the ice core melted before the hills reached their full potential size. The deepest infill at these sites has not been dated.

- *What were palaeogeographical and climatological conditions during pingo decay?*

Because pingo collapse in the study area was not synchronous, formation and decay cannot be attributed to similar climate conditions for all depressions. Mechanical collapse can occur in cold climate conditions, whereas collapse induced by climate change occurs during a transition towards warmer climate conditions.

Late Glacial climate recorded in the pingo remnant depressions indicate a relatively open vegetation cover and increased aeolian sedimentation in cold stage conditions. The Pleniglacial is not recorded in the cores that were analysed in the lab. Towards the Bølling, climate shifted to warmer conditions, yet the vegetation cover remained relatively open and aeolian sedimentation continued. The Bølling is followed by the Earlier Dryas cold stage which is characterised by an increase in openness of the vegetation cover. The transition towards the warmer Allerød is characterised by a decrease in the diversity of herbs and development of a denser forest of *Betula* and subsequently *Pinus*. Due to a more dense vegetation cover, the aeolian activity ceased. Several depressions show signs of soil formation. Cold climate conditions returned at the onset of the Younger Dryas, with reduced vegetation cover resulting in increased aeolian sedimentation. At the onset of the Holocene, a *Betula* and consequently *Pinus* forest developed. This is followed by the immigration of thermophilous trees. Vegetation development led to a decrease in aeolian sedimentation and at many locations, soil formation occurred. Observations are consistent with the pre-existing literature.

- *Is there a geographical trend in shape and/or infill of the pingo remnants?*

  Out of 17 depressions, the five flat-based depressions are all lie in the northernmost study areas, whereas all six cone-shaped depressions lie further towards the south. This trend also accounts for the majority of pingo remnants described in the literature. The cone-shape of several depressions and observations of seepage and chemical precipitation suggest that the depressions are hydraulic or open-system pingo remnants.

  In most cases, infill of the pingo remnant consists of gyttja and peat, with a variable sand content. For two depressions a potential infill could not be distinguished from the surrounding substrate, as both consisted of sand. These depressions each lie in a different study area, hence there is no clear geographical trend.

- *Is there a temporal trend in the infill of the pingo remnants?*

  Of all depressions investigated, two contained an infill of clean sand. All others depressions contain an organic infill of a hydroseral succession, from fine-detrital gyttja and coarse-detrital gyttja to sedge, moss and wood peat. This reflects long-term decrease in water depth, partially due to changing climate conditions, and partially to filling of the depression with peat. The Timmelteich pingo remnant is the only depression in which the succession of fine-detrital and coarse-detrital gyttja occurs twice.

  Indicators of soil formation during the Allerød were found in the Timmelteich and Emstekerfeld pingo remnants. Soil layers have also been found in 7 out of 13 other pingo remnants. Although these have not been dated, most of them seem to correspond to the transition of the Lateglacial into the Holocene. Temporal trends in the deepest section of the pollen diagram of Timmelteich and Emstekerfeld strongly co-vary. The deviating Sleenerstroom I depression demonstrates that the infill of a pingo remnant can also be heavily overprinted by a local signal (e.g. geology, hydrology or vegetation).

- *Can such trends be related to lithology of the surrounding substrate or climate?*

  In all cases in this study, pingo remnant depressions are situated in a glacial till and/or cover sand; the Drenthe and Boxtel Formation in the lithostratigraphy of the Netherlands. Glacial till is of Saalian age, and coversand may be of either Saalian or Weichselian age. Hence, there is little spatial variability between type of substrates in the study area. However, there may be regional differences in characteristics of the material, such as sandiness and thickness of the formations. These may have resulted in the deviant shape of many pingos in the northern study areas. Differences between the substrates in the four study areas should be evaluated in more detail.

  The two depressions that contained a (presumed) infill of solely sand both lie in a very sandy substrate. Possibly, peat did not form in these depressions because ground water level after pingo collapse became too low for the depression to host water, hence, it got filled by aeolian sediments. The low ground water level can be related to the substrate of the depression: permeability of a sandy substrate is much higher than that of a glacial till. Perhaps at the localities of these depressions, the glacial till is absent and permafrost acted as the impermeable layer during pingo formation, or the glacial till lies deeper in the subsurface.

  Temporal variability in the sandiness of the organic infill of the depressions are likely to be due to changing availability of the surrounding substrate for erosion and aeolian transport. The availability is largely controlled by climate conditions, which influence the openness of the vegetation cover.

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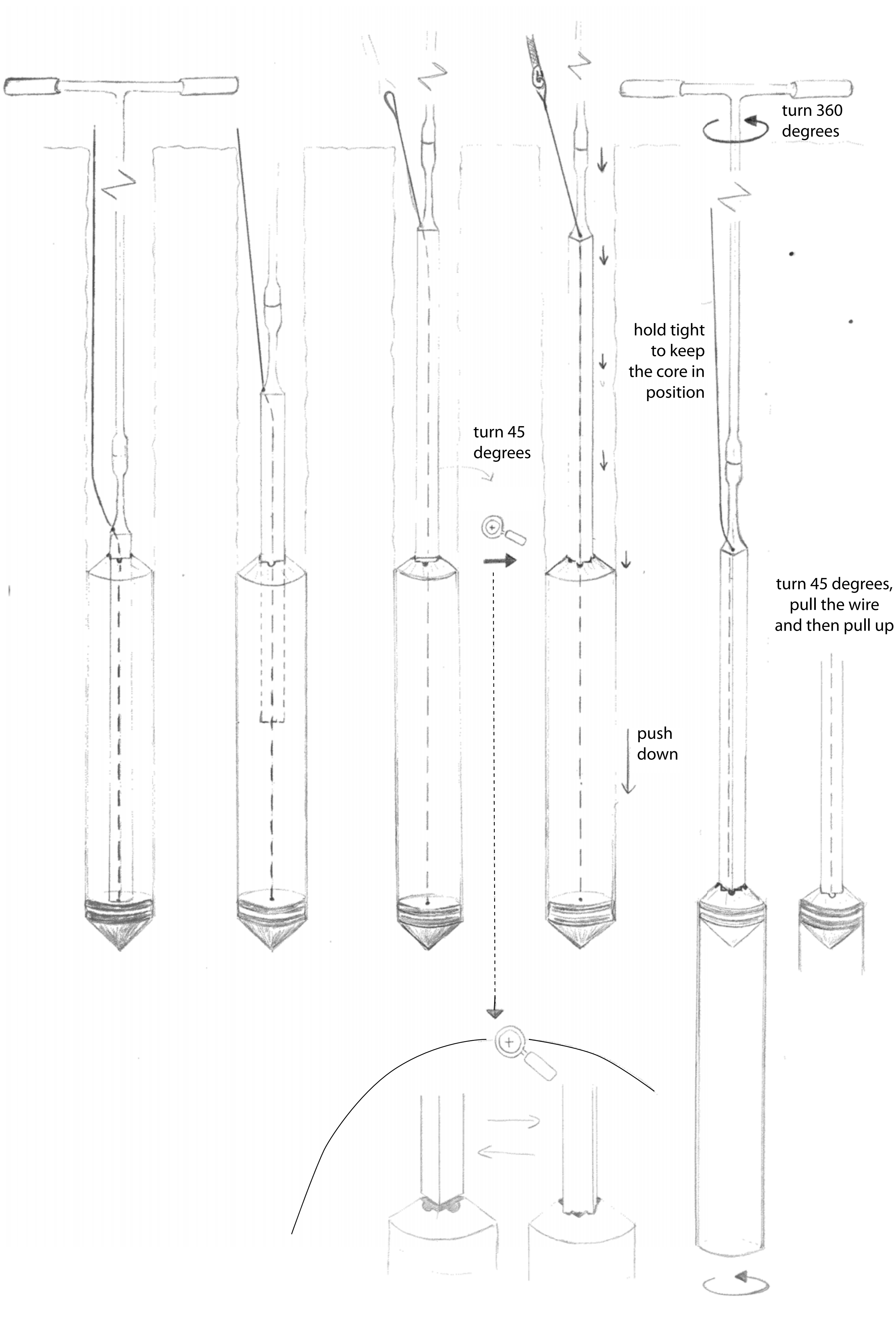
Appendix A. Schematic overview of the pollen zone boundaries

Zone boundaries according to Hoek (1997) have been calibrated to calender years by Hoek & Bohncke (2001) by the method of Stuiver et al. (2008).

Zone	Subzone	14C age (kyr top)	cal age (kyr top)	Description (sub) zone Uteringsveen II (Cleveringa et al., 1997)	Description (sub)zone the Netherlands (Hoek, 1997)
Zone 5				Pollen percentages of Graminae and Cyperaceae are decreasin and those of deciduous trees are increasing. (b) *Corylus* increases to 30%. *Pinus and Betula* are represented by percentages averaging 30%. A continuous curve of *Ulmus* is present. (a) Curve of *Corylus* varies between 0-15%. A few grains of *Quercus* and *Ulmus* are present. *Pinus* is increasing.	*Pinus* forests expanded again, became more dense as a result of rise in temperature. Equivalent to the first part of the Boreal zone (Behre, 1966), or the latter part of the Late Preboreal zone (Van Geel et al., 1981).
Zone 4		9.5	10.71	Tree pollen percentage has increased. First appearance of *Corylus, Ulmus, Fraxinus, Tilia* and *Populus. Empetrum* attains lower percentages than in the preceding zone. Pollen of riparian and aquatic plants become more frequent, as does *Botryococcus*.	*Betula* forests expanded again, marking the onset of the Holocene. Equivalent to the Preboreal zone (Behre, 1966) or Early Preboreal and first part of the Late Preboreal (Van Geel et al., 1981).
	4c	9.5	10.71	*Betula* has maximum and Cyperaceae and *Empetrum* have minima.	*Betula* forests expanded again, *Populus* relatively important constituent of the vegetation.
	4b	9.75	11.175	Cyperaceae and *Empetrum* have maxima.	Vegetation more open, higher values of *Graminae*. Equivalent to the Rammelbeek phase (Van der Hammen, 1971; Van Geel et al., 1981).
	4a	9.95	11.3	*Betula* at a maximum and Cyperaceae and *Empetrum* at minimum.	Characterised by higher values of *Betula* and *Juniperus.* Equivalent to the Friesland oscillation (Behre, 1966) or phase (Van Geel et al., 1981).
Zone 3		10.15	11.745	Percentage of herbs has increased, while percentages of *Pinus* and *Betula* have decreased. Continuous curves of Ericales (predominantly *Empetrum*), *Seliganella* and *Sphagnum* are present. *Myriophyllum* and *Isoethes* dissappear.	Development to a more dense vegetation cover was interrupted. *Pinus* and *Betula* woods diminish in size, herbaceous plant communities developed. Equivalent to the Late Dryas (defined by Van Geel et al., 1989)
	3b	10.15	11.745	Slightly higher *Pinus* and somewhat lower *Betula* percentages.	Ericales, especially *Empetrum nigrum* developed in the (northern) Netherlands
	3a	10.55	12.75	*Pinus* has percentages around 10% and *Betula* around 50%.	
Zone 2		10.95	12.98	*Betula* is dominant. Most herbs have lower percentages than in zone 1. Marsh and water plants and open/habitat plants are less frequent than in preceding zones.	Rather open *Pinus* and *Betula* forests. Equivalent to Allerød zone (Van Geel et al., 1989)
	2b	10.95	12.98	*Pinus* has becomne more important with average percentages of 25%, while *Betula* percentage has decreased. Percentage of Graminae and Cyperaceae are rather constant. *Isoethes* is an important constituent of the vegetation.	*Pinus* phase
	2a	11.25	13.165	(ii) Herbs are represeented by low, and *Betula* by very high percentages. *Salix* attains percentages of up to 10% in the lower parts. Riparian, aquatic and open-habitat plants characteristic of zone 1 have decreased in number. (i) Betula is rapidly rising, whereas most herbs are decreasing. Most aquatic plants and open-habitat plants of zone 1 are still present.	*Betula* phase
Zone 1		11.9	13.96	Lower percentages of Cyperaceae than in preceding zones. *Betula, Salix, Juniperus* and *Pediastrum* attain higher percentages. New arrivals are *Artemisia, Thalictrum, Selaginella* and *Equisetum.*	Herbaceous plant communities and dwarf shrubs developed as a result of temperature rise. First immigrants arrived from the south (e.g. *Hippopae, Juniperus*)
	1c	11.9	13.96	Cyperaceae attain higher percentages, whereas those of *Betula* are lower than in the preceding subzone. *Artemisia, Thalictrum* and *Equisetum* become less frequent.	More open vegetation type, higher values of *Salix.* Equivalent to the Earlier Dryas zone as defined by Van Geel et al., 1989.
	1a/b	12.1	14.1	The onset of this zone is marked by an increase in amount of many pollen types. *Betula* pollen percentages are fairly high, while those of *Salix* and *Pinus* are low.	*Betula* expanded. Equivalent to the Bølling zone as defined by Van Geel et al., 1989.

Appendix B. Schematic drawing Bohncke corer



Appendix C. Protocol pollen preparation

Utrecht University
Department of Physical Geography

Werkvoorschrift pollenpreparatie FG-UU

In met name stap 2 worden sterke zuren gebruikt, raadpleeg vooraf de factsheets over de te gebruiken chemicaliën. Raadpleeg bij onzekerheid altijd Wim Hoek.

1. Ontkalken en uitlogen

- Ca. 0.3 cm^3 materiaal in 15 ml centrifugebuis, aanvullen met aqua dest. tegen oxidatie
- Bij kalkhoudend materiaal: uitzuren met 5% azijnzuur, daarna 2 maal uitwassen met aqua dest. om zuur te verwijderen (aanvullen, centrifugeren 1 min. bij 2000 r.p.m. en decanteren)
- (eventueel Lycopodium toevoegen, t.b.v. absolute pollendiagrammen) 5 ml KOH 5% toevoegen om humusverbindingen te verwijderen
- 60 minuten verwarmen bij stoof 70 graden Celcius
- zeven over 200 mu direct in 15 ml centrifugebuis
- 2 maal uitwassen met aqua dest. om KOH te verwijderen

2. Acetolyse (uit te voeren door gekwalificeerd medewerker)
NB zuren altijd afgieten in speciaal zuurvat

- 2 maal uitwassen met ijsazijn om water te verwijderen (aanvullen tot 5ml)
- acetolyse mengsel: 9 delen azijnzuuranhydride + 1 deel H_2SO_4 (bij 40 samples is dit 180 ml + 20ml)
- ca 4 ml acetolyse mengsel toevoegen en mengen. 5-10 min verwarmen bij 100 graden Celcius in warmtebad. Tussendoor (na het bereiken met 100 graden) eenmaal vortexen
- centrifugeren, acetolyse mengsel afgieten
- tweemaal uitzuren met aqua dest. om zuur te verwijderen

3. Zware vloeistofscheiding
NB resten zware vloeistof altijd afgieten in plastic wasfles voor zware vloeistof

- 4 ml zware vloeistof (natrium-polywolframaat met d = 2.0) toevoegen. vortexen om goed te mengen
- 15 minuten bij 2000 r.p.m. centrifugeren om te scheiden op soortelijk gewicht
- kraag decanteren in conische centrifugebuis. aanvullen met awua dest. tot 10 ml. goed mengen en 5 minuten uitcentrifugeren bij 200 r.p.m., restant zware vloeistof decanteren.
- herhalen: rest van de kraag afgieten in de conische buis. aanvullen met aqua dest. tot 10 ml. Goed mengen en 5 min. uitcentrifugeren bij 2000 r.p.m., restant zware vloeistof decanteren.
- tweemaal wassen met aqua dest.

4. Afwerken

- hierna 2 à driemaal uitwassen met water na 1min bij 3000 r.p.m.
- 1.5 ml alcohol toevoegen na het laatste afgieten
- mengen en overbrengen in Eppendorf cup.
- Eppendorf cup uitcentrifugeren
- decanteren en glycerine toevoegen (eventueel glycerine als monster)
- residu eerst een nacht drogen bij max. 70 graden C.
- preparaat maken met glycerine

Appendix D. Borehole logs

Study area	Site	Borings
The Netherlands, Friesland	Egypte	001-013
	Laarzenpad	014-027
	Opende	028-037
The Netherlands, Drenthe	Sleenerstroom I	061-069, 080-084
	Lammeer	070
	Vlierendijk	071-077
	Sleenerstroom II	078-079
Germany, Ost-Friesland	Timmelteich	085-092, 116-120
	Westerschoo	093
	Brill	094-103
	Wrokmoor	104-115
	Mamburg	122-129
Germany, Cloppenburg/Visbek	Keller-Höhe	038-040
	Rennplatz	041
	Erlte	042-044
	Emstekerfeld	045-057
	Sevelte	058-060

Appendix E. Field results: borehole logs

Study area	Site	Borings
The Netherlands, Friesland	Egypte	001-013
	Laarzenpad	014-027
	Opende	028-037
The Netherlands, Drenthe	Sleenerstroom I	061-069, 080-084
	Lammeer	070
	Vlierendijk	071-077
	Sleenerstroom II	078-079
Germany, Ost-Friesland	Timmelteich	085-092, 116-120
	Westerschoo	093
	Brill	094-103
	Wrokmoor	104-115
	Mamburg	122-129
Germany, Cloppenburg/Visbek	Keller-Höhe	038-040
	Rennplatz	041
	Erlte	042-044
	Emstekerfeld	045-057
	Sevelte	058-060

Borehole: 201107001 Names: R&A Year: 2011 Group: 07 Date: 12-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
203334	585251	RD	1,95	180

MAP LEGEND CODE
Geological map:
Vegetation-map: Egypte
Geomorphogenetical map:
Groundwaterstep:
Soilmap:

Egypte

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							GER. humeus
20	FZ			br			150-210							GER. humeus
30	FZ			br			150-210							GER. humeus
40	FZ			br			150-210							GER. humeus
50	FZ			br			150-210							iets humeus. goed ges.
60	FZ			br			150-210							iets humeus. goed ges.
70	FZ			lbrgr			150-210							iets humeus. goed ges.
80	ZFZ			lbrgr		5	105-150							iets lemig.
90	MZ			lgr		2	210-300							leembrokjes
100	LZ			gr		2				GW				leembrokjes
110	LZ			gr		2								leembrokjes
120	LZ			gr		2								leembrokjes
130	LZ			gr		2								leembrokjes
140	LZ			gr		2								leembrokjes
150	LZ			gr		2								leembrokjes
160	LZ			gr		2								leembrokjes
170	LZ			gr		2								leembrokjes
180	LZ			gr		2								einde boring.

Base of borehole: 201107001

Borehole: 201107002 Names: R&A Year: 2011 Group: 07 Date: 12-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep:	
203319	585262	RD	1,9	150	Vegetation-map: Egypte	Soilmap:	

Egypte. In wal.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br		1	150-210							vuursteentje. ijzerinspoel
20	FZ			br		1	150-210							humeus. podzool. dekzand
30	FZ			br		1	150-210							humeus. podzool. dekzand
40	FZ			br		1	150-210							humeus. podzool. dekzand
50	FZ			br		1	150-210							humeus. podzool. dekzand
60	FZ			br		1	150-210							humeus. podzool. dekzand
70	FZ			lbrgr			150-210							iets lemig.
80	FZ			lbrgr			150-210							iets lemig.
90	FZ			lgrbr		2	150-210							iets lemig.
100	FZ			gr		5	150-210							lemig.
110	FZ			gr		5	150-210							lemig.
120	FZ			gr		5	150-210							lemig.
130	FZ			gr		5	150-210			GW				lemig.
140	FZ			gr		5	150-210							lemig.
150	FZ			gr		5	150-210							einde boring.

Base of borehole: 201107002

Borehole: 201107003 Names: R&A Year: 2011 Group: 07 Date: 12-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
203283	585280	RD	1,3	120

MAP LEGEND CODE
Geomorphogenetical map:
Geological map:
Groundwaterstep:
Vegetation-map: Egypte
Soilmap:

Egypte. alleen 20 cm humeus zand. geen dekzand!

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							GER. Humeus
20	FZ			br			150-210							GER. Humeus
30	FZ			br			150-210							GER. Humeus
40	FZ			br			150-210							GER. Humeus
50	L			blgr		2								brok uit sloot!
60	FZ			lbrgr		2	150-210							humeus zand
70	FZ			lbrgr		2	150-210							humeus zand
80	FZ			lbrgr		2	150-210							humeus zand
90	L			gr		5								keizand
100	L			gr		5								keizand
110	L			gr		5								keizand
120	L			gr		5								einde boring.

Base of borehole: 201107003

Borehole: 201107004 Names: R&A Year: 2011 Group: 07 Date: 12-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
203260	585284	RD	0,98	120

MAP LEGEND CODE	Geomorphogenetical map:
Geological map:	Groundwaterstep:
Vegetation-map: Egypte	Soilmap:

Egypte

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							GER. humeus
20	FZ			br			150-210							GER. humeus
30	FZ			br			150-210							GER. humeus
40	FZ			br			150-210							GER. humeus
50	FZ			br			150-210							GER. humeus
60		V3		dbr										bosveen.
70		V3		dbr										bosveen.
80	FZ			dgr			150-210							podzolbodem.
90	FZ			dgr		2	150-210							podzolbodem.
100	FZ			dgr		2	150-210							podzolbodem.
110	FZ			dgr		3	150-210							podzolbodem.
120	FZ			dgr		5	150-210							einde boring. grind

Base of borehole: 201107004

Borehole: 201107005 Names: R&A Year: 2011 Group: 07 Date: 12-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep:	
203254	585285	RD	0,91	320	Vegetation-map: Egypte	Soilmap:	

Egypte op 105 (in boorstaat 110) bodemvorming, boreaal, droge periode binnen holoceen.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							GER. humeus
20	FZ			br			150-210							GER. humeus
30	FZ			br			150-210							GER. humeus
40	FZ			br			150-210							GER. humeus
50		V3		dbr										zandig. bosveen. zegge.
60		V3		dbr										bosveen. zegge.
70		V3		dbr										bosveen. zegge. mosjes
80		V3		orbr										mosveen. houresten
90		V3		orbr										mosveen. houresten
100		V3		orbr										mosveen. houresten
110		V3		dbr										zandig.
120		V3		br										zandig.
130	LK			br										zandig(75-105)gy.
140	LK			br										zandig(75-105)gy.
150	LK			br										zandig(75-105)gy.
160	LK			br										monster.
170	LK			br										zandig(75-105)gy.
180	LK			br										zandig(75-105)gy.
190	LK			br										zandig(75-105)gy.
200	LK			br										zandig(75-105)gy.
210	MZ			br			210-300							schoon zandje
220	MZ			br			210-300							schoon zandje
230	MZ			br			210-300							schoon zandje
240	MZ			br			210-300							schoon zandje
250	MZ			br			210-300							schoon zandje
260	MZ			br			210-300							schoon zandje
270	MZ			br			210-300							schoon zandje
280	MZ			br			210-300							schoon zandje
290	MZ			br			210-300							schoon zandje
300	MZ			br			210-300							schoon zandje
310	MZ			br			210-300							schoon zandje
320	MZ			br			210-300							einde boring.

Base of borehole: 201107005

Borehole: 201107006	Names: R&A	Year: 2011	Group: 07	Date: 12-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
203251	585289	RD	0,91	360

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Egypte	Soilmap:	

Egypte

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		br										ger. opgehoogd. veraard
20		V1		br										ger. opgehoogd. veraard
30		V1		br										ger. opgehoogd. veraard
40		V1		br										ger. opgehoogd. veraard
50		V1		br										ger. opgehoogd. veraard
60		V1		zwbr										veraard. zegge
70		V1		zwbr										vuursteentje
80		V3		orbr										mosveen. zegge. veenpluis
90		V3		orbr										mosveen. zegge. veenpluis
100		V3		orbr										mosveen. zegge. veenpluis
110		V3		orbr										mosveen. zegge. veenpluis
120		V3		orbr										mosveen. zegge. veenpluis
130		V3		orbr										mosveen. zegge. veenpluis
140		V3		orbr										mosveen. zegge. veenpluis
150		V3		orbr										mosveen. zegge. veenpluis
160		V3		orbr										mosveen. zegge. veenpluis
170		V3		orbr										mosveen. zegge. veenpluis
180		V3		orbr										mosveen. zegge. veenpluis
190		V3		orbr										mosveen. zegge. veenpluis
200		V3		orbr										mosveen. zegge. veenpluis
210		V3		dbr										bodempje
220	LK													hum.zand.siltig. zandgy
230	LK													hum.zand.siltig. zandgy
240	LK													hum.zand.siltig. zandgy
250	LK													hum.zand.siltig. zandgy
260	LK													hum.zand.siltig. zandgy
270	LK													hum.zand.siltig. zandgy
280	LK													hum.zand.siltig. zandgy
290	LK													hum.zand.siltig. zandgy
300	FZ						150-210							ongeveer.
310	FZ						150-210							
320	FZ						150-210							
330	FZ						150-210							
340	FZ						150-210							
350	FZ						150-210							
360	FZ						150-210							einde boring

Base of borehole: 201107006

Borehole: 201107007 Names: R&A Year: 2011 Group: 07 Date: 12-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
203237	585300	RD	0,82	380

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Egypte	Soilmap:	

Egypte

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		grbr										GER. ophoog. veraard.
20		V1		grbr										GER. ophoog. veraard.
30		V1		grbr										GER. ophoog. veraard.
40		V1		grbr										GER. ophoog. veraard.
50		V1		grbr										GER. ophoog. veraard.
60		V1		grbr										GER. ophoog. veraard.
70		V1		grbr										GER. ophoog. veraard.
80		V1		grbr										GER. ophoog. veraard.
90		V3		br										zegge. veraard. bodem.
100		V3		br										zegge. veraard. bodem.
110		V3		br										zegge. veraard. bodem.
120		V3		orbr										mosveen. veenpluis
130		V3		orbr										mosveen. veenpluis
140		V3		orbr										mosveen. veenpluis
150		V3		orbr										mosveen. veenpluis
160		V3		orbr										mosveen. veenpluis
170		V3		orbr										mosveen. veenpluis
180		V3		orbr										mosveen. veenpluis
190		V3		orbr										mosveen. veenpluis
200		V3		orbr										mosveen. veenpluis
210		V3		orbr										mosveen. veenpluis
220		V3		orbr										mosveen. veenpluis
230		V3		orbr										mosveen. veenpluis
240		V3		orbr										mosveen. veenpluis
250		V3		orbr										berkenhout
260				orbr										bodem in zandige gy
270	LK			dbr										bodem in zandige gy
280	LK			dbr										bodem in zandige gy
290	LK			lbr										humeus. UFZ. gelaagd zandbndjs
300	LK			lbr										humeus. UFZ. gelaagd zandbndjs
310	LK			lbr										humeus. UFZ. gelaagd zandbndjs
320	LK			lbr										humeus. UFZ. gelaagd zandbndjs
330	LK			lbr										humeus. UFZ. gelaagd zandbndjs
340	LK			lbr										humeus. UFZ. gelaagd zandbndjs
350	FZ			lbrgr			150-210							
360	FZ			lbrgr			150-210							
370	FZ			lbrgr			150-210							
380	FZ			lbrgr			150-210							einde boring

Base of borehole: 201107007

Borehole: 201107008	Names: R&A	Year: 2011	Group: 07	Date: 12-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
203226	585304	RD	0,99	380

MAP LEGEND CODE		Geomorphogenetical map:	Pingo
Geological map:		Groundwaterstep:	
Vegetation-map: Egypte		Soilmap:	

Egypte

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							Ophoogspul. GER.
20	FZ			br			150-210							Ophoogspul. GER.
30	FZ			br			150-210							Ophoogspul. GER.
40	FZ			br			150-210							Ophoogspul. GER.
50	FZ			br			150-210							Ophoogspul. GER.
60	FZ			br			150-210							Ophoogspul. GER.
70	FZ			br			150-210							Ophoogspul. GER.
80		V3		orbr										mosveen. zegge
90		V3		orbr										mosveen. zegge
100		V3		orbr										mosveen. zegge
110		V3		orbr										mosveen. zegge
120		V3		orbr										mosveen. zegge
130		V3		orbr										mosveen. zegge
140		V3		orbr										mosveen. zegge
150		V3		orbr										mosveen. zegge
160		V3		orbr										mosveen. zegge
170		V3		orbr										mosveen. zegge
180		V3		orbr										mosveen. zegge
190		V3		orbr										mosveen. zegge. meer mos.
200		V3		orbr										mosveen. zegge. meer mos.
210		V3		orbr										mosveen. zegge. meer mos.
220		V3		orbr										mosveen. zegge. meer mos.
230		V3		br										zeggeveen
240		V3		br										zeggeveen
250		V3		br										zeggeveen
260		V3		br										zeggeveen
270		V3		br										zeggeveen
280		V3		br										zeggeveen
290	LK			lbr										geband. humeus.
300	LK			lbr										geband. humeus.
310	LK			lbr										geband. humeus.
320	LK			lbr										geband. humeus.
330	LK			lbr										geband. humeus.
340	FZ			lbr			150-210							humeus.
350	FZ			lbr			150-210							humeus.
360	FZ			gr			150-210							lemig.
370	FZ			gr			150-210							lemig.
380	FZ			gr		2	150-210							einde boring. grind gevoeld

Base of borehole: 201107008

Borehole: 201107009 Names: R&A Year: 2011 Group: 07 Date: 12-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
203219	585309	RD	1	320

MAP LEGEND CODE
Geological map:
Vegetation-map: Egypte
Geomorphogenetical map:
Groundwaterstep:
Soilmap:

Egypte monster 235 monster 250 monster 270

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							GER.
20	FZ			br			150-210							GER.
30	FZ			br			150-210							GER.
40	FZ			br			150-210							GER.
50	FZ			br			150-210							GER.
60	FZ			br			150-210							GER.
70	FZ			br			150-210							GER.
80		V3		zwbr										veraard. met bodem
90		V3		zwbr										veraard. met bodem
100		V3		zwbr										veraard. met bodem
110		V3		orbr										mosveen. witte spikkels
120		V3		orbr										mosveen. witte spikkels
130		V3		orbr										mosveen. witte spikkels
140		V3		orbr										mosveen. witte spikkels
150		V3		orbr										mosveen. witte spikkels
160		V3		orbr										mosveen. witte spikkels
170		V3		orbr										mosveen. witte spikkels
180		V3		orbr										mosveen. witte spikkels
190		V3		orbr										mosveen. witte spikkels
200	LK			orbr										bodem. in gy
210	LK			orbr										bodem. in gy
220	LK			lbr										gy ZFZ
230	LK			lbr										gy ZFZ monster 235
240	LK			dbr										zandig veen
250	LK			dbr										zandig veen
260	LK			br										gy ZFZ
270	LK			br										gy ZFZ
280	LK			br										gy ZFZ
290	LK			br										gy ZFZ
300	LK			br										gy ZFZ
310	LK			br										gy ZFZ
320	LK			br										BOEM einde boring. grind

Base of borehole: 201107009

Borehole: 201107010 Names: R&A Year: 2011 Group: 07 Date: 12-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
203210	585320	RD	0,9	250

MAP LEGEND CODE
Geomorphogenetical map: Pingo
Geological map:
Groundwaterstep:
Vegetation-map: Egypte
Soilmap:

Egypte

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							GER.
20	FZ			br			150-210							GER.
30	FZ			br			150-210							GER.
40	FZ			br			150-210							GER.
50	FZ			br			150-210							GER.
60	FZ			br			150-210							GER.
70	FZ			br			150-210							GER.
80		V1		dbr										veraard veen
90		V1		dbr										veraard veen
100		V3		orbr										mosveen
110		V3		orbr										mosveen
120		V3		br										mosveen
130		V3		br										mosveen
140		V3		br										mosveen
150		V3		br										mosveen
160		V3		br										mosveen
170		V3		br										mosveen
180		V3		br										mosveen
190		V3		br										mosveen
200	LK			br										bodem. veraard gy
210	LK			lbr										zandig(UFZ) gy
220	LK			lbr										zandig(UFZ) gy
230	FZ			grbr			150-210							zandig
240	FZ			grbr			150-210							zandig
250	FZ			grbr		2	150-210							einde boring. grind

Base of borehole: 201107010

Borehole: 201107011 Names: R&A Year: 2011 Group: 07 Date: 12-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
203196	585318	RD	0,89	140

MAP LEGEND CODE	Geomorphogenetical map:
Geological map:	Groundwaterstep:
Vegetation-map: Egypte	Soilmap:

Egypte

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							GER
20	FZ			br			150-210							GER
30	FZ			br			150-210							GER
40	FZ			br			150-210							GER
50	FZ			br			150-210							GER
60	FZ			br			150-210							GER
70	FZ			br			150-210							GER
80		V1		br										zandig veraard
90	LK			dbr										bodem. zandig gy
100	LK			dbr										bodem. zandig gy
110	LK			dbr										bodem. zandig gy
120	LK			dbr										bodem. zandig gy
130	LK			dbr										bodem. zandig gy
140	FZ			dbr		1	150-210							einde boring. grind

Base of borehole: 201107011

Borehole: 201107012 Names: R&A Year: 2011 Group: 07 Date: 12-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
203189	585325	RD	1,02	110

MAP LEGEND CODE Geomorphogenetical map:
Geological map: Groundwaterstep:
Vegetation-map: Egypte Soilmap:

Egypte op andere randwal

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ						150-210							rommel
20	FZ						150-210							rommel
30	FZ						150-210							rommel
40	FZ						150-210							rommel
50	FZ						150-210							rommel
60	FZ						150-210							rommel
70		V1		br										veraard veen
80	FZ			br		10	150-210							humeus. zand. podzol
90	FZ			br		10	150-210							humeus. zand. podzol
100	FZ			br		10	150-210							humeus. zand. podzol
110	FZ			br		10	150-210							einde boring. grind

Base of borehole: 201107012

Borehole: 201107013 Names: R&A Year: 2011 Group: 07 Date: 12-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
203170	585330	RD	1,53	110

MAP LEGEND CODE
Geomorphogenetical map:
Geological map:
Groundwaterstep: 80
Vegetation-map: Egypte
Soilmap:

Egypte. op randwal

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ						150-210							humeus.
20	FZ						150-210							humeus.
30	FZ						150-210							humeus.
40	FZ						150-210							humeus.
50	FZ						150-210							humeus.
60	FZ						150-210							humeus.
70		VZ												podzol
80		VZ								GW				podzol
90		VZ												podzol
100	L			lgrbr										keileem
110	L			lgrbr										einde boring

Base of borehole: 201107013

Borehole: 201107014 Names: R&A Year: 2011 Group: 07 Date: 13-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
204600	584561	RD	-0,16	320

MAP LEGEND CODE
Geomorphogenetical map:
Geological map:
Groundwaterstep: 80
Vegetation-map: Laarzenp
Soilmap:

Laarzenpad. Niet duidelijke pingo.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	MZ			br			210-300							GEr
20	MZ			br			210-300							GEr
30	MZ			br			210-300							GEr
40	MZ			br			210-300							GEr
50	MZ			br			210-300							GEr
60	MZ			br			210-300							GEr
70		V1		zwbr										veraard veen
80		V3	plr	brzw						GW				bosveen. structuurloos. wortel
90		V3	plr	brzw										bosveen. structuurloos. wortel
100		V3	plr	brzw										bosveen. structuurloos. wortel
110		V3	plr	brzw										bosveen. structuurloos. wortel
120		V1	plr	br										zandig(75-105) bosveen
130		V1	plr	br										idem. geband. houtresten. bosv
140		V1	plr	br										idem. geband. houtresten. bosv
150		V1	plr	br										idem. geband. houtresten. bosv
160		V1	plr	br										idem. geband. houtresten. bosv
170		V1	plr	br										idem. geband. houtresten. bosv
180		V1	plr	br										idem. geband. houtresten. bosv
190		V1	plr	br										idem. geband. houtresten. bosv
200		V1	plr	br										idem. geband. houtresten. bosv
210		V1	plr	lbr										zandig veen.
220		V1	plr	lbr										zandig veen.
230		V1	plr	lbr										zandig veen. gelaagd. zegge
240		V1	plr	lbr										zandig veen. gelaagd. zegge
250		V1	plr	lbr										zandig veen. gelaagd. zegge
260		V1	plr	lbr										zandig veen. gelaagd. zegge
270	FZ			brgr			150-210							lemig zand
280	FZ			brgr			150-210							lemig zand
290	UFZ			gr			75-105							
300	FZ			gr			150-210							lemig zand
310	FZ			gr			150-210							lemig zand
320	MZ			gr			210-420							einde boring. grof zandje

Base of borehole: 201107014

Borehole: 201107015 Names: R&A Year: 2011 Group: 07 Date: 13-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
204611	584550	RD	-0,2	320

MAP LEGEND CODE
Geological map:
Vegetation-map: Laarzenp
Geomorphogenetical map: Pingo
Groundwaterstep: 80
Soilmap:

Laarzenpad.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							GER. troep
20	FZ			br			150-210							GER. troep
30	FZ			br			150-210							GER. troep
40	FZ			br			150-210							GER. troep
50	FZ			br			150-210							GER. troep
60	FZ			br			150-210							GER. troep
70		V1		zw										veraard veen
80		V1		zw										veraard veen
90		V1		zw										veraard veen
100		V3	plr	br										bosveen
110		V3	plr	br										bosveen
120		V3	plr	br										bosveen
130		V3	plr	br										bosveen
140		ZV		br										bodem. zandig(150-210)
150		ZV		br										bodem. zandig(150-210)
160		ZV		lbr										bodem. zandig(150-210)
170		ZV		lbr										bodem. zandig(150-210)
180		ZV		lbr										bodem. zandig(150-210)
190	LK		plr	lbr										zandig(75-105)veen. laminea
200	LK		plr	lbr										zandig(75-105)veen. laminea
210	LK		plr	lbr										zandig(75-105)veen. laminea
220	LK		plr	lgrbr										zandig(105-150)veen. laminea
230	LK		plr	lgrbr										zandig(105-150)veen. laminea
240	LK		plr	lgrbr										zandig(105-150)veen. laminea
250	ZFZ			lgrbr			105-150							lemig. (vage grens)
260	ZFZ			lgrbr			105-150							lemig
270	ZFZ			lgrbr			105-150							lemig
280	FZ			lgrbr			150-210							lemig
290	FZ			lgrbr			150-210							lemig
300	FZ			lgrbr			150-210							lemig
310	FZ			lgrbr			150-210							lemig
320	FZ			lgrbr			150-210							einde boring.

Base of borehole: 201107015

Borehole: 201107016	Names: R&A	Year: 2011	Group: 07	Date: 13-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 80	
204622	584541	RD	-0,13	260	Vegetation-map: Laarzenp	Soilmap:	

Laarzenpad

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ						150-210							meuk
20	FZ						150-210							meuk
30	FZ						150-210							meuk
40	FZ						150-210							meuk
50	FZ						150-210							meuk
60		V1		dbr										veraard veen
70		V1		dbr										veraard veen
80		V1		dbr										veraard veen
90		V1		dbr										veraard veen
100		V3	plr	br										zandig(105-150) bosveen
110		V3	plr	br										zandig(105-150) bosveen
120		V3	plr	br										zandig(105-150) bosveen
130		V3	plr	br										zandig(105-150) bosveen
140		V3	plr	br										zandig(105-150) bosveen
150	LK		plr	lbr										gelaagd zandig(150-210) veen
160	LK		plr	lbr										gelaagd zandig(150-210) veen
170	LK		plr	lbr										gelaagd zandig(150-210) veen
180	LK		plr	lbr										gelaagd zandig(150-210) veen
190	LK		plr	lbr										gelaagd zandig(150-210) veen
200	LK		plr	lbr										gelaagd zandig(150-210) veen
210	LK		plr	lbr										gelaagd zandig(150-210) veen
220	ZFZ			lbrgr			105-150							lemig
230	ZFZ			lbrgr			105-150							lemig
240	ZFZ			lbrgr			105-150							lemig
250	ZFZ			lbrgr			105-150							lemig
260	ZFZ			lbrgr			105-150							einde boring.

Base of borehole: 201107016

Borehole: 201107017	Names: R&A	Year: 2011	Group: 07	Date: 13-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
204638	584530	RD	-0,15	160

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 70
Vegetation-map: Laarzenp	Soilmap:

Laarzenpad slechte boring

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ						150-210							prut
20	FZ						150-210							prut
30	FZ						150-210							prut
40	FZ						150-210							prut
50	FZ						150-210							prut
60		V1												veraard veen
70		V1												veraard veen
80		ZV		dbr										zandig (150-210) veen
90		ZV		dbr										zandig (150-210) veen
100		ZV		dbr										zandig (150-210) veen
110		ZV		dbr										zandig (150-210) veen
120	FZ						150-210							geen monster te zandig
130	FZ						150-210							geen monster te zandig
140	FZ						150-210							geen monster te zandig
150	FZ						150-210							geen monster te zandig
160	FZ						150-210							einde boring

Base of borehole: 201107017

Borehole: 201107018	Names: R&A	Year: 2011	Group: 07	Date: 13-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
204668	584513	RD	0,69	170

MAP LEGEND CODE		Geomorphogenetical map:	Pingo
Geological map:		Groundwaterstep:	
Vegetation-map: Laarzenp		Soilmap:	

Laarzenpad. op randwal. monster op 100

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ						150-210							troep, kleiig
20	FZ						150-210							troep, kleiig
30	FZ						150-210							troep, kleiig
40	FZ			brgr			150-210							lemig.Fe brok, leembl.
50	FZ			brgr			150-210							lemig.Fe brok, leembl.
60	FZ			brgr			150-210							lemig.Fe brok, leembl.
70	FZ			brgr			150-210							lemig.Fe brok, leembl.
80	FZ			gr			150-210							lemig.Fe brok, leembl.
90	FZ			gr			150-210							lemig.Fe brok, leembl.
100		V1		br										zegge. monster
110	MZ			gr		10	210-300							iets lemig
120	MZ			gr		5	210-300							iets lemig
130	MZ			gr		2	210-300							iets lemig
140	LZ			gr		2								Fe vlekken. leer lemig MZ
150	LZ			gr		2								Fe vlekken. leer lemig MZ
160	LZ			gr		2								Fe vlekken. leer lemig MZ
170	LZ			gr		2								einde boring

Base of borehole: 201107018

Borehole: 201107019	Names: R&A	Year: 2011	Group: 07	Date: 13-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
204717	584480	RD	0,45	100

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Laarzenp	Soilmap:	

Laarzenpad. Referentieboring, achter pingo

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1												meuk. veraard veen zand+grind
20		V1												meuk. veraard veen zand+grind
30		V1												meuk. veraard veen zand+grind
40		V1												meuk. veraard veen zand+grind
50		V1												meuk. veraard veen zand+grind
60		ZV		lbr										
70		ZV		lbr										
80	LZ			gr		10								keileem. grind tot 2cm
90	LZ			gr		10								keileem. grind tot 2cm
100	LZ			gr		10								einde boring. STEEN

Base of borehole: 201107019

Borehole: 201107020 Names: R&A Year: 2011 Group: 07 Date: 13-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 100	
204663	584517	RD	0,48	140	Vegetation-map: Laarzenp	Soilmap:	

Laarzenpad

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ						150-210							GER. baksteen
20	FZ						150-210							GER. baksteen
30	FZ						150-210							GER. baksteen
40	FZ						150-210							GER. baksteen
50	FZ						150-210							GER. baksteen
60	FZ						150-210							GER. baksteen
70	FZ						150-210							GER. baksteen
80		ZV		zwbr		2								zeer zandig veen. bodem
90		ZV		zwbr		2								zeer zandig veen. bodem
100	LZ			lgrbr		5								mega kei, bond gekleurd
110	LZ			lgrbr		5								mega kei, bond gekleurd
120	LZ			lgrbr		5								mega kei, bond gekleurd
130	LZ			lgrbr		5								mega kei, bond gekleurd
140	LZ			gr		5								einde boring

Base of borehole: 201107020

Borehole: 201107021 Names: R&A Year: 2011 Group: 07 Date: 13-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
204650	584528	RD	-0,18	160

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep:
Vegetation-map: Laarzenp	Soilmap:

Laarzenpad

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ						150-210							GER. kleiig.
20	FZ						150-210							GER. kleiig.
30	FZ						150-210							GER. kleiig.
40	FZ						150-210							GER. kleiig.
50		ZV		brzw										zandig(150-210).
60		ZV		brzw										zandig(150-210). bodem
70		ZV		dbr										zandig(150-210).
80		ZV		br										zandig(150-210).
90	FZ			br			150-210							iets lemig&humeus.
100	FZ			br		5	150-210							iets lemig&humeus.
110	FZ			br		5	150-210							iets lemig&humeus.
120	LZ			gr		10								keileem.
130	LZ			gr		10								keileem.
140	LZ			gr		10								keileem.
150	LZ			gr		10								keileem.
160	LZ			gr		10								einde boring

Base of borehole: 201107021

Borehole: 201107023 Names: R&A Year: 2011 Group: 07 Date: 13-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
204586	584568	RD	-0,15	240

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep:
Vegetation-map: Laarzenp	Soilmap:

Laarzenpad

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							ger. prut
20	FZ			br			150-210							ger. prut
30	FZ			br			150-210							ger. prut
40	FZ			br			150-210							ger. prut
50	FZ			br			150-210							ger. prut
60		V1	plr	zwbr										veraard.
70		V1	plr	zwbr										veraard.
80		V1	plr	zwbr										veraard.
90		V1	plr	zwbr										veraard.
100		V1	plr	zwbr										veraard.
110		V1	plr	zwbr										veraard.
120		V3	plr	br										zandig(105-150)
130		V3	plr	br										zandig(105-150)
140		V3	plr	br										zandig(105-150)
150		V3	plr	br										zandig(105-150)
160		V3	plr	br		10								grindlaagje
170	LK		plr	grbr										licht geband. zandig(105) veen
180	LK		plr	grbr										licht geband. zandig(105) veen
190	LK		plr	grbr										licht geband. zandig(105) veen
200	LK		plr	grbr										licht geband. zandig(105) veen
210	LZ			gr										zeer lemig UFZ
220	LZ			gr										zeer lemig UFZ
230	LZ			gr										zeer lemig UFZ
240	LZ			gr										einde boring

Base of borehole: 201107023

Borehole: 201107024 Names: R&A Year: 2011 Group: 07 Date: 13-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
204572	584579	RD	-0,18	160

MAP LEGEND CODE — Geomorphogenetical map: Pingo
Geological map:
Groundwaterstep:
Vegetation-map: Laarzenp
Soilmap:

Laarzenpad

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		ZV												prut
20		ZV												prut
30		ZV												prut
40		ZV												prut
50		ZV												prut
60		ZV												prut
70		V1		zwbr										veraard veen
80		V1		zwbr										veraard veen
90		V1		zwbr										veraard veen
100		V3	plr	br										zandig(150-210) bosveen
110		V3	plr	br										zandig(150-210) bosveen
120	LZ			gr										zand(105-150)
130	LZ			gr										zand(105-150)
140	LZ			gr										zand(105-150)
150	LZ			gr										zand(105-150)
160	LZ			gr										einde boring. te lemig

Base of borehole: 201107024

Borehole: 201107025 Names: R&A Year: 2011 Group: 07 Date: 13-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
204552	584590	RD	-0,02	100

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 80	
Vegetation-map: Laarzenp	Soilmap:	

Laarzenpad

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		ZV		br										GER. kleiig.
20		ZV		br										GER. kleiig.
30		ZV		br										GER. kleiig.
40		ZV		br										GER. kleiig.
50		ZV		br										GER. kleiig.
60		V1		brzw										veraard veen
70		V1		brzw										veraard veen. bodem
80		ZV	plr	dbr						GW				zandig(150-210) veen
90		ZV	plr	br										zandig(150-210) veen
100		ZV	plr	br										einde boring. beton!

Base of borehole: 201107025

Borehole: 201107026 Names: R&A Year: 2011 Group: 07 Date: 13-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
204538	584597	RD	0,22	100

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Laarzenp	Soilmap:	

Laarzenpad

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		ZV												GER. kleiig
20		ZV												GER. kleiig
30		ZV												GER. kleiig
40		V1		dbr										zandig(150-210). bodem
50		V1		br										zandig(150-210). bodem
60		V3		br										zandig(150-210) veen
70	ZFZ			br			105-150							lemig
80	ZFZ			brgr			105-150							lemiger
90	ZFZ			gr			105-150							nog lemiger
100	ZFZ			gr			105-150							einde boring

Base of borehole: 201107026

Borehole: 201107027 Names: R&A Year: 2011 Group: 07 Date: 13-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
204528	584603	RD	0,24	100

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Laarzenp	Soilmap:	

Laarzenpad

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		ZV												geroerd.
20		ZV												geroerd.
30		ZV												geroerd.
40		ZV												geroerd.
50		V1		brzw										veraard veen
60		V1		brzw										veraard veen
70		ZV		br										zandig(150-210)veen
80	LZ			gr		5								lemig zand(150-210).
90	LZ			gr		5								lemig zand(150-210).
100	LZ			gr		5								einde boring. keileem

Base of borehole: 201107027

Borehole: 201107028 Names: R&A Year: 2011 Group: 07 Date: 14-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map: Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 110
210394	577488	RD	0,86	210	Vegetation-map: Opende	Soilmap:

Opende.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			dbr			150-210							GER
20	FZ			dbr			150-210							GER
30	FZ			dbr			150-210							GER
40	FZ			br			150-210							bodem
50	FZ			br			150-210							bodem
60	FZ			br			150-210							bodem
70	FZ			br			150-210							bodem
80	FZ			br			150-210							
90	FZ			br			150-210							
100	FZ			br			150-210							
110	FZ			br			150-210			GW				
120	FZ			br			150-210							
130	FZ			br			150-210							
140	FZ			br			150-210							
150	FZ			br			150-210							
160	FZ			br			150-210							
170	FZ			br			150-210							
180	FZ			br			150-210							
190	FZ			br			150-210							
200	FZ			br			150-210							
210	FZ			br			150-210							te nat zand

Base of borehole: 201107028

Borehole: 201107029 Names: R&A Year: 2011 Group: 07 Date: 14-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
210412	577366	RD	0,28	200

MAP LEGEND CODE
Geomorphogenetical map:
Geological map:
Groundwaterstep:
Vegetation-map: Opende
Soilmap:

Opende

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			dbr			150-210							GER, iets humeus
20	FZ			dbr			150-210							GER, iets humeus
30	FZ			dbr			150-210							GER, iets humeus
40		V1	plr	zwbr										veraard veen
50		V1	plr	zwbr										veraard veen
60		V1	plr	zwbr										veraard veen
70		V1	plr	zwbr										veraard veen
80		V3	plr	br										heel veel plr. veenpluis
90		V3	plr	br										heel veel plr. veenpluis
100		V3		br										homogeen
110		V3		br										homogeen
120		V3		br										homogeen
130		V3		br										homogeen
140		V3		br										homogeen
150		V1		grbr										iets zandig
160		V3		br										gelaagd, breekt horiz. mos.
170		V3		br										gelaagd, breekt horiz. mos.
180		V3		br										gelaagd, breekt horiz. mos.
190	MZ			gr			210-300							zeer scherpe overgang
200	MZ			gr			210-300							zand

Base of borehole: 201107029

Borehole: 201107030 Names: R&A Year: 2011 Group: 07 Date: 14-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep:
210412	577380	RD	0,06	360	Vegetation-map: Opende	Soilmap:

Opende

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							ger
20	FZ			br			150-210							ger
30	FZ			br			150-210							ger
40		V1		dbr										veraard veen
50		V1		dbr										veraard veen
60		V3		br										veenpluis
70		V3		br										veenpluis
80		V3		br										veenpluis
90		V3		br										veenpluis
100		V3		br										veenpluis
110		V3		br										veenpluis
120		V3		br										veenpluis
130		V3		br										veenpluis
140		V3		br										veenpluis
150		V3		br										veenpluis
160		V3		br										veenpluis
170		V3		br										veenpluis
180		V3		br										veenpluis
190		V3		br										veenpluis
200		V1		gr										smeer? zacht. gy-achtig
210		V3	plr	br										veenpluis
220		V3	plr	br										veenpluis
230		V3	plr	br										veenpluis
240		V3	plr	br										veenpluis
250		V3	plr	br										veenpluis
260		V3	plr	br										erg los, vergaan?
270		V3	plr	br										erg los, vergaan?
280		V3	plr	br										erg los, vergaan?
290		V3	plr	br										erg los, vergaan?
300		V1		gr										smeerlaagje, 2cm
310		V3	plr	br										veen
320		V3	plr	grbr										zegge. gelaagd, gy-achtig?
330		V3	plr	grbr										zegge. gelaagd, gy-achtig?
340	MZ			gr			210-300							scherpe overgang.1 grindje 2mm
350	MZ			gr			210-300							
360	MZ			gr			210-300							te veel zand

Base of borehole: 201107030

Borehole: 201107031 Names: R&A Year: 2011 Group: 07 Date: 14-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
210409	577392	RD	0,03	380

MAP LEGEND CODE	Geomorphogenetical map:
Geological map:	Groundwaterstep:
Vegetation-map: Opende	Soilmap:

Opende

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							ger
20	FZ			br			150-210							ger
30		V1	plr	br										veraard veen
40		V1	plr	br										veraard veen
50		V3	plr	br										veel plr. zegge, veenpluis
60		V3	plr	br										veel plr. zegge, veenpluis
70		V3	plr	br										veel plr. zegge, veenpluis
80		V3	plr	br										veel plr. zegge, veenpluis
90		V3	plr	br										veel plr. zegge, veenpluis
100		V3	plr	br										veel plr. zegge, veenpluis
110		V3	plr	br										veel plr. zegge, veenpluis
120		V3	plr	br										veel plr. zegge, veenpluis
130		V3	plr	br										veel plr. zegge, veenpluis
140		V3	plr	br										veel plr. zegge, veenpluis
150		V3	plr	br										veel plr. zegge, veenpluis
160		V3	plr	br										veel plr. zegge, veenpluis
170		V3	plr	br										veel plr. zegge, veenpluis
180		V3	plr	br										veel plr. zegge, veenpluis
190		V3	plr	br										veel plr. zegge, veenpluis
200		V3	plr	dbr										homogeen, takjes, zegge
210		V3	plr	dbr										homogeen, takjes, zegge
220		V3	plr	dbr										homogeen, takjes, zegge
230		V3	plr	dbr										homogeen, takjes, zegge
240		V3	plr	dbr										homogeen, takjes, zegge
250		V3	plr	dbr										homogeen, takjes, zegge
260		V3	plr	dbr										homogeen, takjes, zegge
270		V3	plr	dbr										boom
280		V3	plr	dbr										homogeen, takjes, zegge
290		V3	plr	dbr										homogeen, takjes, zegge
300		V3	plr	lbr										zegge
310		V3	plr	lbr										zegge
320		V3	plr	lbr										zegge
330		V3	plr	lbr										zegge
340		V3	plr	lbr										zegge
350		V3	plr	lbr										zegge
360	MZ			lbr			300-420							scherpe overgang
370	MZ			lbr			300-420							grindjes, <2% 2mm
380	MZ			lbr			300-420							zand

Base of borehole: 201107031

Borehole: 201107032 Names: A&R Year: 2011 Group: 07 Date: 14-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
210407	577405	RD	0,05	390

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Opende	Soilmap:	

Opende einde boring op 390: zand scherpe overgang op 370

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr										zandig, doorw, ger
20		V1	plr	dbr										zandig, doorw, ger
30		V1	plr	dbr										zandig, doorw, ger
40		V1	plr	dbr										zandig, doorw, ger
50		V3	plr	dbr			150-210							zacht, zegge + hout
60		V3	plr	dbr										veenpluis
70		V3	plr	dbr										veenpluis
80		V3	plr	dbr										veenpluis
90		V3	plr	dbr										veenpluis
100		V3	plr	dbr										veenpluis
110		V3	plr	dbr										veenpluis
120		V3	plr	dbr										veenpluis
130		V3	plr	dbr										veenpluis
140		V3	plr	dbr										veenpluis
150		V3	plr	dbr										veenpluis
160		V3	plr	dbr										veenpluis
170		V3	plr	dbr										veenpluis
180		V3	plr	dbr										veenpluis
190		V3	plr	dbr										veenpluis
200		V3	plr	dbr										veenpluis
210		V3	plr	br										veenpluis, zegge
220		V3	plr	br										veenpluis, zegge
230		V3	plr	br										veenpluis, zegge
240		V3	plr	br										veenpluis, zegge
250		V3	plr	br										veenpluis, zegge
260		V3	plr	br										veenpluis, zegge
270		V3	plr	dbr										homogeen
280		V3	plr	br										homogeen
290		V3	plr	br										homogeen
300		V3	plr	br										homogeen
310		V3	plr	br										homogeen
320	ZFZ			brgr			105-150							humeus, licht gelaagd
330		V3	plr	br										zegge
340		V3	plr	br										zegge
350		V3	plr	lbr										veenpluis, zegge, takjes(?)
360		V3	plr	lbr										veenpluis, zegge, takjes(?)
370	MZ			gr			210-300							
380	MZ						210-300							
390	MZ						210-300							

Base of borehole: 201107032

Borehole: 201107033	Names: A&R	Year: 2011	Group: 07	Date: 14-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
210403	577419	RD	-0,05	440

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep:
Vegetation-map: Opende	Soilmap:

Opende einde boring op 440 - teveel zand

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ		plr	dbr			150-210							ger, doorw, hum
20	FZ		plr	dbr			150-210							ger, doorw, hum
30		V3	plr	dbr										
40		V3	plr	dbr										
50		V3	plr	dbr										
60		V3	plr	dbr										
70		V3	plr	dbr										veenpluis
80		V3	plr	dbr										veenpluis
90		V3	plr	dbr										veenpluis
100		V3	plr	br										veenpluis (mos, zegge)
110		V3	plr	br										veenpluis (mos, zegge)
120		V3	plr	br										veenpluis (mos, zegge)
130		V3	plr	br										veenpluis (mos, zegge)
140		V3	plr	br										veenpluis (mos, zegge)
150		V3	plr	br										veenpluis (mos, zegge)
160		V3	plr	br										veenpluis (mos, zegge)
170		V3	plr	br										veenpluis (mos, zegge)
180		V3	plr	lbr										zegge (veenpluis)
190		V3	plr	lbr										zegge (veenpluis)
200		V3	plr	lbr										zegge (veenpluis)
210		V3	plr	br										homogeen
220		V3	plr	br										homogeen
230		V3	plr	br										homogeen
240		V3	plr	br										homogeen
250		V3	plr	br										homogeen
260		V3	plr	br										homogeen
270		V3	plr	br										homogeen
280		V3	plr	br										homogeen
290		V3	plr	br										homogeen
300		V3	plr	br										homogeen
310		V3	plr	br										homogeen
320		V3	plr	br										homogeen
330	ZFZ			brgr			105-150							humeus, beetje gelaagd
340		V3	plr	br										homogeen, zegge
350		V3	plr	br										homogeen, zegge
360		V3	plr	br										homogeen, zegge
370		V3	plr	lbr										gelaagd, zegge
380		V3	plr	lbr										gelaagd, zegge
390		V3	plr	lbr										gelaagd, zegge
400	MZ			gr			300-420							
410	MZ			gr			300-420							
420	MZ			gr			300-420							
430	MZ			gr			300-420							
440	MZ			gr			300-420							

Base of borehole: 201107033

Borehole: 201107034	Names: A&R	Year: 2011	Group: 07	Date: 14-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
210403	577434	RD	0,08	400

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep:
Vegetation-map: Opende	Soilmap:

Opende einde boring: zand veenpluis tussen zand door bramen op boor.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			dbr			150-210							ger, hum
20	FZ			dbr			150-210							ger, hum
30		V3		zwbr										veraard
40		V3		zwbr										veraard
50		V3	plr	br										doorw. zegge
60		V3	plr	br										doorw. zegge
70		V3	plr	br										veenpluis
80		V3	plr	br										veenpluis
90		V3	plr	br										veenpluis
100		V3	plr	br										veenpluis
110		V3	plr	br										veenpluis
120		V3	plr	br										veenpluis
130		V3	plr	br										veenpluis
140		V3	plr	br										veenpluis
150		V3	plr	br										veenpluis
160		V3	plr	br										veenpluis
170		V3	plr	lbr										zegge, veenpluis
180		V3	plr	lbr										zegge, veenpluis
190		V3	plr	lbr										zegge, veenpluis
200		V3	plr	lbr										zegge, veenpluis
210		V3	plr	dbr										homogeen
220		V3	plr	dbr										homogeen
230		V3	plr	dbr										homogeen
240		V3	plr	dbr										homogeen
250		V3	plr	dbr										homogeen
260		V3	plr	dbr										homogeen
270		V3	plr	br										mos, zegge, meer mos onder
280		V3	plr	br										mos, zegge, meer mos onder
290		V3	plr	br										mos, zegge, meer mos onder
300		V3	plr	lbr										homogeen, zegge
310		V3	plr	lbr										homogeen, zegge
320		V3	plr	lbr										homogeen, zegge
330		V3	plr	lbr										homogeen, zegge
340	MZ			gr			210-300							hum
350	MZ			gr			210-300							hum
360	MZ			gr			210-300							hum
370	MZ			gr			210-300							hum
380	MZ			gr			210-300							hum
390	MZ			gr			210-300							hum
400	MZ			gr			210-300							hum

Base of borehole: 201107034

Borehole: 201107035 Names: A&R Year: 2011 Group: 07 Date: 14-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
210404	577451	RD	0,16	260

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Opende	Soilmap:	

Opende. einde boring: zand

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			dbr			150-210							ger, hum
20	FZ			dbr			150-210							ger, hum
30		V1		zwbr										veraard
40		V1		zwbr										veraard
50		V3	plr	dbr			150-210							zandig, doorw
60		V3	plr	dbr			150-210							zandig, doorw
70		V3	plr	dbr			150-210							zandig, doorw
80		V3	plr	dbr			150-210							zandig, doorw
90		V3	plr	br										zegge
100		V3	plr	br										zegge
110		V3	plr	br										zegge
120		V3	plr	br										zegge
130		V3	plr	br										zegge
140		V3	plr	dbr										
150		V3	plr	dbr										
160	ZFZ			brgr			105-150							humeus, zegge
170		V3	plr	br										homo, onder 20cm comp. 2cm mos
180		V3	plr	br										homo, onder 20cm comp. 2cm mos
190		V3	plr	br										homo, onder 20cm comp. 2cm mos
200		V3	plr	br										homo, onder 20cm comp. 2cm mos
210		V3		lbr										homogeen, zegge, takje onderin
220		V3		lbr										homogeen, zegge, takje onderin
230	MZ			gr			300-420							
240	MZ			gr			300-420							
250	MZ			gr			300-420							
260	MZ			gr			300-420							

Base of borehole: 201107035

Borehole: 201107036 Names: A&R Year: 2011 Group: 07 Date: 14-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
210398	577464	RD	0,44	200

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Opende	Soilmap:	

Opende. Einde boring: nat zand

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	MZ			dbr			210-300							ger
20	MZ			dbr			210-300							ger
30	MZ			dbr			210-300							ger
40	MZ			dbr			210-300							ger
50	MZ			dbr			210-300							ger
60	FZ			orbr			150-210							naar onder lichter naar grbr
70	FZ			orbr			150-210							naar onder lichter naar grbr
80	FZ			orbr			150-210							naar onder lichter naar grbr
90	FZ			orbr			150-210							naar onder lichter naar grbr
100	FZ			orbr			150-210							naar onder lichter naar grbr
110	FZ			orbr			150-210							naar onder lichter naar grbr
120	FZ			orbr			150-210							naar onder lichter naar grbr
130	FZ			orbr			150-210							naar onder lichter naar grbr
140	FZ			grbr			150-210							vuursteen
150	FZ			grbr			150-210							
160	FZ			grbr			150-210							lemig, grind tot 1.5cm
170	FZ			grbr			150-210							lemig, grind tot 1.5cm
180	FZ			grbr			150-210							lemig, grind tot 1.5cm
190	FZ			grbr			150-210							lemig, grind tot 1.5cm
200	FZ			grbr			150-210							lemig, grind tot 1.5cm

Base of borehole: 201107036

Borehole: 201107037	Names: A&R	Year: 2011	Group: 07	Date: 14-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
210400	577458	RD	0,24	210

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Opende	Soilmap:	

Opende. einde boring: zand

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10				dbr										ger. zand
20				dbr										ger. zand
30		V3	plr	dbr			150-210							naar onder meer plr en bruiner
40		V3	plr	dbr			150-210							naar onder meer plr en bruiner
50		V3	plr	dbr			150-210							naar onder meer plr en bruiner
60		V3	plr	dbr			150-210							naar onder meer plr en bruiner
70		V3	plr	br										zegge
80		V3	plr	br										homogeen, iets zandig
90		V3	plr	br										homogeen, iets zandig
100	ZFZ			grbr			105-150							humeus
110		V3	plr	br										mos, naar onderen meer
120		V3	plr	br										mos, naar onderen meer
130		V3	plr	br										mos, naar onderen meer
140		V3	plr	br										mos, naar onderen meer
150		V3	plr	br										mos, naar onderen meer
160		V3	plr	lbr										zegge, beetje gelaagd
170		V3	plr	lbr										zegge, beetje gelaagd
180		V3	plr	lbr										zegge, beetje gelaagd
190	MZ			gr			210-300							<2% grind 2mm
200	MZ			gr			210-300							<2% grind 2mm
210	MZ			gr			210-300							<2% grind 2mm

Base of borehole: 201107037

Borehole: 201107061 Names: R&A Year: 2011 Group: 07 Date: 27-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
248908	530842	RD	12,88	180

MAP LEGEND CODE		Geomorphogenetical map:	Pingo
Geological map:		Groundwaterstep: 120	
Vegetation-map: SS I		Soilmap:	

Sleenerstroom I (oost). Enno's pingo. Verwachting, op randwal.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			br			150-210							GER. iets lemig.
20	FZ			br			150-210							GER. iets lemig.
30	FZ			br			150-210							GER. iets lemig.
40	ZFZ			lbr			105-150		2					iets lemig
50	ZFZ			lbr			105-150		2					iets lemig
60	ZFZ		plr	lgrbr			105-150		2					iets lemig
70	ZFZ		plr	lgrbr			105-150		2					iets lemig
80	ZFZ		plr	lgrbr			105-150		2					iets lemig
90	ZFZ		plr	lgrbr			105-150		2					iets lemig
100	FZ		plr	grbr			150-210		2					heel iets lemig
110	FZ		plr	grbr			150-210		2					heel iets lemig
120	FZ		plr	grbr			150-210		2					heel iets lemig
130	FZ		plr	grbr			150-210		2					heel iets lemig
140	L		plr	gr										br vlekken. iets zandig
150	L		plr	gr										br vlekken. iets zandig
160	L		plr	gr										br vlekken. iets zandig
170	L		plr	gr										br vlekken. iets zandig
180	L		plr	gr										einde boring. gat valt dicht

Base of borehole: 201107061

Borehole: 201107062	Names: R&A	Year: 2011	Group: 07	Date: 27-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 100	
248935	530836	RD	12,82	160	Vegetation-map: SS I	Soilmap:	

Sleenerstroom I (oost)

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ		plr	br			150-210							GER. huneus. doorw.
20	FZ		plr	br			150-210							GER. huneus. doorw.
30	FZ		plr	br			150-210							GER. huneus. doorw.
40	FZ		plr	robr			150-210							GER. huneus. doorw.
50	FZ		plr	robr			150-210							GER. huneus. doorw.
60		V1	plr	zw										laklaag
70	FZ			lbr		2	150-210		2					iets lemig. homogeen. soms org
80	FZ			lbr		2	150-210		2					iets lemig. homogeen. soms org
90	FZ			lbr		2	150-210		2					iets lemig. homogeen. soms org
100	FZ			lbr		2	150-210		2					iets lemig. homogeen. soms org
110	FZ			lbr		2	150-210		2					iets lemig. homogeen. soms org
120	FZ			lbr		2	150-210		2					iets lemig. homogeen. soms org
130	FZ			lbr		2	150-210		2					iets lemig. homogeen. soms org
140	FZ			lbr		2	150-210		2					iets lemig. homogeen. soms org
150	L			gr										iets zandig
160	L			gr										einde boring. gat valt dicht.

Base of borehole: 201107062

Borehole: 201107063 Names: R&A Year: 2011 Group: 07 Date: 27-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
248957	530838	RD	12,64	120

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 60
Vegetation-map: SS I	Soilmap:

Sleenerstroom I (oost).

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr										veraard. ger. doorw. iets zand
20		V1	plr	dbr										veraard. ger. doorw. iets zand
30		V1	plr	dbr										veraard. ger. doorw. iets zand
40		V1	plr	dbr										veraard. ger. doorw. iets zand
50		V3		zw										laklaag. homogeen
60		V3	plr	brgr										zandig.
70		V3	plr	brgr										zandig.
80		V3	plr	br										houtje. gy-achtig
90		V3	plr	br										houtje. gy-achtig
100	FZ		plr	gr		2	150-210							houtjes. lemig.
110	FZ		plr	gr		2	150-210							houtjes. lemig.
120	FZ		plr	gr		2	150-210							einde boring. te zandig

Base of borehole: 201107063

Borehole: 201107064	Names: R&A	Year: 2011	Group: 07	Date: 27-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 60	
248983	530837	RD	12,48	210	Vegetation-map: SS I	Soilmap:	

Sleenerstroom I (oost).

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										GER. doorw.
20		V3	plr	br										GER. doorw.
30		V3	plr	br										GER. doorw.
40		V3	plr	br										boom
50		V3	plr	br										GER. doorw.
60		V3	plr	br										GER. doorw.
70		V3		zw										laklaag. homogeen
80		V3	plr	lbr										hout. zandig.gy-achtig
90		V3	plr	lbr										hout. zandig.gy-achtig
100		V3	plr	dbr										houtresten. iets zandig
110		V3	plr	dbr										houtresten. iets zandig
120		V3	plr	dbr										houtresten. iets zandig
130		V3	plr	dbr										houtresten. iets zandig
140		V3	plr	dbr										houtresten. iets zandig
150		V3	plr	dbr										houtresten. iets zandig
160		V3	plr	dbr										houtresten. iets zandig
170		V3	plr	dbr										homogeen. iets compacter
180		V3	plr	grbr										zandig
190		V3	plr	br										doorw. zandig
200		V3	plr	dbr										grof detr. gy? scherpe ovrgng
210	FZ			gr		2	150-210							einde borign. lemig zand.

Base of borehole: 201107064

Borehole: 201107065	Names: A&R	Year: 2011	Group: 07	Date: 27-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: >60	
249008	530832	RD	12,3	340	Vegetation-map: SS I	Soilmap:	

Sleenerstroom I (oost)

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										geroerd, doorworteld
20		V3	plr	dbr										geroerd, doorworteld
30		V3	plr	dbr										geroerd, doorworteld
40		V3	plr	dbr										geroerd, doorworteld
50		V3		zw								+		homogeen, tot 55cm
60		V3		grbr										laminae, zandig 105-150
70		V3		grbr										laminae, zandig 105-150
80		V3		grbr										laminae, zandig 105-150
90		V3		grbr										laminae, zandig 105-150
100		V3		grbr										laminae, zandig 105-150
110		V3		grbr										laminae, zandig 105-150
120		V3		grbr										laminae, zandig 105-150
130		V3		grbr										laminae, zandig 105-150
140		V3		grbr										laminae, zandig 105-150
150		V3		grbr										laminae, zandig 105-150
160		V3		grbr										laminae, zandig 105-150
170		V3	plr	br										grof detr. gy-8ig, rood zaadje
180		V3	plr	br										grof detr. gy-8ig, rood zaadje
190		V3	plr	br										grof detr. gy-8ig, rood zaadje
200		V3	plr	br										grof detr. gy-8ig, rood zaadje
210		V3	plr	br										grof detr. gy-8ig, rood zaadje
220		V3	plr	br										grof detr. gy-8ig, rood zaadje
230		V3	plr	br										smeuïg, mos
240		V3	plr	br										smeuïg, mos
250		V3	plr	br										smeuïg, mos
260		V3	plr	gnbr										zandig, laminae gegn/gnbr, gy?
270		V3	plr	gnbr										zandig, laminae gegn/gnbr, gy?
280		V3	plr	gnbr										zandig, laminae gegn/gnbr, gy?
290		V3	plr	gnbr										zandig, laminae gegn/gnbr, gy?
300		V3	plr	gnbr										onderin zegge
310		V3	plr	br										zandig, zegge
320		V3		gnbr										gummy, geen breekrichting, gy?
330	FZ			gr			150-210							iets lemig, grind 2-5mm
340	FZ			gr			150-210							einde boring, zand

Base of borehole: 201107065

Borehole: 201107066 Names: A&R Year: 2011 Group: 07 Date: 27-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 60	
249034	530839	RD	12,27	490	Vegetation-map: SS I	Soilmap:	

Sleenerstroom I houtje 220

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	br										zandig, geroerd, doorw
20		V1	plr	br										zandig, geroerd, doorw
30		V3	plr	dbr										
40		V3	plr	dbr										
50		V3	plr	dbr										
60		V3	plr	dbr										
70		V3	plr	dbr										
80		V3	plr	dbr										
90		V3	plr	dbr										
100		V3		br										homogeen, doorw
110		V3		br										homogeen, doorw
120		V3		br										homogeen, doorw
130		V3		br										homogeen, doorw
140		V3		grbr										v.a. 145, zeer zandig 105-150
150		V3	plr	lbr										doorw, zandige laminae, doorw
160		V3	plr	lbr										doorw, zandige laminae, doorw
170		V3	plr	lbr										doorw, zandige laminae, doorw
180		V3	plr	lbr										doorw, zandige laminae, doorw
190		V3	plr	lbr										doorw, zandige laminae, doorw
200		V3	plr	lbr										doorw, zandige laminae, doorw
210		V3	plr	lbr										doorw, zandige laminae, doorw
220		V3	plr	lbr										doorw, zandige laminae, doorw
230		V3	plr	lbr										doorw, zandige laminae, doorw
240		V3	plr	lbr										doorw, zandige laminae, doorw
250		V3	plr	br										iets zandig, compact, grof gy
260		V3	plr	br										iets zandig, compact, grof gy
270		V3	plr	br										iets zandig, compact, grof gy
280		V3	plr	br										iets zandig, compact, grof gy
290		V3	plr	br										iets zandig, compact, grof gy
300		V3	plr	br										iets zandig, compact, grof gy
310		V3	plr	br										iets zandig, compact, grof gy
320		V3	plr	br										iets zandig, compact, grof gy
330		V3	plr	br										iets zandig, compact, grof gy
340		V3	plr	br										iets zandig, compact, grof gy
350		V3	plr	br										iets zandig, compact, grof gy
360		V3	plr	br										iets zandig, compact, grof gy
370		V3	plr	br										iets zandig, compact, grof gy
380		V3	plr	br										iets zandig, compact, grof gy
390		V3	plr	br										iets zandig, compact, grof gy
400		V3		gnbr										gnbr/gebr laminae, fijne gy
410		V3		gnbr										idem, witte stippen geen kalk
420		V3		gnbr										idem laminae niet alles hor.
430		V3		gnbr										idem
440		V3	plr	br										zegge, gy achtig
450		V3	plr	br										zegge, gy achtig
460		V3	plr	br										zegge, gy achtig
470	ZFZ			gr		2	105-150							iets lemig
480	ZFZ			gr		2	105-150							iets lemig
490	ZFZ			gr		2	105-150							iets lemig

Base of borehole: 201107066

Borehole: 201107067 Names: A&R Year: 2011 Group: 07 Date: 27-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep:	
249054	530846	RD	12,28	510	Vegetation-map: SS I	Soilmap:	

Sleenerstroom I

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										veraard, geroerd
20		V3	plr	br										veraard, geroerd
30		V3	plr	br										veraard, geroerd
40		V3	plr	br										veraard, geroerd
50		V3	plr	br										veraard, geroerd
60		V3	plr	br										veraard, geroerd
70		V3	plr	br										zegge, doorworteld
80		V3	plr	br										zegge, doorworteld
90		V3	plr	br										zegge, doorworteld
100		V3	plr	br										zegge, doorworteld
110		V3	plr	lbr										zeer zandig
120		V3	plr	lbr										zeer zandig
130		V3	plr	lbr										zeer zandig
140		V3	plr	lbr										zeer zandig
150		V3	plr	lbr										zeer zandig
160		V3		br										laminae grbr zand 75-105
170		V3		br										laminae grbr zand 75-105
180		V3		br										laminae grbr zand 75-105
190		V3		br										zandig, minder naar onder
200		V3		br										zandig, minder naar onder
210		V3		br										zandig, minder naar onder
220		V3		br										zandig, minder naar onder
230		V3		br										zandig, minder naar onder
240		V3		br										zandig, minder naar onder
250		V3	plr	br				0						zegge witte stipjes, grof gy?
260		V3	plr	br				0						zegge witte stipjes, grof gy?
270		V3	plr	br				0						zegge witte stipjes, grof gy?
280		V3	plr	br				0						zegge witte stipjes, grof gy?
290		V3	plr	br				0						zegge witte stipjes, grof gy?
300		V3	plr	br				0						zegge witte stipjes, grof gy?
310		V3	plr	br				0						zegge witte stipjes, grof gy?
320		V3	plr	br				0						zegge witte stipjes, grof gy?
330		V3	plr	br				0						zegge witte stipjes, grof gy?
340		V3	plr	br				0						zegge witte stipjes, grof gy?
350		V3	plr	br				0						zegge witte stipjes, grof gy?
360		V3	plr	br				0						zegge witte stipjes, grof gy?
370		V3	plr	br				0						zegge witte stipjes, grof gy?
380		V3	plr	br				0						zegge witte stipjes, grof gy?
390		V3	plr	br				0						zegge witte stipjes, grof gy?
400		V3	plr	br				0						zegge witte stipjes, grof gy?
410		V3	plr	br				0						zegge witte stipjes, grof gy?
420		V3		gegr										laminae, wit stipjes zandig gy
430		V3		gegr										laminae, wit stipjes zandig gy
440		V3		gegr										laminae, wit stipjes zandig gy
450		V3		gegr										laminae, wit stipjes zandig gy
460		V3		gegr										laminae, wit stipjes zandig gy
470		V3		gegr										laminae, wit stipjes zandig gy
480		V3	plr	br										zandig
490	FZ			gr			150-210							grindje
500	FZ			gr			150-210							grindje
510	FZ			gr			150-210							einde boring, boor zit vast

Base of borehole: 201107067

Borehole: 201107068	Names: A&R	Year: 2011	Group: 07	Date: 27-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
249077	530855	RD	12,34	440

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: SS I	Soilmap:	

Sleenerstroom I zwarte horizont van 110 tot 111cm

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr										zandig, veraard, doorw. ger
20		V1	plr	dbr										zandig, veraard, doorw. ger
30		V1	plr	dbr										zandig, veraard, doorw. ger
40		V3	plr	dbr										mos
50		V3	plr	dbr										mos
60		V3	plr	dbr										mos
70		V3	plr	dbr										mos
80		V3	plr	dbr										mos
90		V3	plr	dbr										mos
100		V3	plr	dbr										mos
110		V3	plr	lbr										zw horizont, dro zaadjes
120		V3	plr	lbr										dro zaadjes
130		V3	plr	lbr										dro zaadjes
140		V3		lbr										dro zaadjes
150		V3		lbr										dro zaadjes
160		V3		lbr										dro zaadjes
170		V3	plr	br										witte stippen, grof gy, zegge
180		V3	plr	br										witte stippen, grof gy, zegge
190		V3	plr	br										witte stippen, grof gy, zegge
200		V3	plr	br										witte stippen, grof gy, zegge
210		V3	plr	br										witte stippen, grof gy, zegge
220		V3	plr	br										witte stippen, grof gy, zegge
230		V3	plr	br										witte stippen, grof gy, zegge
240		V3	plr	br										witte stippen, grof gy, zegge
250		V3	plr	br										witte stippen, grof gy, zegge
260		V3	plr	br										witte stippen, grof gy, zegge
270		V3	plr	br										witte stippen, grof gy, zegge
280		V3	plr	br										witte stippen, grof gy, zegge
290		V3	plr	br										witte stippen, grof gy, zegge
300		V3	plr	br										witte stippen, grof gy, zegge
310		V3	plr	br										witte stippen, grof gy, zegge
320		V3	plr	br										witte stippen, grof gy, zegge
330		V3	plr	br										witte stippen, grof gy, zegge
340		V3	plr	br										witte stippen, grof gy, zegge
350		V3	plr	br										witte stippen, grof gy, zegge
360		V3	plr	br										witte stippen, grof gy, zegge
370		V3	plr	br										witte stippen, grof gy, zegge
380		V3	plr	br										witte stippen, grof gy, zegge
390		V3	plr	br										witte stippen, grof gy, zegge
400		V3		gnbr										laminae, zandig, witte stippen
410		V3		gnbr										laminae, zandig, witte stippen
420		V3		grbr										zandig, zegge onderin, gy
430	ZFZ			gr			105-150							zeer lemig, grens op 435
440	ZFZ			gr			105-150							einde boring, zand

Base of borehole: 201107068

Borehole: 201107069	Names: R&A	Year: 2011	Group: 07	Date: 27-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE		Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:		Groundwaterstep:	
249107	530833	RD	12,47	410	Vegetation-map: SS I		Soilmap:	

Sleenerstroom I (oost). monster 390 (schoonmaken!)

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr										zandig. veraard veen. GER. doo
20		V1	plr	dbr										zandig. veraard veen. GER. doo
30		V1	plr	dbr										zandig. veraard veen. GER. doo
40		V3	plr	dbr										takjes
50		V3	plr	dbr										takjes
60		V3	plr	dbr										takjes
70		V3	plr	dbr										takjes
80		V3	plr	dbr										takjes
90		V3	plr	dbr										takjes
100		V3		lbr										zand laminae(lbrgr). zandig
110		V3		lbr										zand laminae(lbrgr). zandig
120		V3		lbr										zand laminae(lbrgr). zandig
130		V3		lbr										zand laminae(lbrgr). zandig
140		V3		lbr										zand laminae(lbrgr). zandig
150		V3		lbr										zand laminae(lbrgr). zandig
160		V3		lbr										zand laminae(lbrgr). zandig
170		V3		lbr										zand laminae(lbrgr). zandig
180		V3		lbr										zand laminae(lbrgr). zandig
190		V3		lbr										zand laminae(lbrgr). zandig
200		V3		lbr										zand laminae(lbrgr). zandig
210		V3	plr	br										grof detr gy. wit spikk. zegge
220		V3	plr	br										grof detr gy. wit spikk. zegge
230		V3	plr	br										grof detr gy. wit spikk. zegge
240		V3	plr	br										grof detr gy. wit spikk. zegge
250		V3	plr	br										idem. zandig
260		V3	plr	br										idem. zandig
270		V3	plr	br										idem. zandig
280		V3	plr	br										idem. zandig
290		V3	plr	br										idem. zandig
300		V3	plr	br										idem. zandig
310		V3	plr	br										idem. zandig
320		V3	plr	br										idem. zandig
330		V3	plr	br										idem. zandig
340		V3	plr	br										idem. zandig
350		V3	plr	br										idem. zandig
360		V3		gnbr										glbr laminae. fijn detr gy
370		V3		gnbr										glbr laminae. fijn detr gy
380		V3		gnbr										glbr laminae. fijn detr gy
390		V3		gnbr										glbr laminae. fijn detr gy
400		V3		br										gy?? zegge. monster.
410	FZ			gr			150-210							lemig. einde boring.

Base of borehole: 201107069

Borehole: 201107080	Names: A&R	Year: 2011	Group: 07	Date: 29-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
249044	530862	RD	12,38	450

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: SS I	Soilmap:	

Sleenerstroom I einde boring: grind

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1												
20		V1												
30		V3	plr	dbr										hout
40		V3	plr	dbr										hout
50		V3	plr	dbr										hout
60		V3	plr	dbr										hout
70		V3	plr	dbr										hout
80		V3	plr	dbr										hout
90		V3	plr	dbr										hout
100		V3	plr	dbr										hout
110		V3		grbr			75-105							zandlaagjes, zandig onder meer
120		V3		grbr			75-105							zandlaagjes, zandig onder meer
130		V3		grbr			75-105							zandlaagjes, zandig onder meer
140		V3		grbr			75-105							zandlaagjes, zandig onder meer
150		V3		grbr			75-105							zandlaagjes, zandig onder meer
160		V3		grbr			75-105							zandlaagjes, zandig onder meer
170		V3		grbr			75-105							zandlaagjes, zandig onder meer
180	ZK			br										zandig, vivianiet
190	ZK			br										zandig, vivianiet
200	ZK			br										zandig, vivianiet
210	ZK			br										zandig, vivianiet
220	ZK			br										zandig, vivianiet
230	ZK			br										zandig, vivianiet
240	ZK			br										iets zandig, vivianiet
250	ZK			br										iets zandig, vivianiet
260	ZK			br										iets zandig, vivianiet
270	ZK			br										iets zandig, vivianiet
280	ZK			br										iets zandig, vivianiet
290	ZK			br										iets zandig, vivianiet
300	ZK			br										iets zandig, vivianiet
310	ZK			br										iets zandig, vivianiet
320	ZK			br										iets zandig, vivianiet
330	ZK			br										iets zandig, vivianiet
340	ZK			br										iets zandig, vivianiet
350	ZK			br										iets zandig, vivianiet
360	LK			gngr										zandig
370	LK			gngr										zandig
380	LK			gngr										zandig
390	LK			gngr										zandig
400	LK			gngr										zandig
410	LK			gngr										zandig
420	LK			gngr										zandig
430	LK			dbr										zandig
440	LK			dbr										zandig
450	MZ			gr			219-300							met grind, einde boring

Base of borehole: 201107080

Borehole: 201107081	Names: A&R	Year: 2011	Group: 07	Date: 29-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep:	
249046	530882	RD	12,4	420	Vegetation-map: SS I	Soilmap:	

Sleenerstroom I zandig veen van 100 begint op 95

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		dbr										
20		V1		dbr										
30		V1		dbr										
40		V3	plr	br										bosveen
50		V3	plr	br										bosveen
60		V3	plr	br										bosveen
70		V3	plr	br										bosveen
80		V3	plr	br										bosveen
90		V3	plr	br										bosveen
100		V3		grbr										zandig
110		V3		grbr										zandig
120		V3		brgr			75-105							sterk zandig, zandlaagjes
130		V3		brgr			75-105							sterk zandig, zandlaagjes
140		V3		brgr			75-105							sterk zandig, zandlaagjes
150		V3		brgr			75-105							sterk zandig, zandlaagjes
160	ZK			br										iets zandig, vivianiet
170	ZK			br										iets zandig, vivianiet
180	ZK			br										iets zandig, vivianiet
190	ZK			br										iets zandig, vivianiet
200	ZK			br										iets zandig, vivianiet
210	ZK			br										iets zandig, vivianiet
220	ZK			br										iets zandig, vivianiet
230	ZK			br										iets zandig, vivianiet
240	ZK			br										iets zandig, vivianiet
250	ZK			br										iets zandig, vivianiet
260	ZK			br										iets zandig, vivianiet
270	ZK			br										iets zandig, vivianiet
280	ZK			br										iets zandig, vivianiet
290	ZK			br										iets zandig, vivianiet
300	ZK			br										iets zandig, vivianiet
310	LK			gngr										zandig, gelaagd
320	LK			gngr										zandig, gelaagd
330	LK			gngr										zandig, gelaagd
340	LK			lgngr										gelaagd (zandig/sterk zandig)
350	LK			lgngr										gelaagd (zandig/sterk zandig)
360	LK			lgngr										gelaagd (zandig/sterk zandig)
370	LK			dgngr										sterk zandig
380	LK			br										zandig
390	LK			gnbr										sterk zandig, zegge
400	FZ			gr			150-210							met grind 1 cm
410	FZ			gr			150-210							met grind 1 cm
420	FZ			gr			150-210							met grind 1 cm, einde boring

Base of borehole: 201107081

Borehole: 201107082 Names: A&R Year: 2011 Group: 07 Date: 29-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep:	
249065	530877	RD	12,34	400	Vegetation-map: SS I	Soilmap:	

Sleenerstroom I scherpe overgang op 110 overgang van 390 zat op 385 einde boring op 405

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		dbr										zandig
20		V1		dbr										zandig
30		V3		dbr										hout
40		V3		dbr										hout
50		V3		dbr										hout
60		V3		dbr										hout
70		V3		dbr										hout
80		V3		dbr										hout
90		V3		dbr										hout
100		V3		dbr										hout
110		V3		grbr										zandig
120		V3		grbr										zandig
130		V3		grbr										sterk zandig, gelaagd
140		V3		grbr										sterk zandig, gelaagd
150		V3		grbr										sterk zandig, gelaagd
160		V3		br										iets zandig
170		V3		br										iets zandig
180		V3		br										iets zandig
190		V3		br										iets zandig
200		V3		br										rond 200 minder zandig
210		V3		br										iets zandig
220		V3		br										iets zandig
230		V3		br										iets zandig
240		V3		br										iets zandig
250		V3		br										iets zandig
260	ZK			br										
270	ZK			br										
280	ZK			br										
290	ZK			br										
300	ZK			br										
310	ZK			br										
320	ZK			br										
330	ZK			br										
340	ZK			br										
350		V3		lbr										zandig
360	LK			lgngr										olijfkleuren
370	LK			lgngr										olijfkleuren
380	LK			lgngr										olijfkleuren
390	LK			gnbr										sterk zandig
400	LK			gnbr										sterk zandig, 405 zand gevoeld

Base of borehole: 201107082

Borehole: 201107083 Names: A&R Year: 2011 Group: 07 Date: 29-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
249060	530829	RD	12,26	560

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: SS I	Soilmap:	

Sleenerstroom I houtrandje op 125 sterk zandige gy van 190 is naar onder minder gelaagd grof detr. gy vanaf 250 rondom 360 minder zandig, betula nana

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		dbr										zandig
20		V1		dbr										zandig
30		V1		dbr										zandig
40		V3	plr	dbr										houtresten
50		V3	plr	dbr										houtresten
60		V3	plr	dbr										houtresten
70		V3	plr	dbr										houtresten
80		V3	plr	dbr										houtresten
90	ZK		plr	br										rood zaadje, zegge
100	ZK		plr	br										rood zaadje, zegge
110	ZK		plr	br										rood zaadje, zegge
120	ZK		plr	br										rood zaadje, zegge
130	LK			grbr										sterk zandig
140	LK			grbr										sterk zandig
150	LK			grbr										sterk zandig
160	LK			grbr										sterk zandig
170	LK			grbr										sterk zandig
180	LK			grbr										sterk zandig
190	LK			lbrgr										sterk zandig, gelaagd
200	LK			lbrgr										sterk zandig, gelaagd
210	LK			lbrgr										sterk zandig, gelaagd
220	LK			lbrgr										sterk zandig, gelaagd
230	LK			lbrgr										sterk zandig, gelaagd
240	LK			lbrgr										sterk zandig, gelaagd
250	ZK			br										zandig, vivianiet, rood zaadje
260	ZK			br										zandig, vivianiet, rood zaadje
270	ZK			br										zandig, vivianiet, rood zaadje
280	ZK			br										zandig, vivianiet, rood zaadje
290	ZK			br										zandig, vivianiet, rood zaadje
300	ZK			br										zandig, vivianiet, rood zaadje
310	ZK			br										zandig, vivianiet, rood zaadje
320	ZK			br										zandig, vivianiet, rood zaadje
330	ZK			br										zandig, vivianiet, rood zaadje
340	ZK			br										zandig, vivianiet, rood zaadje
350	ZK			br										zandig, vivianiet, rood zaadje
360	ZK			br										zandig, vivianiet, rood zaadje
370	ZK			br										zandig, vivianiet, rood zaadje
380	ZK			br										zandig, vivianiet, rood zaadje
390	ZK			br										zandig, vivianiet, rood zaadje
400	ZK			br										zandig, vivianiet, rood zaadje
410	ZK			br										zandig, vivianiet, rood zaadje
420	ZK			br										zandig, vivianiet, rood zaadje
430	ZK			br										zandig, vivianiet, rood zaadje
440	ZK			br										zandig, vivianiet, rood zaadje
450	ZK			br										zandig, vivianiet, rood zaadje
460	LK			gnbr										zeer zandig, laminae, sideriet
470	LK			gnbr										zeer zandig, laminae, sideriet
480	LK			gnbr										zeer zandig, laminae, sideriet
490	LK			gnbr										zeer zandig, laminae, sideriet
500	LK			gnbr										zeer zandig, laminae, sideriet
510	LK			gnbr										zeer zandig, laminae, sideriet
520	LK			gnbr										zeer zandig, laminae, sideriet
530	LK			gnbr										zeer zandig, laminae, sideriet
540	LK			gnbr										zeer zandig, laminae, sideriet
550	FZ			gr			150-210							
560	FZ			gr			150-210							einde boring

Base of borehole: 201107083

Borehole: 201107084		Names: A&R			Year: 2011	Group: 07		Date: 29-9-2011
Coordinates			Elevation	Depth	MAP LEGEND CODE		Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:		Groundwaterstep:	
249070	530829	RD	12,37	620	Vegetation-map: SS I		Soilmap:	

Sleenerstroom I Locatie klopt niet! Coordinaten zijn willekeurig aangepaste coordinaten van 2011 07 083 stonden niet genoteerd

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		dbr										ger, veraard
20		V1		dbr										ger, veraard
30		V1		dbr										ger, veraard
40		V3	plr	dbr										hout
50		V3	plr	dbr										hout
60		V3	plr	dbr										hout
70		V3	plr	dbr										hout
80		V3	plr	br										hout
90		V3	plr	br										hout
100	ZK			br										zandig
110	ZK			br										zandig
120	ZK			br										zandig
130	ZK			br										zandig
140	ZK			grbr										zandig, scherpe overgang
150	ZK			grbr										zandig, scherpe overgang
160	ZK			grbr										zandig, scherpe overgang
170	ZK			grbr										zandig, scherpe overgang
180	ZK			grbr										zandig, scherpe overgang
190	ZK			grbr										zandig, scherpe overgang
200	LK			grbr										zandig, laminae
210	LK			grbr										zandig, laminae
220	LK			grbr										zandig, laminae
230	LK			grbr										zandig, laminae
240	LK			grbr										zandig, laminae
250	LK			grbr										zandig, laminae
260	LK			br										iets zandig, witte puntjes
270	LK			br										iets zandig, witte puntjes
280	LK			br										iets zandig, witte puntjes
290	LK			br										iets zandig, witte puntjes
300	LK			br										iets zandig, witte puntjes
310	LK			br										iets zandig, witte puntjes
320	LK			br										iets zandig, witte puntjes
330	LK			br										iets zandig, witte puntjes
340	LK			br										iets zandig, witte puntjes
350	LK			br										iets zandig, witte puntjes
360	LK			br										iets zandig, witte puntjes
370	LK			br										iets zandig, witte puntjes
380	LK			br										iets zandig, witte puntjes
390	LK			br										iets zandig, witte puntjes
400	LK			br										iets zandig, witte puntjes
410	LK			br										iets zandig, witte puntjes
420	LK			br										iets zandig, witte puntjes
430	LK			br										iets zandig, witte puntjes
440	LK			br										iets zandig, witte puntjes
450	LK			br										witte puntjes, zegge
460	LK			br										witte puntjes, zegge
470	LK			br										witte puntjes, zegge
480	LK			br										witte puntjes, zegge
490	LK			br										witte puntjes, zegge
500	LK			br										witte puntjes, zegge
510	LK			br										witte puntjes, zegge
520	LK			br										witte puntjes, zegge
530	LK			br										witte puntjes, zegge
540	LK			gnbr										witte puntjes, LAMINAE, zandig
550	LK			gnbr										witte puntjes, LAMINAE, zandig
560	LK			gnbr										witte puntjes, LAMINAE, zandig
570	LK			gnbr										witte puntjes, LAMINAE, zandig
580	LK			gnbr										witte puntjes, LAMINAE, zandig
590	LK			gnbr										witte puntjes, LAMINAE, zandig
600	LK			br										zandig, mos

Boring: 201107084

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
610	FZ			gr			150-210							
620	FZ			gr			150-210							einde boring

Base of borehole: 201107084

Borehole: 201107070	Names: R&A	Year: 2011	Group: 07	Date: 28-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Depressi
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 330	
251820	541257	RD	0	370	Vegetation-map: Bos	Soilmap:	

Lammeer. Op zoek naar een pingo. We boren in het midden van de depressie. Zeer duidelijke 'randwal'.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	ZFZ		plr	dgr			105-150							doorw. bodem
20	ZFZ		plr	dgr			105-150							doorw. bodem
30	ZFZ		plr	dgr			105-150							doorw. bodem
40	ZFZ		plr	br			105-150							humeus. bodem
50	ZFZ		plr	lbr			105-150							humeus. bodem
60	ZFZ		plr	lbr			105-150							humeus. bodem
70	ZFZ		plr	lbr		2	105-150							humeus. bodem
80	ZFZ		plr	lbr		2	105-150							humeus. bodem. donkere vlekken
90	ZFZ		plr	lbr		2	105-150							humeus. bodem
100	ZFZ		plr	lbr		2	105-150							humeus. bodem
110	FZ		plr	lbr		2	150-210							humeus. bodem
120	FZ		plr	lbr		2	150-210							humeus. bodem
130	FZ		plr	lbr		2	150-210							humeus. bodem
140	FZ		plr	lbr		2	150-210							humeus. bodem
150	ZFZ		plr	lbr		2	105-150							iets humeus. bodem
160	ZFZ		plr	lbr		2	105-150							iets humeus. bodem
170	ZFZ		plr	lbr		2	105-150							iets humeus. bodem
180	ZFZ		plr	lbr		2	105-150							iets humeus. bodem
190	ZFZ		plr	lbr		2	105-150							iets humeus. bodem
200	ZFZ		plr	lgrbr		2	105-150							bodem
210	ZFZ		plr	lgrbr		2	105-150							bodem
220	ZFZ		plr	lgrbr		2	105-150							bodem
230	ZFZ		plr	lgrbr		2	105-150							bodem
240	ZFZ		plr	lgrbr		2	105-150							bodem
250	MZ		plr	lgrbr		2	210-300							
260	MZ		plr	lgrbr		2	210-300							
270	MZ		plr	lgrbr		2	210-300							
280	MZ		plr	lgrbr		2	210-300							
290	MZ		plr	lgrbr		2	210-300							
300	MZ		plr	lgrbr		2	210-300							
310	MZ		plr	lgrbr		2	210-300							
320	MZ		plr	lgrbr		2	210-300							
330	MZ		plr	lgrbr		2	210-300			GW				
340	FZ		plr	lgrbr		2	150-210							iets lemig.
350	FZ		plr	lgrbr		2	150-210							iets lemig.
360	FZ		plr	lgrbr		2	150-210							iets lemig.
370	FZ		plr	lgrbr		2	150-210							einde boring. te veel zand.

Base of borehole: 201107070

Borehole: 201107071 Names: R&A Year: 2011 Group: 07 Date: 28-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
246412	537134	RD	16,8	210

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 20
Vegetation-map: Vlierend	Soilmap:

Vlierendijk.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ		plr	dgrbr			150-210							doorw. humeus
20	FZ		plr	dgrbr			150-210							doorw. humeus
30	FZ		plr	dgrbr			150-210							doorw. humeus
40	FZ		plr	dgrbr			150-210							doorw. humeus
50	FZ		plr	dgrbr			150-210							doorw. humeus
60		V3	plr	br										doorw. mos?
70		V3	plr	br										zandig
80		V3	plr	br										zandig
90		V3	plr	lbr										zandig, compacter
100		V3	plr	lbr										zandig, compacter
110		V3	plr	lbr										zandig, compacter
120		V3	plr	lbr										zandig, compacter
130		V3	plr	lbr										zandig, compacter
140		V3		lbrgr										zandig, doorw. smeerbaar
150		V3		lbrgr										zandig, doorw. smeerbaar
160		V3		lbrgr										zandig, doorw. smeerbaar
170		V3		lbrgr										zandig, doorw. smeerbaar
180	FZ			lbrgr		2	150-210							iets lemig.
190	FZ			lbrgr		2	150-210							iets lemig.
200	FZ			lbrgr		2	150-210							iets lemig.
210	FZ			lbrgr		2	150-210							einde boring. zand

Base of borehole: 201107071

Borehole: 201107072	Names: R&A	Year: 2011	Group: 07	Date: 28-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
246444	537126	RD	16,78	480

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 10	
Vegetation-map: Vlierend	Soilmap:	

Vlierendijk.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										doorw. takjes. worteltje.
20		V3	plr	dbr										idem. valt uit guts
30		V3	plr	dbr										idem. valt uit guts
40		V3	plr	dbr										idem. valt uit guts
50		V3	plr	dbr										idem. valt uit guts
60		V3	plr	dbr										idem. valt uit guts
70		V3	plr	dbr										idem. valt uit guts
80		V3	plr	dbr										idem. valt uit guts
90		V3	plr	dbr										idem. valt uit guts
100		V3	plr	dbr										idem. valt uit guts
110		V3	plr	dbr										idem. valt uit guts
120		V3	plr	dbr										idem. valt uit guts
130		V3	plr	dbr										idem. valt uit guts
140		V3	plr	dbr										idem. valt uit guts
150		V3	plr	dbr										idem. valt uit guts
160		V3		br										zegge. veenpluis
170		V3		br										zegge. veenpluis
180		V3		br										zegge. veenpluis
190		V3		br										zegge. veenpluis
200		V3		br										zegge. veenpluis
210		V3		br										zegge. veenpluis
220		V3		br										zegge. veenpluis
230		V3		br										zegge. veenpluis
240		V3		br										zegge. veenpluis
250		V3		br										zegge. veenpluis
260		V3		br										zegge. veenpluis
270		V3		br										zegge. veenpluis
280		V3		br										zegge. veenpluis
290		V3	plr	dgrbr										homoveen. nat&smeerbr.
300		V3	plr	dgrbr										homoveen. nat&smeerbr.
310		V3	plr	dgrbr										homoveen. nat&smeerbr.
320		V3	plr	dgrbr										homoveen. nat&smeerbr.
330		V3	plr	dgrbr										homoveen. nat&smeerbr.
340		V3	plr	dgrbr										homoveen. nat&smeerbr.
350		V3	plr	dgrbr										homoveen. nat&smeerbr.
360		V3	plr	dgrbr										homoveen. nat&smeerbr.
370		V3	plr	dgrbr										homoveen. nat&smeerbr.
380		V3	plr	dgrbr										homoveen. nat&smeerbr.
390		V3	plr	dgrbr										homoveen. nat&smeerbr.
400		V3	plr	dgrbr										homoveen. nat&smeerbr.
410		V3	plr	dgrbr										homoveen. nat&smeerbr.
420		V3	plr	dgrbr										homoveen. nat&smeerbr.
430		V3	plr	dgrbr										einde boring. te nat.
440		V3	plr	gnbr										zegge. zandig
450		V3	plr	gnbr										zegge. zandig
460		V3		gngr										fijne gy
470	FZ			gr		2	150-210							iets lemig
480	FZ			gr		2	150-210							einde boring

Base of borehole: 201107072

Borehole: 201107073	Names: R&A	Year: 2011	Group: 07	Date: 28-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 30	
246465	537114	RD	16,98	750	Vegetation-map: Vlierend	Soilmap:	

Vlierendijk. Diepste punt.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										bosveen. houtjes. doorw.
20		V3	plr	dbr										bosveen. houtjes. doorw.
30		V3	plr	dbr										mosveen. veenpl. takjes
40		V3	plr	dbr										mosveen. veenpl. takjes
50		V3	plr	dbr										mosveen. veenpl. takjes
60		V3	plr	dbr										
70		V3	plr	dbr										
80		V3	plr	dbr										
90		V3	plr	dbr										
100		V3	plr	br										veenpluis!. takjes
110		V3	plr	br										veenpluis!. takjes
120		V3	plr	br										veenpluis!. takjes
130		V3	plr	br										veenpluis!. takjes
140		V3	plr	br										veenpluis!. takjes
150		V3	plr	br										veenpluis!. takjes
160		V3	plr	br										mos? takjes. losse prut
170		V3	plr	br										mos? takjes. losse prut
180		V3	plr	br										mos? takjes. losse prut
190		V3	plr	br										mos? takjes. losse prut
200		V3	plr	br										mos? takjes. losse prut
210		V3	plr	br										mos? takjes. losse prut
220		V3	plr	br										mos? takjes. losse prut
230		V3	plr	br										mos? takjes. losse prut
240		V3	plr	br										mos? takjes. losse prut
250		V3	plr	br										idem. + zegge, veenpluis
260		V3	plr	br										idem. + zegge, veenpluis
270		V3	plr	br										idem. + zegge, veenpluis
280		V3	plr	br										idem. + zegge, veenpluis
290		V3	plr	br										idem. + zegge, veenpluis
300		V3	plr	br										idem. + zegge, veenpluis
310		V3	plr	br										idem. + zegge, veenpluis
320		V3	plr	br										idem. + zegge, veenpluis
330		V3	plr	br										idem. + zegge, veenpluis
340		V3	plr	br										idem. + zegge, veenpluis
350		V3		dgr										homosmurrie. smeerbaar.
360		V3		dgr										homosmurrie. smeerbaar.
370		V3		dgr										homosmurrie. smeerbaar.
380		V3		dgr										homosmurrie. smeerbaar.
390		V3		dgr										homosmurrie. smeerbaar.
400		V3		dgr										homosmurrie. smeerbaar.
410		V3		dgr										homosmurrie. smeerbaar.
420		V3		dgr										homosmurrie. smeerbaar.
430		V3		dgr										homosmurrie. smeerbaar.
440		V3		dgr										homosmurrie. smeerbaar.
450		V3		dgr										homosmurrie. smeerbaar.
460		V3		dgr										homosmurrie. smeerbaar.
470		V3		dgr										homosmurrie. smeerbaar.
480		V3		dgr										homosmurrie. smeerbaar.
490		V3		dgr										homosmurrie. smeerbaar.
500		V3		dgr										homosmurrie. smeerbaar.
510		V3		dgr										homosmurrie. smeerbaar.
520		V3		dgr										homosmurrie. smeerbaar.
530		V3		gnbr										zandige smurrie
540		V3		gnbr										zandige smurrie
550		V3		gnbr										zandige smurrie
560		V3		gnbr										zandige smurrie
570		V3		gnbr										zandige smurrie
580		V3		gnbr										zandige smurrie
590		V3	plr	grbr										zooi
600		V3	plr	grbr										zooi

Boring: 201107073

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
610		V3	plr	dgnbr										gy-achtig. smeer.
620		V3	plr	dgnbr										gy-achtig. smeer.
630		V3	plr	dgnbr										gy-achtig. smeer.
640		V3	plr	dgnbr										gy-achtig. smeer.
650		V3	plr	dgnbr										gy-achtig. smeer.
660		V3	plr	dgnbr										gy-achtig. smeer.
670		V3	plr	dgnbr										gy-achtig. smeer.
680		V3	plr	dbrgr										gy-achtig. smeer. bodempje?
690		V3	plr	lgngr										zegge. zandig.
700		V3	plr	lgngr										idem. naar onder grijzer
710		V3	plr	lgngr										idem. naar onder grijzer
720		V3		lbrgr										gy. zandig. lemig?
730	FZ			gr			150-210							lemig
740	FZ			gr			150-210							lemig
750	FZ			gr			150-210							einde boring. zand!

Base of borehole: 201107073

Borehole: 201107074	Names: R&A	Year: 2011	Group: 07	Date: 28-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
246481	537106	RD	17,07	530

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 10	
Vegetation-map: Vlierend	Soilmap:	

Vlierendijk. Monster op 465 en 475

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	lbr										mosveen
20		V3	plr	lbr										mosveen
30		V3	plr	lbr										mosveen, zegge, rode takjes
40		V3	plr	lbr										mosveen, zegge, rode takjes
50		V3	plr	br										veel plr:takjes/wortl prutveen
60		V3	plr	br										veel plr:takjes/wortl prutveen
70		V3	plr	br										veel plr:takjes/wortl prutveen
80		V3	plr	br										veel plr:takjes/wortl prutveen
90		V3	plr	br										veel plr:takjes/wortl prutveen
100		V3	plr	br										veel plr:takjes/wortl prutveen
110		V3	plr	br										veel plr:takjes/wortl prutveen
120		V3	plr	br										veenpluis! zegge takjes
130		V3	plr	br										veenpluis! zegge takjes
140		V3	plr	br										veenpluis! zegge takjes
150		V3	plr	br										veenpluis! zegge takjes
160		V3	plr	br										veenpluis! zegge takjes
170		V3	plr	br										veenpluis! zegge takjes
180		V3	plr	br										veenpluis! zegge takjes
190		V3	plr	br										veenpluis! zegge takjes
200		V3	plr	br										doorw. takjes.
210		V3	plr	br										doorw. takjes.
220		V3	plr	br										doorw. takjes.
230		V3	plr	br										doorw. takjes.
240		V3	plr	br										doorw. takjes.
250		V3	plr	br										doorw. takjes.
260		V3	plr	br										doorw. takjes.
270		V3	plr	br										doorw. takjes.
280		V3	plr	br										doorw. takjes.
290		V3	plr	dgrbr										smurrie. beetje plr
300		V3	plr	dgrbr										smurrie. beetje plr
310		V3	plr	dgrbr										smurrie. beetje plr
320		V3	plr	dgrbr										smurrie. beetje plr
330		V3	plr	dgrbr										smurrie. beetje plr
340		V3	plr	dgrbr										smurrie. beetje plr
350		V3	plr	dgrbr										smurrie. beetje plr
360	LK		plr	dgnbr										smurrie. zandig gy
370	LK		plr	dgnbr										smurrie. zandig gy
380	LK		plr	dgnbr										smurrie. zandig gy
390	LK		plr	dgnbr										smurrie. zandig gy
400	LK		plr	dgnbr										smurrie. zandig gy
410	LK		plr	dgnbr										smurrie. zandig gy
420	LK		plr	dgnbr										smurrie. zandig gy
430	LK		plr	dgnbr										smurrie. zandig gy
440	LK		plr	dgnbr										smurrie. zandig gy
450	LK		plr	lgnbr										zandige gy
460	LK		plr	lgnbr										zandige gy
470	ZL		plr	lgngr										leem? zeer zandig.smeer.loess?
480	FZ		plr	lgngr		2	150-210							lemig
490	FZ		plr	lgngr		2	150-210							lemig
500	FZ		plr	lgngr		2	150-210							lemig
510	FZ		plr	lgngr		2	150-210							lemig
520	FZ		plr	lgngr		2	150-210							lemig
530	FZ		plr	lgngr		2	150-210							einde boring. te veel zand

Base of borehole: 201107074

Borehole: 201107075 Names: R&A Year: 2011 Group: 07 Date: 28-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
246494	537101	RD	17,02	530

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 30	
Vegetation-map: Vlierend	Soilmap:	

Vlierendijk.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										bosveen. mos. doorw. takjes
20		V3	plr	br										bosveen. mos. doorw. takjes
30		V3	plr	br										bosveen. mos. doorw. takjes
40		V3	plr	br										bosveen. mos. doorw. takjes
50		V3	plr	dbr										takjes. doorw.
60		V3	plr	dbr										takjes. doorw.
70		V3	plr	dbr										takjes. doorw.
80		V3	plr	dbr										takjes. doorw.
90		V3	plr	br										takjes. doorw.
100		V3	plr	br										takjes. doorw.
110		V3	plr	br										takjes. doorw.
120		V3	plr	br										mos
130		V3	plr	br										mos
140		V3	plr	lbr										zeggeveen
150		V3	plr	lbr										zeggeveen
160		V3	plr	lbr										zeggeveen
170		V3	plr	lbr										zeggeveen
180		V3	plr	lbr										zeggeveen
190		V3	plr	lbr										zeggeveen
200		V3	plr	lbr										zeggeveen
210		V3	plr	dgrbr										smurrie takjes. houtjes
220		V3	plr	dgrbr										smurrie takjes. houtjes
230		V3	plr	dgrbr										smurrie takjes. houtjes
240		V3	plr	dgrbr										smurrie takjes. houtjes
250		V3	plr	dgrbr										smurrie takjes. houtjes
260		V3	plr	dgrbr										smurrie takjes. houtjes
270		V3	plr	dgrbr										smurrie takjes. houtjes
280		V3	plr	dgrbr										smurrie takjes. houtjes
290		V3	plr	dgrbr										smurrie takjes. houtjes
300		V3	plr	dgrbr										smurrie takjes. houtjes
310		V3		dgnbr										zandnestje. smurrie. homog
320		V3		dgnbr										smurrie. homogeen.
330		V3		dgnbr										smurrie. homogeen.
340		V3		dgnbr										smurrie. homogeen.
350		V3		dgnbr										smurrie. homogeen.
360		V3		dgnbr										smurrie. homogeen.
370		V3		dgnbr										smurrie. homogeen.
380		V3		dgnbr										smurrie. homogeen.
390		V3		dgnbr										smurrie. homogeen.
400	LK			lgnbr										zandige gy. smeer
410	LK			lgnbr										zandige gy. smeer
420	LK			dgngr										idem. korreliger
430	LK			dgngr										idem. korreliger
440	LK			gngr										zegge gy?
450	LK			gngr										zegge gy?
460	LK			lgngr										zegge. zeer zandig. nr ondr gr
470	LK			lgngr										zegge. zeer zandig. nr ondr gr
480	LK			lgngr										zegge. zeer zandig. nr ondr gr
490	ZL			lgngr										loess? homog. lemig zand
500	ZL			lgngr										loess? homog. lemig zand
510	FZ			lgngr			150-210							uit guts
520	FZ			lgngr			150-210							uit guts
530	FZ			lgngr			150-210							einde boring.

Base of borehole: 201107075

Borehole: 201107076	Names: R&A	Year: 2011	Group: 07	Date: 28-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
246510	537091	RD	16,83	260

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 10	
Vegetation-map: Vlierend	Soilmap:	

Vlierendijk.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	lbr										mosveen. doorw
20		V3	plr	lbr										mosveen. doorw
30		V3	plr	lbr										mosveen. doorw
40		V3	plr	lbr										mosveen. doorw
50		V3	plr	lbr										mosveen. doorw
60		V3	plr	lbr										mosveen. doorw
70		V3	plr	dbr										doorw. houtresten
80		V3	plr	dbr										doorw. houtresten
90		V3	plr	dbr										doorw. houtresten
100		V3	plr	dbr										doorw. houtresten
110		V3	plr	dbr										doorw. houtresten
120		V3	plr	dbr										doorw. houtresten
130		V3	plr	dbr										doorw. houtresten
140		V3	plr	dbr										doorw. houtresten
150		V3	plr	dbr										doorw. houtresten
160		V3	plr	dbr										doorw. houtresten
170		ZV	plr	lgrbr										heen doorw. lijkt gy-acht
180		ZV	plr	lgrbr										heen doorw. lijkt gy-acht
190		ZV	plr	lgrbr										heen doorw. lijkt gy-acht
200		ZV	plr	lgrbr										heen doorw. lijkt gy-acht
210		ZV	plr	lgrbr										heen doorw. lijkt gy-acht
220		ZV	plr	lgrbr										heen doorw. lijkt gy-acht
230		ZV	plr	lgrbr										2cm heel zandig. houtranje+zdj
240	LK		plr	lgngr										smeerbr. homogeen. zgy
250	FZ		plr	lbrgr			150-210							lemig.
260	FZ		plr	lbrgr			150-210							einde boring

Base of borehole: 201107076

Borehole: 201107077 Names: R&A Year: 2011 Group: 07 Date: 28-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
246528	537079	RD	17,03	100

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 20
Vegetation-map: Vlierend	Soilmap:

Vlierendijk

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	lbr										mos. doorw.
20		ZV	plr	zw										smeer. zandig. bodem.
30		ZV	plr	zw										smeer. zandig. bodem.
40		ZV	plr	zw										smeer. zandig. bodem.
50		ZV	plr	zw										idem.houtrestn.pikzw.bros.5cm
60		VZ	plr	grbr										smeer. zandig. bodem.
70	MZ		plr	lbr		2	210-300							humeus. plakt
80	FZ		plr	lgrbr		2	150-210							lemig.
90	FZ		plr	lgrbr		2	150-210							lemig.
100	FZ		plr	lgrbr		2	150-210							einde boring

Base of borehole: 201107077

Borehole: 201107078 Names: A&R Year: 2011 Group: 07 Date: 28-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
248476	530875	RD	0	150

MAP LEGEND CODE	Geomorphogenetical map:	Laagte
Geological map:	Groundwaterstep:	
Vegetation-map:	Soilmap:	

Sleenerstroom II (west) - georadar depressie Enno? boze boer Laagte in Grasland met mogelijk delen van een randwal. Lijkt geen pingo te zijn gezien ondiepe invulling. lemig zand begint op 135

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		br										zandig, doorw
20		V1		br										zandig, doorw
30		V1		br										zandig, doorw
40		V3	plr	br										zandig, doorw, houtresten
50		V3	plr	br										zandig, doorw, houtresten
60		V3	plr	grbr										zandig, stevig
70		V3	plr	dbr										veel houtresten, bosveen
80		V3	plr	dbr										veel houtresten, bosveen
90		V3	plr	dbr										veel houtresten, bosveen
100		V3	plr	dbr										veel houtresten, bosveen
110		V3	plr	lgrbr								+		iets zandig, laklaag boven 1cm
120		V3		dbr										veel houtresten
130		V3		dbr										veel houtresten
140	FZ			gr			150-210							lemig
150	FZ			gr			150-210							lemig

Base of borehole: 201107078

Borehole: 201107079 Names: A&R Year: 2011 Group: 07 Date: 29-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
248472	530901	RD	0	240

MAP LEGEND CODE	Geomorphogenetical map: Laagte
Geological map:	Groundwaterstep:
Vegetation-map:	Soilmap:

Sleenerstroom II

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		dbr										zandig, doorw
20		V1		dbr										zandig, doorw
30		V1		dbr										zandig, doorw
40		V1	plr	dbr										zandig, doorw, hout, bosveen
50		V1	plr	dbr										zandig, doorw, hout, bosveen
60		V1	plr	dbr										idem, iets zegge
70		V1	plr	dbr										zandig, doorw, hout, bosveen
80		V3	plr	grbr										zandig, houtresten
90		V3	plr	grbr										zandig
100		V3	plr	dbr										hout, zandig
110		V3	plr	dbr										hout, zandig
120		V3	plr	dbr										hout, zandig
130		V3	plr	dbr										hout, zandig
140		V3		grbr										beetje smeerbaar
150		V3	plr	dbr										houtresten
160		V3	plr	dbr										houtresten
170		V3	plr	dbr										houtresten
180		V3	plr	dbr										houtresten
190		V3	plr	dbr										houtresten
200		V3												zandig, hout, bovenin donker
210		V3												zandig, hout, bovenin donker
220	MZ			gr			210-300							lemig
230	MZ			gr			210-300							lemig
240	MZ			gr			210-300							lemig, einde boring zand

Base of borehole: 201107079

Borehole: 201107085 | Names: A&R | Year: 2011 | Group: 07 | Date: 3-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep:	
297342	599944	RD	0	180	Vegetation-map:	Soilmap:	

Timmelteich. zandlaagje op 80cm 90-95 lbr V3, zandig, plr. 95-100 lbr grindlaagje, matrix hum zand 300-420 naar onder groffer. dbrgr MZ 120-125.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		dbr										iets zandig, doorw
20		V1		dbr										iets zandig, doorw
30		V3		dbr										zaadjes, takje
40		V3	plr	dbr										zaadjes, takje
50		V3	plr	dbr										zaadjes, takje
60		V3	plr	dbr										zaadjes, takje
70		V3	plr	dbr										zaadjes, takje
80		V3	plr	dbr										zaadjes, takje
90		V3	plr	lbr										zandig, zie opmerkingen
100	ZL		plr	brgr										stug, droog
110	ZL		plr	brgr										stug, droog
120	MZ			dbrgr		5	210-300							grind tot 5mm
130	MZ			brgr			300-420							
140	MZ			brgr			300-420							
150	MZ			brgr			300-420							
160	MZ			brgr			300-420							
170	MZ			brgr			300-420							
180	MZ			brgr			300-420							einde boring, steen

Base of borehole: 201107085

Borehole: 201107086 Names: A&R Year: 2011 Group: 07 Date: 3-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 50	
297313	599975	RD	0	440	Vegetation-map:	Soilmap:	

Timmelteich. 210 boom 50mm. 360-365 lgnbr gy (beschreven), 365-370 grbr naar onder lichter, v.a. 370 bovenste 2cm bodem

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr										zandig, veraard, doorw
20		V1	plr	dbr										zandig, veraard, doorw
30		V3	plr	br										zeer zandig
40		V3	plr	br										zeer zandig
50		V3	plr	dbr										iets zandig, takjes, zaadjes
60		V3	plr	dbr										iets zandig, takjes, zaadjes
70		V3	plr	dbr										iets zandig, takjes, zaadjes
80		V3	plr	dbr										iets zandig, takjes, zaadjes
90		V3	plr	dbr										iets zandig, takjes, zaadjes
100		V3	plr	dbr										iets zandig, takjes, zaadjes
110		V3	plr	dbr										idem, boom 5cm
120		V3	plr	dbr										iets zandig, takjes, zaadjes
130		V3	plr	dbr										iets zandig, takjes, zaadjes
140		V3	plr	dbr										iets zandig, takjes, zaadjes
150		V3	plr	dbr										iets zandig, takjes, zaadjes
160	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
170	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
180	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
190	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
200	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
210	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
220	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
230	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
240	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
250	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
260	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
270	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
280	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
290	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
300	LK		plr	zwbr										zndig,smeerbaar,homog.,gy?hout
310	LK		plr	dgnbr										zandig, naar onder groeniger
320	ZK		plr	dgnbr										zandig, naar onder groeniger
330	ZK		plr	dgnbr										zandig, naar onder groeniger
340	ZK		plr	dgnbr										zandig, naar onder groeniger
350	ZK		plr	dgnbr										zandig, naar onder groeniger
360	LK			lgnbr										zandig
370	LK		plr	br										zandig, doorw, onder - plr
380	LK		plr	br										zandig, doorw, onder - plr
390	LK		plr	br										zandig, doorw, onder - plr
400	LK		plr	br										zandig, doorw, onder - plr
410	FZ			gr			150-210							heel iets lemig
420	FZ			gr			150-210							heel iets lemig
430	FZ			gr			150-210							heel iets lemig
440	FZ			gr			150-210							heel iets lemig

Base of borehole: 201107086

Borehole: 201107087	Names: A&R	Year: 2011	Group: 07	Date: 3-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 50	
297313	599960	RD	0	300	Vegetation-map:	Soilmap:	

Timmelteich 228 zeer zandig lbr V3 (gy???) dbr gy van 242-247, grbr van 247 tot 280 grbr gy 247-255 mos in de gytja???

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr					1					zandigdoorw. veraard, hum, ger
20		V1	plr	dbr					1					zandigdoorw. veraard, hum, ger
30		V1	plr	dbr					1					idem, vuursteen
40		V1	plr	dbr					1					idem, hout
50		V3	plr	br										doorw. hout, baksteen
60		V3	plr	br										doorw. hout, baksteen
70		V3	plr	br										doorw. hout, baksteen
80		V3	plr	br										doorw. hout, baksteen
90		V3	plr	br										doorw. hout, baksteen
100		V3	plr	br										doorw. hout, baksteen
110	ZK		plr	dbr										1 witte pikkel, afwissel zandi
120	ZK		plr	dbr										1 witte pikkel, afwissel zandi
130	ZK		plr	dbr										1 witte pikkel, afwissel zandi
140	ZK		plr	dbr										1 witte pikkel, afwissel zandi
150	LK			dbr										zandig
160	LK			dbr										zandig
170	LK			dbr										zandig
180	LK			dbr										niet zandig
190	LK			dbr										niet zandig
200	LK			dbr										niet zandig
210	LK			dbr										niet zandig
220	LK			dbr										niet zandig
230	LK		plr	grbr										zandig
240	LK			dbr										zandig
250	LK			grbr										zandig, lichter beneden, mos??
260	LK			grbr										zandig, lichter beneden, zegge
270	LK			grbr										zandig, lichter beneden
280	FZ			grbr			150-210							iets hum.
290	FZ			grbr			150-210							iets hum.
300	FZ			grbr			150-210							iets hum.

Base of borehole: 201107087

Borehole: 201107088 Names: A&R Year: 2011 Group: 07 Date: 3-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
297308	599948	RD	0	250

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 50
Vegetation-map:	Soilmap:

Timmelteich. 167-169 lbr laagje heel zandige gy 190-195 dbr gy 195-225 br gy oranje? grover zand bovenin 225-235 br V3

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr										doorw, ger
20		V1	plr	dbr										doorw, ger
30		V3	plr	br										zegge
40		V3	plr	br										zegge
50		V3	plr	br										zegge
60		V3	plr	br										zegge, zandig
70		V3	plr	br										zegge, zandig
80		V3	plr	br										zegge, zandig
90	ZK		plr	dbr										doorw
100	ZK		plr	dbr										doorw
110	ZK		plr	dbr										doorw
120	ZK		plr	dbr										doorw
130	ZK		plr	dbr										doorw
140	ZK		plr	dbr										doorw, zandig
150	ZK		plr	dbr										doorw, zandig
160	ZK		plr	dbr										doorw, zandig
170	LK		plr	grbr										zandig
180	LK		plr	grbr										zandig
190	LK			dbr										zandig, bodemple
200	LK		plr	br										mos/takjes? naar onder lgrbr
210	LK		plr	br										mos/takjes? naar onder lgrbr
220	LK		plr	br										mos/takjes? naar onder lgrbr
230		V3	plr	br										zandig
240	FZ			lbrgr			150-210							iets humeus of lemig
250	FZ			lbrgr			150-210							iets humeus of lemig

Base of borehole: 201107088

Borehole: 201107089 Names: R&A Year: 2011 Group: 07 Date: 3-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
297305	599929	RD	0	200

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 60
Vegetation-map: Park	Soilmap:

Timmelteich

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr					1					zandig, veraard, bebaksteend
20		V1	plr	dbr					1					zandig, veraard, bebaksteend
30		V1	plr	dbr					1					zandig, veraard, bebaksteend
40		V1	plr	dbr					1					zandig, veraard, bebaksteend
50		V3	plr	br					1					zandig, takje/hout
60		V3	plr	br					1					zandig, takje/hout
70		V3	plr	br					1					zandig, takje/hout
80	ZK		plr	dbr										zandig. zegge. doorw
90	ZK		plr	dbr										zandig. zegge. doorw
100	ZK		plr	dbr										zandig. zegge. doorw
110	ZK		plr	dbr										zandig. zegge. doorw
120	ZK		plr	dbr										iets zandig. fijner
130	ZK		plr	dbr										iets zandig. fijner
140	ZK		plr	dbr										iets zandig. fijner
150	LK		plr	lbr										zeer zandig
160	LK		plr	dbr										zandig. op 65 moslaag 5cm
170	LK		plr	lgrbr										zeer zandig
180	LK		plr	lgrbr										zeer zandig
190	FZ			lbrgr		1	150-210							humeus
200	FZ			lbrgr		1	150-210							einde boring. zand

Base of borehole: 201107089

Borehole: 201107090 Names: R&A Year: 2011 Group: 07 Date: 3-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 70	
297307	599916	RD	0,2	200	Vegetation-map: Park	Soilmap:	

Timmelteich. onderste 25 cm sterk afgerond.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		dbr										GER, zandig veraard
20		V1		dbr										GER, zandig veraard
30		V1		dbr										GER, zandig veraard
40		V1		dbr		1								GER, zandig veraard, baksteen
50		V1		dbr		1								GER, zandig veraard
60		V1		dbr		1								GER, zandig veraard
70		V1		dbr		1								GER, zandig veraard
80		V3		dbr										zegge, hout
90		V3		dbr										zegge, hout
100	LK		plr	dbr										doorw. zegge. blaadje
110	LK		plr	dbr										doorw. zegge. blaadje
120	LK		plr	dbr										doorw. zegge. blaadje
130	LK		plr	dbr										doorw. zegge. blaadje
140	LK		plr	dbr										doorw. zegge. blaadje
150	LK			br										bovnst 2cm lbr. zegge
160	LK			lgrbr										zandig
170	LK			dbr										bodem, zandig.
180	LK		plr	lgrbr										bovnst 2cm orbr mosje
190	FZ			brgr			150-210							humeus
200	FZ			brgr			150-210							einde boring. zand

Base of borehole: 201107090

Borehole: 201107091 Names: R&A Year: 2011 Group: 07 Date: 3-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
297307	599901	RD	0,2	360

MAP LEGEND CODE	Geomorphogenetical map:	?
Geological map:	Groundwaterstep: 70	
Vegetation-map: Park	Soilmap:	

Timmelteich

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr										GER, zandig bijgemengt
20		V1	plr	dbr										GER, zandig bijgemengt, bakstn
30		V1	plr	dbr										GER, zandig bijgemengt, bakstn
40		V1	plr	dbr										GER, zandig
50		V1	plr	dbr										GER, zandig
60		V1	plr	dbr										GER, zandig
70		V3	plr	dbr										zandig, houtje
80		V3	plr	dbr										zandig. houtje
90		V3	plr	dbr										zegge, zaadje
100		V3	plr	dbr										zegge, zaadje
110		V3	plr	dbr										zegge, zaadje
120		V3	plr	dbr										zegge, zaadje
130	ZK		plr	dbr										doorw. grof detr gy
140	ZK		plr	dbr										doorw. grof detr gy
150	ZK		plr	dbr										doorw. grof detr gy
160	LK		plr	dbr										doorw. grof detr gy
170	LK		plr	dbr										doorw. grof detr gy
180	LK		plr	dbr										doorw. grof detr gy
190	LK		plr	dbr										doorw. grof detr gy
200	LK		plr	dbr										doorw. grof detr gy
210	LK		plr	dbr										doorw. grof detr gy
220	LK		plr	dbr										doorw. grof detr gy
230	LK		plr	dbr										doorw. grof detr gy
240	LK		plr	dbr										doorw. grof detr gy
250	LK		plr	dbr										doorw. grof detr gy
260	LK			dbr										bodempje
270	LK			br										mosje. gy?
280	LK			br										doorw. grof detr gy
290	LK			lgrbr										zandig. laminea. zegge
300	LK			lgrbr										zandig. laminea. zegge
310	FZ			lbrgr		2	150-210							iets lemig.
320	FZ			lbrgr		2	150-210							iets lemig.
330	FZ			lbrgr		2	150-210							iets lemig.
340	FZ			lbrgr		2	150-210							iets lemig.
350	FZ			gr			150-210							lemig.
360	FZ			gr			150-210							einde boring. zand

Base of borehole: 201107091

Borehole: 201107092 Names: R&A Year: 2011 Group: 07 Date: 3-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map: Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 60
297320	600008	RD	0	620	Vegetation-map: Park	Soilmap:

Timmelteich

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										worteltj.
20		V3	plr	dbr										worteltj.
30		V3	plr	dbr										worteltj.
40		V3	plr	dbr										worteltj.
50		V3	plr	dbr										worteltj. 1 zeggetje
60		V3	plr	dbr										worteltj.
70		V3	plr	br										iets zegge. doorw. zandig
80		V3	plr	br										iets zegge. doorw. zandig
90		V3	plr	br										iets zegge. doorw. heel zandig
100		V3	plr	br										iets zegge. hout. heel zandig
110		V3	plr	br										iets zegge. heel zandig
120		V3	plr	br										iets zegge. heel zandig
130	ZK		plr	br										zandig. blaadje doorw.
140	ZK		plr	br										zandig. blaadje doorw.
150	ZK		plr	br										zandig. blaadje doorw.
160	ZK		plr	br										zandig. blaadje doorw.
170	ZK		plr	br										zandig. blaadje doorw.
180	ZK		plr	br										zandig laagje (of op 280?)
190	ZK		plr	br										zandig. blaadje doorw.
200	ZK		plr	br										zandig. blaadje doorw.
210	ZK		plr	br										zandig. blaadje doorw.
220	ZK		plr	br										zandig. blaadje doorw.
230	ZK		plr	br										zandig. blaadje doorw.
240	ZK		plr	br										zandig. blaadje doorw.
250	ZK		plr	br										zandig. blaadje doorw.
260	ZK		plr	br										zandig. blaadje doorw.
270	ZK		plr	br										zandig. blaadje doorw.
280	ZK		plr	br										zandig laagje (of op 180?)
290	ZK		plr	br										zandig. blaadje doorw.
300	ZK		plr	br										zandig. blaadje doorw.
310	ZK		plr	br										zandig. blaadje doorw.
320	ZK		plr	br										idem. extra plr. zaadjes
330	ZK		plr	br										idem. extra plr. zaadjes
340	ZK		plr	br										idem. extra plr. zaadjes
350	ZK		plr	br										idem. extra plr. zaadjes
360	LK		plr	dbr										beejte plr. iets zandig
370	LK		plr	dbr										beejte plr. iets zandig
380	LK		plr	dbr										beejte plr. iets zandig
390	LK		plr	dbr										beejte plr. iets zandig
400	LK		plr	dbr										beejte plr. iets zandig
410	LK		plr	dbr										beejte plr. iets zandig
420	LK		plr	dbr										beejte plr. iets zandig
430		V3	plr	dbr										los. meer plr. gy?
440		V3	plr	dbr										los. meer plr. gy?
450		V3	plr	dbr										los. meer plr. gy?
460		V3	plr	dbr										los. meer plr. gy?
470		V3	plr	dbr										los. meer plr. gy?
480		V3	plr	lgrbr										zandig
490		V3	plr	lgrbr										zandig
500		V3	plr	lgrbr										op 506 zandlaagje
510		V3	plr	br										mos, zegge, zandig
520	LK		plr	grbr										heel zandig.stug boven bodem?
530	LK		plr	grbr										heel zandig, stug en gummy.
540	LK		plr	grbr										heel zandig, stug en gummy.
550	LK		plr	grbr										heel zandig, stug en gummy.
560	LK		plr	grbr										idem. onderste 5cm donkerder
570	FZ			gr		5	150-210							humeus (1st 5cm brgr)
580	FZ			gr		5	150-210							
590	ZL			blgr		5								niet afgerond grind
600	ZL			blgr		5								niet afgerond grind

Boring: 201107092

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
610	ZL			blgr		5								niet afgerond grind
620	ZL			blgr		5								einde boring. zand/leem

Base of borehole: 201107092

Borehole: 201107116	Names: A&R	Year: 2011	Group: 07	Date: 6-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
297317	600029	RD	0	400

MAP LEGEND CODE		Geomorphogenetical map:	Pingo
Geological map:		Groundwaterstep:	
Vegetation-map:		Soilmap:	

Timmelteich 300 houtskooltje (zwart hout, brand of oxidatie?) bodem vanaf 300 338-340 zeggelaagje, scherpe overgangen!

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		ZV		dbr										veraard, zeer zandig, geroerd
20		ZV		dbr										veraard, zeer zandig, geroerd
30		V3	plr	br										zeer zandig
40		V3	plr	br										zeer zandig
50		V3	plr	br										zeer zandig
60		V3	plr	br										zeer zandig
70		V3	plr	br										zeer zandig
80		V3	plr	br										zeer zandig
90		V3	plr	br										zeer zandig
100		V3	plr	br										zeer zandig
110		V3	plr	br										zeer zandig
120		V3	plr	br										zeer zandig
130		V3	plr	br										zeer zandig
140		V3	plr	dbr										zeer zandig, hout, zegge
150		V3	plr	dbr										zeer zandig, hout, zegge
160		V3	plr	dbr										zeer zandig, hout, zegge
170		V3	plr	dbr										zeer zandig, hout, zegge
180	LK		plr	dbr										iets doorw., iets zegge
190	LK		plr	dbr										iets doorw., iets zegge
200	LK		plr	dbr										iets doorw., iets zegge
210	LK		plr	dbr										iets doorw., iets zegge
220	ZK		plr	dbr										iets zandig, doorw
230	ZK		plr	dbr										iets zandig, doorw
240	ZK		plr	dbr										iets zandig, doorw
250	ZK		plr	dbr										iets zandig, doorw
260	ZK		plr	dbr										iets zandig, doorw
270	ZK		plr	dbr										iets zandig, doorw
280	ZK		plr	dbr										iets zandig, doorw
290	ZK		plr	dbr										iets zandig, doorw
300	LK		plr	dbr										zandig, doorw
310	LK		plr	dbr										zandig, doorw
320	LK			grbr										zandig, doorw
330	LK			lgrbr										zeer zandig
340	LK			br										zeer zandig
350	LK			br										zeer zandig
360	LK			br										zeer zandig aquamos
370	LK			lgrbr										zandig, laminae, zegge
380	LK			lgrbr										zandig, laminae, zegge
390	FZ			gr		10	150-210							grind 2-8mm, iets lemig
400	FZ			gr		10	150-210							grind 2-8mm, iets lemig

Base of borehole: 201107116

Borehole: 201107117	Names: A&R	Year: 2011	Group: 07	Date: 6-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE		Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:		Groundwaterstep:	
297319	600041	RD	0	260	Vegetation-map:		Soilmap:	

Timmelteich 150-160 geen monster bodem vanaf 180 grindlaagje op 225 1x grind 10mm op 250

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		dbr										zeer zandig, veraard, geroerd
20		V1		dbr										zeer zandig, veraard, geroerd
30		V1		dbr										zeer zandig, veraard, geroerd
40		V3		dbr										zeer zandig, doorw
50		V3		dbr										zeer zandig, doorw
60		V3		dbr										zeer zandig, doorw
70		V3		dbr										zeer zandig, doorw
80		V3		dbr										zeer zandig, doorw
90		V3	plr	dbr										zandig, zegge, houtjes
100		V3	plr	dbr										zandig, zegge, houtjes
110		V3		br										grof detr. gy? nee. zegge
120		V3		br										grof detr. gy? nee. zegge
130	LK		plr	dgrbr										zeer zandig
140	LK		plr	grbr										zeer zandig
150	LK		plr	grbr										zeer zandig
160	LK		plr	grbr										zeer zandig
170	LK		plr	grbr										zeer zandig
180	LK			dbr										bovenkant bodem
190	LK		plr	br										zandig, zegge, mos
200	LK		plr	lgrbr										zandig
210	LK		plr	lgrbr										zandig
220	FZ			gr		10	150-210							iets lemig
230	FZ			gr		2	150-210							lemig
240	FZ			gr		10	150-210							iets lemig
250	FZ			gr		2	150-210							lemig
260	FZ			gr		2	150-210							einde boring, zand

Base of borehole: 201107117

Borehole: 201107118 Names: A&R Year: 2011 Group: 07 Date: 6-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
297319	600061	RD	0	120

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map:	Soilmap:	

Timmelteich rond 60 houtskool, paar cm zwart

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		dbr										zeer zandig, veraard, doorw
20		V1		dbr										zeer zandig, veraard, doorw
30		V1		dbr										zeer zandig, veraard, doorw
40		V1		dbr										zeer zandig, veraard, doorw
50		V3	plr	dbr										zandig, hout, doorw
60	ZK		plr	dgrbr										zandig
70	ZK		plr	dgrbr										zandig
80	ZK		plr	dgrbr										zandig
90	FZ			brgr			150-210							iets humeus, doorw
100	FZ			brgr			150-210							iets humeus, doorw
110	FZ			brgr			150-210							iets humeus, doorw
120	FZ			brgr			150-210							iets humeus, doorw

Base of borehole: 201107118

Borehole: 201107119 Names: A&R Year: 2011 Group: 07 Date: 6-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep:	
297319	600081	RD	0	100	Vegetation-map:	Soilmap:	

Timmelteich grindlaagje op 95, 1x 2cm diameter,

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ		plr	dbr			150-210							humeus, geroerd
20	FZ		plr	dbr			150-210							humeus, geroerd
30	FZ		plr	dbr			150-210							humeus, geroerd
40	FZ		plr	dbr			150-210							humeus, geroerd
50	FZ			brgr			150-210		1					gley, lemig onder minder
60	FZ			brgr			150-210		1					gley, lemig onder minder
70	FZ			brgr			150-210		1					gley, lemig onder minder
80	FZ			brgr			150-210		1					gley, lemig onder minder
90	FZ			brgr			150-210		1					gley, lemig onder minder
100	FZ			brgr			150-210		1					gley, lemig

Base of borehole: 201107119

Borehole: 201107120	Names: A&R	Year: 2011	Group: 07	Date: 6-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep:	
297313	600014	RD	0	530	Vegetation-map:	Soilmap:	

Timmelteich. naast de sloot stukjes baksteen tot 150 cm wilgenblaadje op 380

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3		dbr										zeer zandig, doorw, geroerd
20		V3		dbr										zeer zandig, doorw, geroerd
30		V3	plr	dbr										doorw
40		V3		zwbr										korreltjes geoxideerd veen
50	ZK			dbr										zandig
60	ZK			dbr										zandig
70	ZK			dbr										zandig
80	ZK			dbr										zandig
90	ZK			dbr										zandig
100	ZK			dbr										zandig
110	ZK			dbr										zandig
120	ZK			dbr										zandig
130	ZK			dbr										zandig
140	ZK			dbr										zandig
150	ZK			dbr										zandig
160	ZK			dbr										zandig
170	ZK			dbr										zandig
180	ZK			dbr										zandig
190	ZK			dbr										zandig
200	ZK			dbr										zandig
210	LK		plr	dbr										iets zandig, zandnestjes, zegg
220	LK		plr	dbr										iets zandig, zandnestjes, zegg
230	LK		plr	dbr										iets zandig, zandnestjes, zegg
240	LK		plr	dbr										iets zandig, zandnestjes, zegg
250	LK		plr	dbr										iets zandig, zandnestjes, zegg
260	LK		plr	dbr										iets zandig, zandnestjes, zegg
270	LK		plr	dbr										iets zandig, zandnestjes, zegg
280	LK		plr	dbr										iets zandig, zandnestjes, zegg
290	LK		plr	dbr										iets zandig, zandnestjes, zegg
300	LK		plr	dbr										iets zandig, zandnestjes, zegg
310	LK		plr	dbr										iets zandig, zandnestjes, zegg
320	LK		plr	dbr										iets zandig, zandnestjes, zegg
330	LK		plr	dbr										iets zandig, zandnestjes, zegg
340	LK		plr	dbr										iets zandig, zandnestjes, zegg
350	LK		plr	dbr										iets zandig, zandnestjes, zegg
360	LK		plr	dbr										iets zandig, zandnestjes, zegg
370	LK		plr	dbr										iets zandig, zandnestjes, zegg
380	LK		plr	dbr										iets zandig, zandnestjes, zegg
390	LK			dbr										zeer zandig
400	LK			dbr										zeer zandig
410	UFZ			grbr			75-105							top humeus (eerder gy genoemd)
420	UFZ			grbr			75-105							(eerder gy genoemd)
430	UFZ			grbr			75-105							(eerder gy genoemd)
440	UFZ			grbr			75-105							(eerder gy genoemd)
450	LK			br										zandige gy.
460	LK			lgrbr										aqua mos.zeer zandig. groenig
470	LK			lgrbr										aqua mos.zeer zandig. groenig
480	LK			lgrbr										aqua mos.zeer zandig. groenig
490	LK			lgrbr										aqua mos.zeer zandig. groenig
500	FZ			blgr		2	150-210							lemig. lamine,
510	FZ			blgr		2	150-210							lemig. lamine,
520	FZ			gr		2	150-210							
530	FZ			gr		2	150-210							einde boring

Base of borehole: 201107120

Borehole: 201107093 Names: R&A Year: 2011 Group: 07 Date: 4-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
297618	624683	RD	0	90

MAP LEGEND CODE	Geomorphogenetical map: Laagte
Geological map:	Groundwaterstep: 30
Vegetation-map: Bospingo	Soilmap:

Westerschoo. Bospingo. In nat bos met drainage uit 1859 en heel erg veel muggen.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										bosveen, hout/takjes/blaadjes
20		ZV	plr	dbr										doorw. iets minder plr. zandig
30		ZV	plr	dbr										doorw. iets minder plr. zandig
40	FZ		plr	dbr			150-210							humeus
50	FZ		plr	dbr			150-210							humeus
60	MZ		plr	dbr		2	210-300							humeus, lemig
70	MZ		plr	dbr		2	210-300							humeus, lemig
80	MZ		plr	grbr		2	210-300							humeus, lemig
90	MZ		plr	grbr		2	210-300							einde boring. steen

Base of borehole: 201107093

Borehole: 201107094	Names: R&A	Year: 2011	Group: 07	Date: 4-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
302808	623409	RD	0	250

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 70	
Vegetation-map: Brill	Soilmap:	

Brill pingo. Zandige invulling in water afgezet? Lastig te benoemen. In profiel als LK (gyttja) maar is zeer zandig! Zie remarks. Op 165 zwbr. bodem? heel zandige stugge gy.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										bosveen. doorw. zandig.
20		V3	plr	br										bosveen. doorw. zandig.
30		V3	plr	br										bosveen. doorw. zandig.
40		V3	plr	orbr										mosveen.
50		V3	plr	orbr										mosveen.
60		V3	plr	orbr										veenpluis
70	LK		plr	dbr										gy-achtig. doorw.
80	LK		plr	dbr										gy-achtig. doorw.
90	LK		plr	dbr										gy-achtig. doorw.
100	LK		plr	dbr										gy-achtig. doorw.
110	LK		plr	dbr										gy-achtig. doorw.
120	LK		plr	dbr										gy-achtig. doorw.
130	LK		plr	dbr										gy-achtig. doorw.
140	LK		plr	dbr										gy-achtig. doorw.
150	LK		plr	dbr										gy-achtig. doorw.
160	LK			dbr								+		niet grof detr. zandig. gummy
170	LK			br										heel stug. heel zandig. gy?
180	LK			br										idem. naar onder lichter
190	LK			br										idem. naar onder lichter
200	LK			br										idem. naar onder lichter
210	LK			br										idem. naar onder lichter
220	LK			lbr										zandig. veert(afdraaien) droog
230	LK			lbr										idem. leem?zand?veen?
240	FZ			lbr			150-210							humeus zand
250	FZ			lbr			150-210							einde boring. geen beweging.

Base of borehole: 201107094

Borehole: 201107095	Names: R&A	Year: 2011	Group: 07	Date: 4-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
302817	623408	RD	0	310

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 50	
Vegetation-map: Brill	Soilmap:	

Brill pingo. monster 288 monster 291 (organischer laagje)

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										doorw. zandig
20		V3	plr	dbr										doorw. zandig
30		V3	plr	orbr										mosveen
40	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
50	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
60	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
70	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
80	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
90	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
100	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
110	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
120	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
130	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
140	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
150	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
160	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
170	ZK		plr	dbr										V3takje.breekt hor.gy-achtig.
180	ZK		plr	zwbr								+		bodem. zandig. doorw.
190	ZK		plr	dbr										heel zandig. stug. hard. zand?
200	ZK		plr	br										heel zandig. stug. hard. zand?
210	ZK		plr	br										heel zandig. stug. hard. zand?
220	ZK		plr	br										heel zandig. stug. hard. zand?
230	ZK		plr	br										heel zandig. stug. hard. zand?
240	ZK		plr	br										heel zandig. stug. hard. zand?
250	ZK		plr	br										heel zandig. stug. hard. zand?
260	ZK		plr	lbr										heel zandig. stug. hard. zand?
270	ZK		plr	lbr										heel zandig. stug. hard. zand?
280	ZK		plr	lbr										heel zandig. stug. hard. zand?
290	ZFZ		plr	lgrbr			105-150							humeus en lemig
300	ZFZ		plr	lgrbr			105-150							
310	ZFZ		plr	lgrbr			105-150							einde boring

Base of borehole: 201107095

Borehole: 201107096 Names: R&A Year: 2011 Group: 07 Date: 4-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 70	
302824	623408	RD	0	210	Vegetation-map: Brill	Soilmap:	

Brill pingo

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										bosveen. zandige bijmenging
20		V3	plr	dbr										bosveen. zandige bijmenging
30		V3	plr	dbr										bosveen. zandige bijmenging
40		V3	plr	orbr										mosveen
50		V3	plr	orbr										mosveen
60		V3	plr	orbr										mosveen
70		V3	plr	orbr										mosveen
80		V3	plr	dbr										zegge. doorw.
90		V3	plr	dbr										zegge. doorw.
100		V3	plr	dbr										zegge. doorw.
110		V3	plr	dbr										zegge. doorw.
120		V3	plr	dbr										zegge. doorw.
130		V3	plr	dbr										zegge. doorw.
140	LK			zwbr										zeer zandig v3
150	LK			dbr										idem. steeds zandiger
160	LK			dbr										idem. wat is het?
170	LK			dbr										idem. zand is keihard!
180	LK			br										idem. wat is het?
190	LK			br										idem. wat is het?
200	LK			br										idem. niet meer uit de guts...
210	LK			br										einde boring... beton.

Base of borehole: 201107096

Borehole: 201107097 Names: R&A Year: 2011 Group: 07 Date: 4-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
302831	623408	RD	0	100

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 70
Vegetation-map: Brill	Soilmap:

Brill pingo. Pal naast provinciale weg. troep en stinkboring.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	MZ		plr	grbr			210-300							ophoogzand. GER.
20	MZ		plr	grbr			210-300							ophoogzand. GER.
30		V3	plr	dbr										prutveen. los. veel plr
40		V3	plr	dbr										prutveen. los. veel plr
50		V3	plr	dbr										prutveen. los. veel plr
60		ZV	plr	zwbr										heel zandig, humeus
70		ZV	plr	zwbr										heel zandig, humeus
80	MZ			brgr			210-300							hoort hier niet.
90	MZ			gr			210-300							hoort hier niet.
100	MZ			gr			210-300							einde boring. niet in situ

Base of borehole: 201107097

Borehole: 201107098	Names: R&A	Year: 2011	Group: 07	Date: 4-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
302819	623419	RD	0,5	120

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 70
Vegetation-map: Brill	Soilmap:

Brill pingo.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr										zandplup
20		V1	plr	dbr										zandplup
30		V1	plr	dbr										zandplup
40		V1	plr	dbr										zandplup
50		V1	plr	dbr										zandplup
60		V1	plr	dbr										zandplup
70		VZ		zwbr										bodem
80		VZ		dbr										bodem
90		VZ		br										bodem
100		VZ		br										bodem
110		VZ		br										bodem
120		VZ		br										einde boring. zand uit guts

Base of borehole: 201107098

Borehole: 201107099 Names: R&A Year: 2011 Group: 07 Date: 4-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
302820	623427	RD	0,5	140

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Brill	Soilmap:	

Brill pingo

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		ZV	plr	dbr										zandig veen
20		ZV	plr	dbr										zandig veen
30		ZV	plr	dbr										zandig veen
40	ZFZ			brgr			105-150							ophoogzandje? stinkt
50	ZFZ			brgr			105-150							ophoogzandje? stinkt
60	ZFZ			brgr			105-150							ophoogzandje? stinkt
70	ZFZ			br			105-150							humeus
80	ZFZ			br			105-150							humeus
90	ZFZ			br			105-150							humeus
100	ZFZ			br			105-150							humeus
110	ZFZ			br			105-150							humeus
120	ZFZ			br			105-150							humeus
130	ZFZ			br			105-150							humeus
140	ZFZ			br			105-150							einde boring. te veel zand

Base of borehole: 201107099

Borehole: 201107100 Names: R&A Year: 2011 Group: 07 Date: 4-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
302821	623442	RD	0,5	100

MAP LEGEND CODE	Geomorphogenetical map:
Geological map:	Groundwaterstep:
Vegetation-map: Brill	Soilmap:

Brill.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		ZV	plr	dbr										heel zandig
20	ZFZ			dbrgr			105-150							humeus
30	ZFZ			dbrgr			105-150							humeus
40	ZFZ			lbrgr			105-150							zacht.
50	ZFZ			lbrgr			105-150							zacht.
60	ZFZ			br			105-150							humeus
70	ZFZ			robr			105-150							Fe? naar onder lichter
80	ZFZ			robr			105-150							humeus
90	ZFZ			orbr			105-150							dekzand?
100	ZFZ			orbr			105-150							einde boring

Base of borehole: 201107100

Borehole: 201107101 | Names: R&A | Year: 2011 | Group: 07 | Date: 4-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
302801	623409	RD	0	220

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 70
Vegetation-map: Brill	Soilmap:

Brill pingo

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										iets zandig.
20		V3	plr	br										takje
30		V3	plr	br										takje
40		V3	plr	orbr										mosveen
50		V3	plr	orbr										mosveen
60		V3	plr	orbr										mosveen
70		V3	plr	zwbr										iets zandig veen
80		V3	plr	zwbr										iets zandig veen
90		V3	plr	zwbr										iets zandig veen
100	ZK		plr	dbr										lagen. gy? veel plr. vaag
110	ZK		plr	dbr										lagen. gy? veel plr. vaag
120	ZK		plr	dbr										lagen. gy? veel plr. vaag
130	ZK		plr	dbr										lagen. gy? veel plr. vaag
140	LK			zwbr										zeer zandig. rampspul. gy?
150	LK			br										zeer zandig. rampspul. gy?
160	LK			br										zeer zandig. rampspul. gy?
170	LK			br										zeer zandig. rampspul. gy?
180	LK			br										idem. bodempje?
190	LK			lbr										zeer zandig. rampspul. gy?
200	LK			lbr										zeer zandig. rampspul. gy?
210	LK			lbr										zeer zandig. rampspul. gy?
220	LK			lbr										einde boring. rampspul

Base of borehole: 201107101

Borehole: 201107102 Names: R&A Year: 2011 Group: 07 Date: 4-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
302817	623401	RD	0	370

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 50
Vegetation-map: Brill	Soilmap:

Brill. Met Axel Heinze.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3		dbr										
20		V3		dbr										
30		V3		dbr										bosveen. doorw.
40		V3		dbr										bosveen. doorw.
50		V3		dbr						GW				bosveen. doorw.
60		V3	plr	dbr										bosveen. doorw.
70		V3	plr	dbr										bosveen. doorw.
80		V3	plr	dbr										bosveen. doorw.
90		V3	plr	dbr										bosveen. doorw.
100		V3	plr	dbr										bosveen. doorw.
110		V3	plr	dbr										bosveen. doorw.
120		V3	plr	dbr										bosveen. doorw.
130		V3	plr	dbr										bosveen. doorw.
140		V3	plr	dbr										bosveen. doorw.
150		V3	plr	dbr										bosveen. doorw.
160	ZK		plr	br										gelaagd V3. doorw. zegge
170	ZK		plr	br										gelaagd V3. doorw. zegge
180	ZK		plr	br										gelaagd V3. doorw. zegge
190	ZK		plr	br										gelaagd V3. doorw. zegge
200	ZK		plr	br										gelaagd V3. doorw. zegge
210	ZK		plr	br										gelaagd V3. doorw. zegge
220		V3	plr	zwbr										
230		V3	plr	zwbr										
240		V3	plr	lbr										zandig.
250	LK		plr	br										zv (105-150)
260	LK		plr	lbr										zzv (105-150)
270	LK		plr	br										zzv (105-150)
280	LK		plr	br										iets zandig V3. gelaagd
290	LK		plr	br										iets zandig V3. gelaagd
300	LK		plr	br										iets zandig V3. gelaagd
310	LK		plr	br										iets zandig V3. gelaagd
320	LK		plr	br										iets zandig V3. gelaagd
330	LK		plr	br										zzv (105-150) doorw. stug
340	LK		plr	br										zzv (105-150) doorw. stug
350	LK		plr	br										zzv (105-150) doorw. stug
360	ZFZ		plr	br			105-150							iets lemig
370	ZFZ		plr	brgr			105-150							einde boring. lemig

Base of borehole: 201107102

Borehole: 201107103	Names: R&A	Year: 2011	Group: 07	Date: 4-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
302797	623410	RD	0,3	110

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 50	
Vegetation-map: Brill	Soilmap:	

Brill

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										hout
20		V3	plr	dbr										hout
30		V3	plr	dbr										ger. zand
40		V3	plr	dbr										hout
50		V3	plr	dbr										hout
60		ZV	plr	zwbr										
70		ZV	plr	zwbr										
80	LK			dbr										zzv (105-150)
90	LK			br										zzv (105-150) zeer stug
100	LK			br										zzv (105-150) zeer stug
110	LK			br										einde boring

Base of borehole: 201107103

Borehole: 201107104 Names: R&A Year: 2011 Group: 07 Date: 5-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 140	
316033	611312	RD	1,5	300	Vegetation-map: Wrokmoor	Soilmap:	

Wrokmoor. Op randwal. ongeveer 1,5 meter hoger dan pingo laagte.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		ZV		br										veraard veen
20		ZV		br										veraard veen
30	ZFZ	H0		grbr			105-150							bodem
40	ZFZ	H0		lgrbr			105-150							bodem
50	ZFZ	H0		lgrbr			105-150							bodem
60	ZFZ			lbrgr			105-150							iets lemig
70	ZFZ			lbrgr			105-150							iets lemig
80	ZFZ			lbrgr			105-150							iets lemig
90	ZFZ			lbrgr			105-150							iets lemig
100	FZ			lgr			150-210							iets lemig
110	FZ			lgr			150-210							iets lemig
120	FZ			lgr			150-210							iets lemig
130	FZ			lbrgr			150-210							grindlaagje?
140	FZ			lbrgr			150-210		1					lemig.
150	FZ			lbrgr			150-210		1					lemig.
160	FZ		plr	lbrgr			150-210							lemig. hout
170	FZ		plr	lbrgr			150-210							lemig. hout
180	FZ		plr	lbrgr			150-210							lemig. hout
190	FZ		plr	gr			150-210							lemig. hout
200	LZ	H0	plr	brgr										lemig. hout
210	LZ	H0	plr	brgr										lemig. hout
220	LZ	H0	plr	brgr										minder hout. donder&grijs nr o
230	LZ	H0	plr	brgr										minder hout. donder&grijs nr o
240	LZ	H0	plr	brgr										minder hout. donder&grijs nr o
250	LZ	H0		gr										minder hout. donder&grijs nr o
260	LZ	H0		gr										minder hout. donder&grijs nr o
270	LZ	H0		gr										minder hout. donder&grijs nr o
280	LZ	H0		gr										minder hout. donder&grijs nr o
290	LZ	H0		gr										minder hout. donder&grijs nr o
300	LZ	H0		gr										einde boring. te veel lemig za

Base of borehole: 201107104

Borehole: 201107105 Names: R&A Year: 2011 Group: 07 Date: 5-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
316031	611309	RD	0,5	200

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 70	
Vegetation-map: Wrokmoor	Soilmap:	

Wrokmoor.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3		dbr										zandig
20		V3		dbr										zandig
30	ZFZ	H0	plr	br			105-150							humeus. plr
40	ZFZ	H0	plr	br			105-150							humeus. plr
50	ZFZ	H0	plr	br			105-150							humeus. plr
60	ZFZ	H0	plr	lbr			105-150							iets plr. houtje
70	ZFZ	H0	plr	lbr			105-150			GW				iets plr. houtje
80	ZFZ	H0	plr	lbr			105-150							iets plr. houtje
90	ZFZ			lbrgr			105-150							grindlaagje op 95
100	ZFZ			gr			105-150							lemig
110	ZFZ			gr			105-150		1					lemig
120	ZFZ			gr			105-150							zeer lemig.
130	ZFZ			gr			105-150							zeer lemig.
140	ZFZ			gr			105-150							zeer lemig.
150	ZFZ			gr			105-150							zeer lemig.
160	ZFZ			gr			105-150							idem. houtje
170	ZFZ			gr			105-150							zeer lemig.
180	ZFZ			gr			105-150							zeer lemig.
190	ZFZ			gr		1	105-150							zeer lemig.
200	ZFZ			gr		1	105-150							einde boring.

Base of borehole: 201107105

Borehole: 201107106 Names: R&A Year: 2011 Group: 07 Date: 5-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
316019	611319	RD	0	140

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 80	
Vegetation-map: Wrokmoor	Soilmap:	

Wrokmoor

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										mosveen
20		V3	plr	dbr										mosveen
30		V3	plr	dbr										mosveen
40	ZFZ	H0	plr	br			105-150							
50	ZFZ	H0	plr	lbr			105-150							
60	ZFZ	H0	plr	lbr			105-150							scherpe overgang
70	MZ	H0	plr	grbr			210-300							scherpe overgang
80	ZFZ		plr	grbr			105-150							
90	ZFZ		plr	grbr			105-150							
100	ZFZ		plr	grbr			105-150							
110	ZFZ		plr	grbr			105-150							
120	ZFZ		plr	grbr			105-150							
130	ZFZ		plr	grbr			105-150							
140	ZFZ		plr	grbr			105-150							einde boring. valt uit guts

Base of borehole: 201107106

Borehole: 201107107 Names: R&A Year: 2011 Group: 07 Date: 5-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
316010	611323	RD	0	160

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 60
Vegetation-map: Wrokmoor	Soilmap:

Wrokmoor

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										mosveen. doorw.
20		V3	plr	br										mosveen. doorw.
30		V3	plr	br										mosveen. doorw.
40		V3	plr	br										mosveen. doorw.
50		V3	plr	br										mosveen. doorw.
60		V3	plr	br										mosveen. doorw.
70		V3	plr	br										mosveen. doorw.
80	ZFZ	H0	plr	lbr			105-150							droog. hard. humeus. gy?
90	ZFZ	H0	plr	lbr			105-150							droog. hard. humeus. gy?
100	ZK		plr	br										zzv. breekt gelaagd
110	ZK		plr	br										zzv. breekt gelaagd
120	ZK		plr	br										zzv. breekt gelaagd
130	ZK		plr	br										zzv. breekt gelaagd
140	LK		plr	lbrgr		1								zandig gy? laminae.
150	LK		plr	lbrgr										zandig gy? laminae.
160	FZ			lbrgr			150-210							einde boring. iets lemig

Base of borehole: 201107107

Borehole: 201107108 Names: R&A Year: 2011 Group: 07 Date: 5-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
315999	611331	RD	0	260

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 40	
Vegetation-map: Wrokmoor	Soilmap:	

Wrokmoor

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										mosveen.doorw
20		V3	plr	br										mosveen.doorw
30		V3	plr	dbr										doorw. takjes
40		V3	plr	dbr										doorw. takjes
50		V3	plr	dbr										doorw. takjes
60		V3	plr	dbr										doorw. takjes
70		V3	plr	dbr										doorw. takjes
80		V3	plr	dbr										doorw. takjes
90	ZK		plr	br										breekt gelaagd zegge. doorw.v3
100	ZK		plr	br										breekt gelaagd zegge. doorw.v3
110	ZK		plr	br										iets zandig. v3
120	ZK		plr	br										iets zandig. v3
130	ZK		plr	br										iets zandig. v3
140	ZK		plr	dbr										zandig doorw. v3
150	LK		plr	dbr										zandig iets wortltjs. v3
160	LK		plr	dbr										zandig iets wortltjs. v3
170	LK		plr	br										zandig wortltjs,zegge,
180	LK		plr	br										zandig wortltjs,zegge,
190	LK		plr	lbr										zandig wortltjs,zegge,
200	ZFZ	H0	plr	grbr			105-150							zandig wortltjs,zegge,
210	ZFZ	H0	plr	grbr			105-150							zandig wortltjs,zegge,
220	ZFZ	H0	plr	grbr			105-150							zandig wortltjs,zegge,
230	ZFZ		plr	grbr			105-150							valt uit guts
240	ZFZ		plr	grbr			105-150							valt uit guts
250	ZFZ		plr	grbr			105-150							valt uit guts
260	ZFZ		plr	grbr			105-150							einde boring

Base of borehole: 201107108

Borehole: 201107109 Names: R&A Year: 2011 Group: 07 Date: 5-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 10	
315989	611346	RD	0	400	Vegetation-map: Wrokmoor	Soilmap:	

Wrokmoor

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										mosveen
20		V3	plr	br										mosveen
30		V3	plr	dbr										doorw
40		V3	plr	dbr										doorw
50		V3	plr	dbr										doorw
60		V3	plr	dbr										doorw
70		V3	plr	dbr										doorw
80		V3	plr	dbr										doorw
90		V3	plr	zw										houtskool
100		V3	plr	br										prutveen. heel veel plr. takjs
110		V3	plr	br										prutveen. heel veel plr. takjs
120		V3	plr	br										prutveen. heel veel plr. takjs
130		V3	plr	br										prutveen. heel veel plr. takjs
140		V3	plr	br										prutveen. heel veel plr. takjs
150		V3	plr	br										prutveen. heel veel plr. takjs
160		V3	plr	br										minder los. zegge mos
170		V3	plr	br										minder los. zegge mos
180		V3	plr	br										minder los. zegge mos
190		V3	plr	br										minder los. zegge mos
200		V3	plr	br										minder los. zegge mos
210		V3	plr	br										minder los. zegge mos
220		V3	plr	br										veenpluis
230		V3	plr	br										minder los. zegge mos
240		V3	plr	br										minder los. zegge mos
250		V3	plr	br										minder los. zegge mos
260		V3	plr	br										minder los. zegge mos
270	LK			grbr								+		smeerbaar. zeer fijn zandig
280	ZK		plr	br										erg zandig. gelaagd.
290	ZK		plr	dbr										idem. blaadjes
300	LK		plr	grbr										zeer zandig. zegge. houtjes
310	LK		plr	grbr										zeer zandig. zegge. houtjes
320	LK		plr	grbr										zeer zandig. zegge. houtjes
330	LK		plr	grbr										zeer zandig. zegge. houtjes
340	LK			brgr										breekt gelaagd. zv
350	LK			brgr										idem. groenig
360	FZ			gr			150-210							iets lemig
370	FZ			gr			150-210							iets lemig
380	FZ			gr			150-210							iets lemig
390	FZ			gr			150-210							iets lemig
400	FZ			gr			150-210							einde boring.

Base of borehole: 201107109

Borehole: 201107110 Names: R&A Year: 2011 Group: 07 Date: 5-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
315981	611355	RD	0	530

MAP LEGEND CODE | Geomorphogenetical map: Pingo
Geological map: | Groundwaterstep: 20
Vegetation-map: Wrokmoor | Soilmap:

Wrokmoor Monster op 470 monster op 508

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										mosveen
20		V3	plr	br										mosveen
30		V3	plr	dbr										veen doorw
40		V3	plr	dbr										veen doorw
50		V3	plr	dbr										veen doorw
60		V3	plr	dbr										veen doorw
70		V3	plr	dbr										veen doorw
80		V3	plr	zw										houtskool
90		V3	plr	zw										houtskool
100		V3	plr	dbr										prutveen. takjes doorw
110		V3	plr	dbr										prutveen. takjes doorw
120		V3	plr	dbr										prutveen. takjes doorw
130		V3	plr	dbr										prutveen. takjes doorw
140		V3	plr	dbr										prutveen. takjes doorw
150		V3	plr	dbr										prutveen. takjes doorw
160		V3	plr	dbr										prutveen. takjes doorw
170		V3	plr	dbr										prutveen. takjes doorw
180		V3	plr	dbr										prutveen. takjes doorw
190		V3	plr	dbr										prutveen. takjes doorw
200		V3	plr	dbr										veenpluis
210		V3	plr	dbr										veenpluis
220		V3	plr	dbr										veenpluis
230		V3	plr	dbr										veenpluis
240		V3	plr	dbr										veenpluis
250		V3	plr	dbr										veenpluis
260		V3	plr	dbr										veenpluis
270		V3	plr	dbr										veenpluis
280		V3	plr	dbr										veenpluis
290		V3	plr	br										minder los. veel plr zegge
300		V3	plr	br										minder los. veel plr zegge
310		V3	plr	br										minder los. veel plr zegge
320		V3	plr	br										minder los. veel plr zegge
330		V3	plr	br										minder los. veel plr mos
340		V3	plr	br										minder los. veel plr mos
350		V3	plr	br										minder los. veel plr mos
360		V3	plr	br										idem. witte spikkels
370		V3	plr	dbr										gy? verstoord
380		V3	plr	dbr										gy? verstoord
390		V3	plr	dbr										gy? verstoord
400	LK		plr	grbr								+		smeerbaar. hout .zeer zandig
410	ZK		plr	dbr										veenpl? zandig. takjes
420	ZK		plr	dbr										veenpl? zandig. takjes
430	ZK		plr	dbr										veenpl? zandig. takjes
440	LK		plr	br										supermoie gy. iets zandig V3
450	LK		plr	br										supermoie gy. iets zandig V3
460	LK		plr	br										supermoie gy. iets zandig V3
470	LK		plr	br										supermoie gy. iets zandig V3
480	LK		plr	brgr										supermoie gy. iets zandig V3
490	LK		plr	brgr										idem. tak zandiger. groenig
500	LK		plr	brgr										idem. zandiger. groenig
510	ZFZ			gr			105-150							bovenste 5cm blauwgr. lemig
520	ZFZ			gr			105-150							bovenste 5cm blauwgr. lemig
530	ZFZ			gr			105-150							einde boring

Base of borehole: 201107110

Borehole: 201107111 Names: R&A Year: 2011 Group: 07 Date: 5-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
315971	611366	RD	0	560

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 10	
Vegetation-map: Wrokmoor	Soilmap:	

Wrokmoor

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										mosveen
20		V3	plr	br										mosveen. blauwe schilfertjes
30		V3	plr	br										mosveen
40		V3	plr	dbr										doorw.
50		V3	plr	dbr										doorw.
60		V3	plr	dbr										doorw.
70		V3	plr	dbr										doorw.
80		V3	plr	dbr										doorw.
90		V3	plr	dbr										doorw.
100		V3	plr	dbr										idem. witte puntjes
110		V3	plr	dbr										doorw.
120		V3	plr	dbr										idem. veenpluis
130		V3	plr	dbr										doorw.
140		V3	plr	dbr										doorw.
150		V3	plr	dbr										doorw.
160		V3	plr	dbr										doorw.
170		V3	plr	dbr										doorw.
180		V3	plr	br										zeggeveen.
190		V3	plr	br										zeggeveen.
200		V3	plr	br										zeggeveen.
210		V3	plr	br										zeggeveen.
220		V3	plr	br										zeggeveen.
230		V3	plr	br										zeggeveen.
240		V3	plr	br										zeggeveen.
250		V3	plr	br										zeggeveen.
260		V3	plr	br										zeggeveen.
270		V3	plr	br										zeggeveen
280		V3	plr	br										zo'n rood zaadje
290		V3	plr	dbr										mosveen
300		V3	plr	dbr										mosveen
310		V3	plr	dbr										mosveen
320		V3	plr	dbr										mosveen
330	LK		plr	grbr								+		smeerbaar. gy? zandig V1
340	LK		plr	grbr										smeerbaar. gy? zandig V1
350	ZK		plr	dgrbr										idem. iets zandig. plr rechtop
360	ZK		plr	dgrbr										idem. iets zandig. plr rechtop
370	ZK		plr	dgrbr										idem. iets zandig. plr rechtop
380	ZK		plr	dgrbr										idem. iets zandig. plr rechtop
390	LK		plr	br										zandig. zegge.
400	LK			grbr										megazandig (105-150). breekt
410	LK			grbr										megazandig (105-150). breekt
420	LK			grbr										megazandig (105-150). breekt
430	LK			grbr										megazandig (105-150). breekt
440	LK			grbr										megazandig (105-150). breekt
450	LK			lgrbr										zfz. gy-achtig.
460	LK			lgrbr										zfz. gy-achtig.
470	LK			lgrbr										zfz. gy-achtig.
480	LK			lgrbr										zfz. gy-achtig.
490	LK			lgrbr										zfz. gy-achtig.
500	LK			lgrbr										zfz. gy-achtig.
510	LK		plr	gnbr										zfz. gy-achtig.
520	LK		plr	gnbr										zfz. gy-achtig.
530	LK		plr	gnbr										zfz. gy-achtig.
540	LK		plr	gr										plakkerig, pindakaas.silt?
550	ZFZ			gr			105-150							lemig
560	ZFZ			gr			105-150							einde boring.boor vast..

Base of borehole: 201107111

Borehole: 201107112	Names: R&A	Year: 2011	Group: 07	Date: 5-10-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 10	
315952	611371	RD	0	300	Vegetation-map: Wrokmoor	Soilmap:	

Wrokmoor

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										mosveen
20		V3	plr	br										mosveen
30		V3	plr	br										mosveen
40		V3	plr	dbr										doorw. hout. zacht los
50		V3	plr	dbr										doorw. hout. zacht los
60		V3	plr	dbr										doorw. hout. zacht los
70		V3	plr	dbr										doorw. hout. zacht los
80		V3	plr	dbr										doorw. hout. zacht los
90		V3	plr	dbr										doorw. hout. zacht los
100		V3	plr	br										los
110		V3	plr	br										los
120		V3	plr	br										los
130		V3	plr	br										los
140		V3	plr	br										los
150		V3	plr	br										los
160	LK		plr	grbr										smeerbaar. fijn gy. zandig V3
170	LK		plr	grbr										smeerbaar. fijn gy. zandig V3
180	LK		plr	grbr										smeerbaar. fijn gy. zandig V3
190	ZK		plr	dbr										grof detr. gy.
200	ZK		plr	dbr										grof detr. gy.
210	ZK		plr	dbr										idem. veel zegge
220	ZK		plr	dbr										idem. veel zegge
230	ZK		plr	lbr										idem. veel zegge
240	LK			grbr										smeerspul. heel zandig
250	LK			grbr										smeerspul. heel zandig
260	LK			grbr										smeerspul. heel zandig
270	ZFZ			gr			105-150							lemig
280	ZFZ			gr			105-150							lemig
290	ZFZ			gr			105-150							lemig
300	ZFZ			gr			105-150							einde boring

Base of borehole: 201107112

Borehole: 201107113 Names: R&A Year: 2011 Group: 07 Date: 5-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
315939	611377	RD	0	180

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: -10	
Vegetation-map: Wrokmoor	Soilmap:	

Wrokmoor. In het water....

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	lbr										mosveen met rietjes.
20		V3	plr	lbr										mosveen met rietjes.
30		V3	plr	lbr										mosveen met rietjes.
40		V3	plr	dbr										losse prutveen
50		V3	plr	dbr										losse prutveen
60		V3	plr	dbr										losse prutveen
70		V3	plr	dbr										losse prutveen
80	LK		plr	zwbr										smeerbaar. doorw. zandigv3
90	LK		plr	br										stug. doorw. veen zandig
100	LK		plr	br										stug. doorw. veen zandig
110	LK		plr	br										stug. doorw. veen zandig
120	LK		plr	grbr										zandigv3 zegge
130	LK		plr	grbr										zandigv3 zegge
140	LK		plr	br										zandigv3 zegge
150	LK		plr	br										zandigv3 zegge
160	LK		plr	lbr										zandigv3 zegge
170	LK		plr	lbr										zandigv3 zegge
180	LK		plr	lbr										einde boring. we zakken weg...

Base of borehole: 201107113

Borehole: 201107114 Names: R&A Year: 2011 Group: 07 Date: 5-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
315925	611380	RD	0	180

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 100
Vegetation-map: Wrokmoor	Soilmap:

Wrokmoor Net zo hoog, maar hier wel droog

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	ZFZ	H0		dbr			105-150							bodem
20	ZFZ	H0		dbr			105-150							bodem
30	ZFZ	H0		br			105-150							bodem
40	ZFZ	H0		br			105-150							bodem
50	ZFZ	H0		grbr			105-150							bodem
60	ZFZ	H0	plr	grbr			105-150							bodem
70	ZFZ	H0	plr	grbr			105-150							bodem
80	ZFZ	H0		lbr			105-150							bodem
90	ZFZ	H0		lbr			105-150							bodem
100	ZFZ			lgrbr			105-150							iets humeus. lemig
110	ZFZ			lgrbr			105-150							iets humeus. lemig
120	ZFZ			lgrbr			105-150							minder lemig naar onder
130	ZFZ			lgrbr			105-150							minder lemig naar onder
140	ZFZ			lgrbr			105-150							minder lemig naar onder
150	ZFZ			lgrbr			105-150							minder lemig naar onder
160	ZFZ			lgrbr			105-150							te nat en niet lemig
170	ZFZ			lgrbr			105-150							te nat en niet lemig
180	ZFZ			lgrbr			105-150							einde boring. zand uit boor

Base of borehole: 201107114

Borehole: 201107115 Names: R&A Year: 2011 Group: 07 Date: 5-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
315911	611390	RD	0,5	90

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Wrokmoor	Soilmap:	

Wrokmoor

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	ZFZ			dgrbr			105-150							
20	ZFZ			dgrbr			105-150							
30	ZFZ			gr			105-150							geroerd
40	ZFZ			brgr			105-150							geroerd
50	ZFZ			brgr			105-150							geroerd
60	ZFZ			brgr			105-150							geroerd
70	ZFZ			dbr			105-150							Bodem
80	ZFZ			br			105-150							Bodem. ijzerkleurtje
90	ZFZ			br			105-150							einde boring.

Base of borehole: 201107115

Borehole: 201107122 Names: A&R Year: 2011 Group: 07 Date: 7-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
303974	628950	RD	0	270

MAP LEGEND CODE
Geomorphogenetical map: Pingo
Geological map:
Groundwaterstep: 69
Vegetation-map: Mamburg
Soilmap:

Mamburg. 156-158 moslaagje

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ						150-210							doorw, ger, hum
20	FZ						150-210							doorw, ger, hum
30	FZ						150-210							doorw, ger, hum
40	FZ						150-210							doorw, ger, hum
50	FZ						150-210							doorw, ger, hum
60	ZK		plr	br										doorw, plr! zegge
70	ZK		plr	br										doorw, plr! zegge
80	ZK			dbr										iets zandig
90	ZK			dbr										iets zandig
100	ZK			dbr										iets zandig
110	ZK		plr	br										zegge, mos?
120	ZK		plr	br										zegge, mos?
130	ZK		plr	br										zegge, mos?
140	ZK		plr	dbr										zwarte draadjes
150	ZK		plr	dbr										zwarte draadjes
160	ZK			grbr										zeer zandig, zegge, korrelig
170	ZK		plr	dgrbr										zeer zandig, langw. blaadjes
180	ZK			lgrbr										zz, zegge, groenig
190	LK			lbrgr										50-75
200	ZFZ			lbrgr			105-150							iets humeus
210	ZFZ			lbrgr			105-150							iets humeus
220	ZFZ			lbrgr			105-150							iets humeus
230	ZFZ			lbrgr			105-150							iets humeus
240	ZFZ			lbrgr			105-150							iets humeus
250	ZFZ			lbrgr			105-150							iets humeus
260	ZFZ			lbrgr			105-150							iets humeus
270	ZFZ			lbrgr			105-150							iets humeus

Base of borehole: 201107122

Borehole: 201107123 Names: A&R Year: 2011 Group: 07 Date: 7-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
303958	628961	RD	0	290

MAP LEGEND CODE
Geomorphogenetical map: Pingo
Geological map:
Groundwaterstep: 10
Vegetation-map: Mamburg
Soilmap:

Mamburg bodempje op 190? bovenin dbr

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			grbr			150-210							lemig, humeus, geroerd
20	FZ			grbr			150-210							lemig, humeus, geroerd
30	FZ			grbr			150-210							lemig, humeus, geroerd
40	FZ			grbr			150-210							lemig, humeus, geroerd
50	ZK			zwbr										zegge, doorw, rood hout
60	ZK			zwbr										zegge, doorw, rood hout
70	ZK			zwbr										zegge, doorw, rood hout
80	ZK		plr	br										doorw, tak, zegge, veenpluis
90	ZK		plr	br										doorw, tak, zegge, veenpluis
100	ZK		plr	br										doorw, tak, zegge, veenpluis
110	ZK		plr	br										doorw, tak, zegge, veenpluis
120	ZK		plr	br										doorw, tak, zegge, veenpluis
130	ZK		plr	br										doorw, tak, zegge, veenpluis
140	ZK		plr	br										doorw, tak, zegge, veenpluis
150		V3	plr	dbr										zandig, korreltjes
160		V3	plr	dbr										zandig, korreltjes
170	ZK		plr	grbr										korrelig, zegge, droog
180	ZK		plr	grbr										korrelig, zegge, droog
190	LK		plr	grbr										zz, zegge, naar onder grijzer
200	LK		plr	grbr										zz, zegge, naar onder grijzer
210	LK		plr	grbr										zz, zegge, naar onder grijzer
220	LK		plr	grbr										zz, zegge, naar onder grijzer
230	LK		plr	grbr										zz, zegge, naar onder grijzer
240	LK		plr	grbr										zz, zegge, naar onder grijzer
250	LK			brgr										zand(ig)? humeus
260	LK			brgr										zand(ig)? humeus
270	UFZ			gr			75-105							lemig
280	UFZ			gr			75-105							
290	UFZ			gr			75-105							

Base of borehole: 201107123

Borehole: 201107124 Names: A&R Year: 2011 Group: 07 Date: 7-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
303945	628938	RD	0	230

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 50
Vegetation-map: Mamburg	Soilmap:

Mamburg 165-170: lbr korrelig droog zandig zegge monsters op 175/208/211 cm diep

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			grbr			150-210							venig, doorw, geroerd
20	FZ			grbr			150-210							venig, doorw, geroerd
30	FZ			grbr			150-210							venig, doorw, geroerd
40		V1	plr	br										zandig, geroerd
50	ZK			zwbr										homogeen, doorw, stink
60	ZK			zwbr										homogeen, doorw, stink
70	ZK		plr	dbr										zegge, hout
80	ZK		plr	dbr										zegge, hout
90	ZK		plr	dbr										zegge, hout
100	ZK		plr	dbr										zegge, hout
110		V3	plr	br										zegge, ligt plat
120		V3	plr	br										zegge, ligt plat
130		V3	plr	br										mos
140		V3	plr	br										mos
150		V3	plr	dbr										korrel, zaad, zwarte wortel
160	ZK			grbr										zandig, korrel, droog
170	LK			dgrbr										platte bladen
180	LK		plr	grbr										onder grijzer, zegge, fizandig
190	LK		plr	grbr										onder grijzer, zegge, fizandig
200	LK		plr	grbr										onder grijzer, zegge, fizandig
210	UFZ			brgr			75-105							breekt plat, humeus, plak
220	UFZ			brgr			75-105							breekt plat, humeus
230	UFZ			brgr			75-105							breekt plat, humeus

Base of borehole: 201107124

Borehole: 201107125 Names: A&R Year: 2011 Group: 07 Date: 7-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
303938	628919	RD	0	180

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: -10	
Vegetation-map: Mamburg	Soilmap:	

Mamburg op 90 zwarte draadjes 2cm lang

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			grbr			150-210							venig, geroerd
20	FZ			grbr			150-210							venig, geroerd
30	FZ			grbr			150-210							venig, geroerd
40	FZ			grbr			150-210							venig, geroerd
50	ZK			zwbr										homogeen, doorw
60	ZK		plr	br										zegge
70	ZK		plr	br										zegge
80	ZK		plr	dbr										zegge
90	ZK		plr	br										korrelig, droog, zw. wortel
100	ZK		plr	br										korrelig, droog, zw. wortel
110	LK		plr	grbr										zeer zandig, zegge
120	LK		plr	grbr										zeer zandig, zegge
130	LK		plr	grbr										zeer zandig, zegge
140	LK			lgrbr										zeer zandig
150	LK			lgrbr										zeer zandig
160	UFZ			brgr			75-105							plakkerig
170	UFZ						75-105							lege guts
180	UFZ						75-105							lege guts

Base of borehole: 201107125

Borehole: 201107126 Names: A&R Year: 2011 Group: 07 Date: 7-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
303930	628901	RD	0,3	150

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 70
Vegetation-map: Mamburg	Soilmap:

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			dgrbr			150-210							humeus, doorw
20	FZ			dgrbr			150-210							humeus, doorw
30	FZ			dgrbr			150-210							humeus, doorw
40		V3		zwbr										
50		V3		br										zeer zandig
60	UFZ			br			75-105							humeus, bodem?
70	UFZ			br			75-105							humeus, bodem?
80	ZFZ			lbr			105-150							humeus, grindje 2mm
90	ZFZ			lbr			105-150							humeus, grindje 2mm
100	Z			brgr		2								zeer lemig
110	LZ			brgr		2								zeer lemig
120	ZL			dgr		2								
130	ZL			dgr		2								
140	ZL			dgr		2								
150	ZL			dgr		2								

Base of borehole: 201107126

Borehole: 201107127	Names: A&R	Year: 2011	Group: 07	Date: 7-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
303919	628872	RD	0,5	200

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Mamburg	Soilmap:	

35-37 V3 zwbr veraard, bodem, homogeen? grens 40 ligt op 37

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			grbr			150-210							
20	FZ			grbr			150-210							
30	FZ			grbr			150-210							
40	FZ			br			150-210							humeus, grindjes 5mm
50	FZ			br			150-210							humeus, grindjes 5mm
60	LZ			lbr		2								plakkerig, 150-210, zeer lemig
70	LZ			lbr		2								plakkerig, 150-210, lemig
80	LZ			lbr		2								plakkerig, 150-210, lemig
90	ZL			lgrbr		2			1					
100	ZL			lgrbr		2			1					
110	ZL			lgrbr		2			1					
120	ZL			brgr		2			1					
130	ZL			brgr		2			1					
140	ZL			brgr		2			1					
150	ZL			brgr		2			1					
160	ZL			brgr		2			1					
170	ZL			dgr		2								
180	ZL			dgr		2								kleibaarder
190	ZL			dgr		2								kleibaarder
200	ZL			dgr		2								kleibaarder

Base of borehole: 201107127

Borehole: 201107128 Names: A&R Year: 2011 Group: 07 Date: 7-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
303977	628990	RD	0	170

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 120
Vegetation-map: Mamburg	Soilmap:

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			grbr			150-210							humeus
20	FZ			grbr			150-210							humeus
30	FZ			grbr			150-210							humeus
40		V3		dbr										homogeen, stink
50		V3		zwbr										homogeen, zandig
60	FZ			br			150-210							
70	FZ			br			150-210							
80	FZ			br			150-210							
90	FZ			br			150-210							iets zwarte wortels
100	FZ			br			150-210							
110	FZ			br			150-210							plakkeriger
120	FZ			br			150-210							plakkeriger
130	FZ			br			150-210							plakkeriger
140	LZ			br										150-210
150	FZ			lbrgr			150-210							humeus
160	FZ			lbrgr			150-210							humeus
170	FZ			lbrgr			150-210							humeus

Base of borehole: 201107128

Borehole: 201107129	Names: A&R	Year: 2011	Group: 07	Date: 7-10-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
303964	628973	RD	0	230

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep:	
Vegetation-map: Mamburg	Soilmap:	

40-42 2cm zwbr veen, korrelig, geoxideerd grens 170 ligt op 165 grens 210 ligt op 205

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			grbr			150-210							doorw
20	FZ			grbr			150-210							doorw
30	FZ			grbr			150-210							doorw
40		V3	plr	br										doorw, zegge
50		V3	plr	br										doorw, zegge
60	ZK		plr	dbr										iets zandig, zegge, doorw
70	ZK		plr	dbr										iets zandig, zegge, doorw
80	ZK		plr	dbr										iets zandig, zegge, doorw
90	ZK		plr	dbr										iets zandig, zegge, doorw
100	ZK		plr	dbr										iets zandig, zegge, doorw
110	ZK		plr	br										zegge
120	ZK		plr	br										zegge
130	ZK		plr	br										zegge
140	ZK		plr	br										zegge, mos
150	ZK		plr	br										zegge, mos
160	ZK		plr	br										zegge, mos
170	LK		plr	grbr										zeer zandig, gr.bladen, zegge?
180	LK			lgrbr										zeer zandig, zegge
190	LK			lgrbr										zeer zandig, zegge
200	LK			lgrbr										zeer zandig, zegge
210	UFZ			lbrgr			75-105							gy? gelaagd
220	UFZ			lbrgr			75-105							
230	UFZ			lbrgr			75-105							

Base of borehole: 201107129

Borehole: 201107038 Names: R&A Year: 2011 Group: 07 Date: 19-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Laagte
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 380	
337284	548531	RD	41	420	Vegetation-map:	Soilmap:	

Kellerhöhe. Expectation: Pingo remnant. Perfect rampart of which 40% is visible and in grassland. Rest in corn. On a higher 'plateau'. Dekzand?

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	ZFZ			zwbr			105-150							GER. wortels, bodem (60cm)
20	ZFZ			zwbr			105-150							GER. wortels, bodem (60cm)
30	ZFZ			zwbr			105-150							GER. wortels, bodem (60cm)
40	ZFZ			br			105-150							bodem (60cm)
50	ZFZ			br			105-150							bodem (60cm)
60	ZFZ			br			105-150							bodem (60cm)
70	ZFZ			lbr			105-150							hetzelfde
80	ZFZ			lbr			105-150							hetzelfde
90	ZFZ			lbr			105-150							hetzelfde
100	ZFZ			lbr			105-150							hetzelfde
110	ZFZ			lbr			105-150							hetzelfde
120	ZFZ			lbr			105-150							hetzelfde
130	ZFZ			lbr			105-150							hetzelfde
140	ZFZ			lbr			105-150							hetzelfde
150	ZFZ			lbr			105-150							hetzelfde
160	ZFZ			lbr			105-150							hetzelfde
170	ZFZ			lbr			105-150							hetzelfde
180	ZFZ			lbr			105-150							hetzelfde
190	ZFZ			lbr			105-150							hetzelfde
200	ZFZ			lbr			105-150							hetzelfde
210	ZFZ			lbr			105-150							hetzelfde
220	ZFZ			lbr			105-150							hetzelfde
230	ZFZ			lbr			105-150							hetzelfde
240	ZFZ			lbr			105-150							hetzelfde
250	ZFZ			lbr			105-150							hetzelfde
260	ZFZ			lbr			105-150							hetzelfde
270	ZFZ			lbr			105-150							hetzelfde
280	ZFZ			lbr			105-150							hetzelfde
290	ZFZ			lbr			105-150							hetzelfde
300	ZFZ			lbr			105-150							hetzelfde
310	ZFZ			lbr			105-150							hetzelfde
320	ZFZ			lbr			105-150							hetzelfde, nat zand, iets plak
330	ZFZ			lbr			105-150							hetzelfde, nat zand, iets plak
340	ZFZ			lbr			105-150							hetzelfde
350	ZFZ			lbr			105-150							hetzelfde
360	ZFZ			lbr			105-150							hetzelfde
370	ZFZ			lbr			105-150							hetzelfde
380	ZFZ			lbr			105-150			GW				GW
390	ZFZ			lbr			105-150							hetzelfde
400	ZFZ			lbr			105-150							hetzelfde
410	ZFZ			lbr			105-150							hetzelfde
420	ZFZ			lbr			105-150							nat zand uit de boor

Base of borehole: 201107038

Borehole: 201107039	Names: R&A	Year: 2011	Group: 07	Date: 19-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE		Geomorphogenetical map:	Laagte
XCO	YCO	Coord. sys		[cm]	Geological map:		Groundwaterstep:	
337388	548595	RD	45	380	Vegetation-map:		Soilmap:	

On 'rampart'. Groundwater level not reached.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	ZFZ			zwbr			105-150							Ger,
20	ZFZ			zwbr			105-150							Ger,
30	ZFZ			br			105-150							
40	ZFZ			br			105-150							
50	ZFZ			br			105-150							
60	ZFZ			br			105-150							
70	ZFZ			br			105-150							
80	ZFZ			br			105-150							
90	ZFZ			br			105-150							
100	ZFZ			lbr			105-150							
110	ZFZ			lbr			105-150							heel iets lemig.
120	ZFZ			lgrbr			105-150							grindjes, 3 x 2cm
130	ZFZ			lgrbr			105-150							
140	ZFZ			lgrbr			105-150							kleine grindjes
150	ZFZ			lgrbr			105-150							schoon zand
160	ZFZ			lgrbr			105-150							
170	ZFZ			lgrbr			105-150							
180	ZFZ			lgrbr			105-150							
190	ZFZ			lgrbr			105-150							
200	ZFZ			lgrbr			105-150							
210	ZFZ			lgrbr			105-150							
220	ZFZ			lgrbr			105-150							
230	ZFZ			lgrbr			105-150							
240	ZFZ			lgrbr			105-150							
250	ZFZ			lgrbr			105-150							
260	ZFZ			lgrbr			105-150							
270	ZFZ			lgr			105-150							grindje,ijzervlekken
280	ZFZ			lgr			105-150							ijzervlekken
290	ZFZ			lgr			105-150							ijzervlekken
300	ZFZ			lgr			105-150							
310	ZFZ			lgr			105-150							
320	ZFZ			lgr			105-150							
330	ZFZ			lgr			105-150							
340	ZFZ			lgr			105-150							
350	ZFZ			lgr			105-150							
360	ZFZ			lgr			105-150							
370	ZFZ			lgr			105-150							
380	ZFZ			lgr			105-150							te veel zand

Base of borehole: 201107039

Borehole: 201107040 Names: R&A Year: 2011 Group: 07 Date: 19-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
337335	548561	RD	42	420

MAP LEGEND CODE
Geomorphogenetical map: Laagte
Geological map:
Groundwaterstep: 370
Vegetation-map:
Soilmap:

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	ZFZ			zwbr			105-150							ger
20	ZFZ			zwbr			105-150							ger
30	ZFZ			zwbr			105-150							ger
40	ZFZ			br			105-150							bodem
50	ZFZ			br			105-150							bodem
60	ZFZ			br			105-150							bodem
70	ZFZ			br			105-150							bodem, grindje.
80	ZFZ			br			105-150							bodem, veel grind
90	ZFZ			br			105-150							bodem, veel grind
100	ZFZ			br			105-150							bodem, grindje.
110	ZFZ			br			105-150							
120	ZFZ			br			105-150							
130	ZFZ			br			105-150							
140	ZFZ			lbrgr			105-150							
150	ZFZ			lbrgr			105-150							
160	ZFZ			lbrgr			105-150							
170	ZFZ			lbrgr			105-150							
180	ZFZ			lbrgr			105-150							heel iets lemig? nattig
190	ZFZ			lgr			105-150							
200	ZFZ			lgr			105-150							
210	ZFZ			lgr			105-150							
220	ZFZ			lgr			105-150							
230	ZFZ			lgr			105-150							
240	ZFZ			lgr			105-150							
250	ZFZ			lgr			105-150							
260	ZFZ			lgr			105-150							
270	ZFZ			lgr			105-150							
280	ZFZ			lgr			105-150							
290	ZFZ			lgr			105-150							
300	ZFZ			lgr			105-150							
310	ZFZ			lgr			105-150							
320	ZFZ			lgr			105-150							
330	ZFZ			lgr			105-150							
340	ZFZ			lgr			105-150							
350	ZFZ			lgr			105-150							
360	ZFZ			lgr			105-150			GW				
370	ZFZ			lgr			105-150							
380	ZFZ			lgr			105-150							
390	ZFZ			lgr			105-150							
400	ZFZ			lgr			105-150							
410	ZFZ			lgr			105-150							
420	ZFZ			lgr			105-150							

Base of borehole: 201107040

Borehole: 201107041 Names: A&R Year: 2011 Group: 07 Date: 20-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
351347	540914	RD	73	280

MAP LEGEND CODE	Geomorphogenetical map:	Laagte
Geological map:	Groundwaterstep: 120	
Vegetation-map:	Soilmap:	

Rennplats. Vlak naast meertje (8*30 m) in een bosje/brandnetels. De rest eromheen mais en geploegde akker. Weinig hoogteverschil.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	LK		plr	br										zandig. doorw
20	LK		plr	br										zandig. doorw
30	LK		plr	br										zandig. doorw
40	LK		plr	br										zandig. doorw
50	LK			lbr										zandig
60	LK			lbr										zandig
70		V1		dbr										doorw
80		V1		br										zandig (75-105)
90		V1		br										zandig (75-105)
100	LK			lbr						GW				zandig (75-105), humeus
110	LK			br										zandig (75-105), humeus
120	LK			br										zandig (75-105), humeus
130	LK			br										zandig (75-105), humeus
140	LK			br										zandig (75-105), humeus
150	LK			br										zandig (75-105), humeus
160	FZ			lbr			150-210							plakkerig, iets lemig
170	FZ			lbr			150-210							lemig
180	ZFZ			lbrgr			105-150							zeer lemig
190	ZFZ			lbrgr			105-150							zeer lemig
200	ZFZ			lbrgr			105-150							zeer lemig
210	ZFZ			gr			105-150							zeer lemig
220	ZFZ			gr			105-150							zeer lemig
230	ZFZ			gr			105-150							zeer lemig
240	ZL			gr										300-420 grind (2-5%) tot 3 cm
250	ZL			gr										300-420 grind (2-5%) tot 3 cm
260	ZL			gr										300-420 grind (2-5%) tot 3 cm
270	ZL			gr										300-420 grind (2-5%) tot 3 cm
280	ZL			gr										300-420 grind (2-5%) tot 3 cm

Base of borehole: 201107041

Borehole: 201107042 Names: A&R Year: 2011 Group: 07 Date: 20-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Laagte
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 120	
350320	542848	RD	0	160	Vegetation-map:	Soilmap:	

Erlte.Laagte is mooi rond, weggetje en bomen eromheen. Vijver van (25-60m) doorsnede met hutje. Riet eromheen. Ten zuiden van vijver nat bosje.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ			dbr			150-210							GER. doorw. humeus
20	FZ			dbr			150-210							GER. doorw. humeus
30	FZ			dbr			150-210							GER. doorw. humeus
40		V1	plr	dbr										doorw. humeus
50		V1	plr	dbr										doorw. humeus
60	LK		plr	br										zandig, droog.
70	LK		plr	br										zandig, droog.
80	LK		plr	br										zandig. droog, zandnest (210-3
90	LK		plr	br										grind tot 0.5cm
100	ZL			br					2					zg(210-300) grind(10%) <3cm
110	ZL			br					2					zg(210-300) grind(10%) <3cm
120	ZL			blgr					2	GW				zg(210-300)
130	ZL			blgr					2					zg(210-300)
140	ZL			blgr					2					zg(210-300)
150	ZL			blgr					2					zg(210-300)
160	ZL			blgr					2					zg(210-300)

Base of borehole: 201107042

Borehole: 201107043 Names: R&A Year: 2011 Group: 07 Date: 20-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
350316	524830	RD	0	110

MAP LEGEND CODE	Geomorphogenetical map: Laagte
Geological map:	Groundwaterstep: 70
Vegetation-map:	Soilmap:

Erlte

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	FZ		plr	dbr			150-210							GER. doorw.Humeus
20	FZ		plr	dbr			150-210							GER. doorw.Humeus
30	FZ		plr	dbr			150-210							GER. doorw.Humeus
40	FZ		plr	dbr			150-210							GER. doorw.Humeus
50	FZ		plr	dbr			150-210							GER. doorw.Humeus
60		V1	plr	br										zandig (150-210)
70	MZ			br			210-300			GW				
80	MZ			lbr			210-300							grind(5%)
90	L			gr										grind(5%) <3cm zandig(210-300)
100	L			gr										grind(5%) <3cm zandig(210-300)
110	L			gr										einde boring; steen

Base of borehole: 201107043

Borehole: 201107044	Names: R&A	Year: 2011	Group: 07	Date: 20-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
350352	542829	RD	0	120

MAP LEGEND CODE	Geomorphogenetical map:	Laagte
Geological map:	Groundwaterstep: 90	
Vegetation-map:	Soilmap:	

Erlte.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	LK		plr	dbr										GER. doorw. zandig. humeus
20	LK		plr	dbr										GER. doorw. zandig. humeus
30	LK		plr	dbr										GER. doorw. zandig. humeus
40	LK			br										dooorw. humeus. zandig
50	LK			br										dooorw. humeus. zandig
60	LK			br										dooorw. humeus. zandig
70	LK			br										dooorw. humeus. zandig
80	L			gr					2					zandig(300-420). grind(2%)
90	L			gr					2					zandig(300-420). grind(2%)
100	L			blgr					2					zandig(300-420). grind(5%)
110	L			blgr					2					zandig(300-420). grind(5%)
120	L			blgr					2					te veel keileem

Base of borehole: 201107044

Borehole: 201107045 Names: R&A Year: 2011 Group: 07 Date: 21-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
337892	541695	RD	0	200

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 70	
Vegetation-map: Bos	Soilmap:	

Emstekerfeld. In bosje, vorm onduidelijk (lijkt rond met 1 hoek, ong 300m??). Mais rondom het bosje. Geen water. Vegetatie zeer verschillend.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr										GER. doorw. zandnesten
20		V1	plr	dbr										GER. doorw. zandnesten
30		V1	plr	dbr										GER. doorw. zandnesten
40		V1	plr	dbr										GER. doorw. zandnesten
50		V1	plr	dbr										GER. doorw. zandnesten
60		V3	plr	dgrbr										
70		V3	plr	dgrbr										
80		V3	plr	br										
90	ZL		plr	lgrbr		2								Niet gelaagd.droog.grindje(1cm
100	ZL		plr	lgrbr		2								Niet gelaagd.droog.grindje(1cm
110	ZL		plr	lgrbr		2								zandig (210-300)
120	ZL			gr		2								zandig (210-300), grind(<.5cm)
130	MZ			lgrbr		2	210-300							grindjes.
140	MZ			lgrbr		2	210-300							grindjes.
150	MZ			gr		2	210-300							zeer lemig.
160	MZ			lgrbr		2	210-300							iets lemig. grind(2%)
170	MZ			lgrbr		2	210-300							iets lemig. grind(2%)
180	MZ			lgrbr		2	210-300							iets lemig. grind(2%)
190	MZ			lgrbr		2	210-300							iets lemig. grind(2%)
200	MZ			lgrbr		2	210-300							einde boring.zand uit boor.

Base of borehole: 201107045

Borehole: 201107046 Names: R&A Year: 2011 Group: 07 Date: 21-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 60	
337902	541652	RD	0	560	Vegetation-map: Bos	Soilmap:	

Emstekerfeld.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										doorw.
20		V3	plr	dbr										doorw.
30		V3	plr	dbr										doorw.
40		V3	plr	dbr										doorw.
50		V3	plr	dbr										doorw. veenpluis
60		V3	plr	br						GW				stinkt. oranje achtig.heel nat
70		V3	plr	br										stinkt. oranje achtig.heel nat
80		V3	plr	br										stinkt. oranje achtig.heel nat
90		V3	plr	br										stinkt. oranje achtig.heel nat
100		V3	plr	br										stinkt. oranje achtig.heel nat
110		V3	plr	br										stinkt. oranje achtig.heel nat
120		V3	plr	br										stinkt. oranje achtig.heel nat
130		V3	plr	br										stinkt. oranje achtig.heel nat
140		V3	plr	br										stinkt. oranje achtig.heel nat
150		V3	plr	br										stinkt. oranje achtig.heel nat
160		V3	plr	br										stinkt. oranje achtig.heel nat
170		V3	plr	br										stinkt. oranje achtig.heel nat
180		V3	plr	br										stinkt. oranje achtig.heel nat
190		V3	plr	br										stinkt. oranje achtig.heel nat
200		V3	plr	br										stinkt. oranje achtig.heel nat
210		V3	plr	br										stinkt. oranje achtig.heel nat
220		V3	plr	br										stinkt. oranje achtig.heel nat
230		V3	plr	br										stinkt. oranje achtig.heel nat
240		V3	plr	br										stinkt. oranje achtig.heel nat
250		V3	plr	br										stinkt. oranje achtig.heel nat
260		V3	plr	br										stinkt. oranje achtig.heel nat
270		V3	plr	br										stinkt. oranje achtig.heel nat
280		V3	plr	br										stinkt. oranje achtig.heel nat
290		V3	plr	br										stinkt. oranje achtig.heel nat
300		V3	plr	br										stinkt. oranje achtig.heel nat
310		V3	plr	br										stinkt. oranje achtig.heel nat
320		V3	plr	br										stinkt. oranje achtig.heel nat
330		V3	plr	br										stinkt. oranje achtig.heel nat
340		V3	plr	br										stinkt. oranje achtig.heel nat
350		V3	plr	br										stinkt. oranje achtig.heel nat
360		V3	plr	br										stinkt. oranje achtig.heel nat
370		V3	plr	br										stinkt. oranje achtig.heel nat
380		V3	plr	dgrbr										homogeen, smeerspul
390		V3	plr	dgrbr										homogeen, smeerspul
400		V3	plr	dgrbr										homogeen, smeerspul
410		V3	plr	dgrbr										homogeen, smeerspul
420		V3	plr	dgrbr										homogeen, smeerspul
430		V3	plr	dgrbr										homogeen, smeerspul
440		V3		grbr										homogeen, smeerspul
450		V3		grbr										homogeen, smeerspul
460		V3		grbr										homogeen, smeerspul
470		V3		grbr										homogeen, smeerspul
480		V3		dbr										homogeen, kleine takjes
490		V3		br										mosveen. oranje achterig
500		V3	plr	grbr										veenpluis. gy-achtig.zegge.
510		V3	plr	lbrgr										veenpluis. gy-achtig.zegge.
520	ZL		plr	gr										
530	ZL		plr	gr										schoensmeer
540	LZ		plr	gr										150-210.iets grind(<2%)<2mm
550	LZ		plr	gr										150-210.iets grind(<2%)<2mm
560	LZ		plr	gr										einde boring.boor zit vast!

Base of borehole: 201107046

Borehole: 201107047 Names: R&A Year: 2011 Group: 07 Date: 21-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 80	
337901	541668	RD	0	460	Vegetation-map: Bos	Soilmap:	

Emstekerfeld.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr										doorw.veraard
20		V1	plr	dbr										doorw.veraard
30		V1	plr	dbr										doorw.veraard
40		V1	plr	dbr										doorw. iets zandig(150-210)
50		V1	plr	dbr										doorw. iets zandig(150-210)
60		V1	plr	dbr										doorw. iets zandig(150-210)
70		V3	plr	br										oranjeachtig.stinkt.nat
80		V3	plr	br										stinkt.nat
90		V3	plr	br										veenpluis.stinkt.nat
100		V3	plr	br										veenpluis.stinkt.nat
110		V3	plr	orbr										mosveen? valt uit elkaar
120		V3	plr	orbr										mosveen? valt uit elkaar
130		V3	plr	orbr										mosveen? valt uit elkaar
140		V3	plr	orbr										mosveen? valt uit elkaar
150		V3	plr	orbr										mosveen? valt uit elkaar
160		V3	plr	orbr										veel veenpl.rode wortl. zeggev
170		V3	plr	orbr										veel veenpl.rode wortl. zeggev
180		V3	plr	orbr										veel veenpl.rode wortl. zeggev
190		V3	plr	orbr										veel veenpl.rode wortl. zeggev
200		V3	plr	orbr										veel veenpl.rode wortl. zeggev
210		V3	plr	orbr										veel veenpl.rode wortl. zeggev
220		V3	plr	orbr										veel veenpl.rode wortl. zeggev
230		V3	plr	orbr										veel veenpl.rode wortl. zeggev
240		V3	plr	orbr										veel veenpl.rode wortl. zeggev
250		V3	plr	orbr										veel veenpl.rode wortl. zeggev
260		V3	plr	orbr										veel veenpl.rode wortl. zeggev
270		V3	plr	dbr										veel veenpl.rode wortl. zeggev
280		V3	plr	dbr										zegge. houtje
290		V3	plr	dbr										zegge
300		V3	plr	dbr										zegge
310		V3	plr	dgrbr										homogeen. smeerspul.weinig plr
320		V3	plr	dgrbr										homogeen. smeerspul.weinig plr
330		V3	plr	dgrbr										homogeen. smeerspul.weinig plr
340		V3	plr	lbr										zegge
350		V3	plr	lbr										zegge
360		V3	plr	lbr										zegge
370	L		plr	lbrgr										zegge
380	L		plr	lbrgr										zegge
390	L		plr	lbrgr										zegge
400	L		plr	lbrgr										zegge
410	L		plr	lbrgr										zegge
420	L		plr	lbrgr										zegge
430	L		plr	lbrgr										zegge
440	L			gr										iets zandig
450	MZ			gr		2	300-420							gind (2%)
460	MZ			gr		2	300-420							einde boring.te grof voor guts

Base of borehole: 201107047

Borehole: 201107048 Names: R&A Year: 2011 Group: 07 Date: 21-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 10	
337907	541632	RD	0	660	Vegetation-map: Bos	Soilmap:	

Emstekerfeld.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr						GW				doorw.
20		V3	plr	lbr										rode takjes
30		V3	plr	lbr										rode takjes
40		V3	plr	lbr										rode takjes
50		V3	plr	lbr										rode takjes
60		V3	plr	br										zegge en veenpluis
70		V3	plr	br										zegge en veenpluis
80		V3	plr	br										zegge en veenpluis
90		V3	plr	br										zegge en veenpluis
100		V3	plr	br										zegge en veenpluis
110		V3	plr	br										zegge en veenpluis
120		V3	plr	br										zegge en veenpluis
130		V3	plr	br										zegge en veenpluis
140		V3	plr	br										zegge en veenpluis
150		V3	plr	br										zegge en veenpluis
160		V3	plr	br										zegge en veenpluis
170		V3	plr	br										zegge en veenpluis
180		V3	plr	br										mos. valt uit guts.iets oranje
190		V3	plr	br										mos. valt uit guts.iets oranje
200		V3	plr	br										mos. valt uit guts.iets oranje
210		V3	plr	br										mos. valt uit guts.iets oranje
220		V3	plr	br										mos. valt uit guts.iets oranje
230		V3	plr	br										mos. valt uit guts.iets oranje
240		V3	plr	br										mos. valt uit guts.iets oranje
250		V3	plr	br										mos. valt uit guts.iets oranje
260		V3	plr	br										vergane veenpluis.
270		V3	plr	br										vergane veenpluis.
280		V3	plr	br										vergane veenpluis.
290		V3	plr	br										vergane veenpluis.
300		V3	plr	br										vergane veenpluis.
310		V3	plr	br										vergane veenpluis.
320		V3	plr	br										vergane veenpluis.
330		V3	plr	br										vergane veenpluis.
340		V3	plr	br										vergane veenpluis.
350		V3	plr	br										vergane veenpluis.
360		V3	plr	br										vergane veenpluis.
370		V3	plr	br										vergane veenpluis.
380		V3	plr	br										vergane veenpluis.
390		V3	plr	br										vergane veenpluis.
400		V3	plr	br										vergane veenpluis.
410		V3	plr	br										vergane veenpluis.
420		V3	plr	dgrbr										zegge.beetje veenpluis
430		V3	plr	dgrbr										zegge.beetje veenpluis
440		V3	plr	dgrbr										zegge.beetje veenpluis
450		V3	plr	dgrbr										zegge.beetje veenpluis
460		V3	plr	dgrbr										zegge.beetje veenpluis
470		V3	plr	dgrbr										zegge.beetje veenpluis
480		V3	plr	dgrbr										zegge.beetje veenpluis
490		V3	plr	dgrbr										zegge.beetje veenpluis
500		V3	plr	dgrbr										zegge.beetje veenpluis
510		V3	plr	dgrbr										zegge.beetje veenpluis
520		V3	plr	dgrbr										zegge.beetje veenpluis
530		V3	plr	dgrbr										zegge.beetje veenpluis
540		V3	plr	dgrbr										zegge.beetje veenpluis
550		V3	plr	dgrbr										zegge.beetje veenpluis
560		V3	plr	dgrbr										zegge.beetje veenpluis
570		V3	plr	dgrbr										zegge.beetje veenpluis
580		V3	plr	dgrbr										zegge.beetje veenpluis
590		V3	plr	dgrbr										zegge.beetje veenpluis
600		V3	plr	dgrbr										zegge.beetje veenpluis

Boring: 201107048

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
610		V3	plr	dgrbr										zegge.beetje veenpluis
620		V3	plr	dgrbr										minder plr. homogeen
630		V3	plr	dgrbr										minder plr. homogeen
640		V3	plr	dgrbr										minder plr. homogeen
650		V3	plr	dgrbr										minder plr. homogeen
660		V3	plr	dgrbr										einde broing.verlengstukken op

Base of borehole: 201107048

Borehole: 201107049	Names: R&A	Year: 2011	Group: 07	Date: 21-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 40	
337920	541623	RD	0	660	Vegetation-map: Bos	Soilmap:	

Emstekerfeld.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	lbr										mos
20		V3	plr	lbr										mos
30		V3	plr	dbr										takjes.veenpluis
40		V3	plr	dbr						GW				takjes.veenpluis
50		V3	plr	dbr										takjes.veenpluis
60		V3	plr	br										mosv.valt uit guts.veenpl zegg
70		V3	plr	br										mosv.valt uit guts.veenpl zegg
80		V3	plr	br										mosv.valt uit guts.veenpl zegg
90		V3	plr	br										mosv.valt uit guts.veenpl zegg
100		V3	plr	br										mosv.valt uit guts.veenpl zegg
110		V3	plr	br										mosv.valt uit guts.veenpl zegg
120		V3	plr	br										mosv.valt uit guts.veenpl zegg
130		V3	plr	br										mosv.valt uit guts.veenpl zegg
140		V3	plr	br										mosv.valt uit guts.veenpl zegg
150		V3	plr	br										mosv.valt uit guts.veenpl zegg
160		V3	plr	br										mosv.valt uit guts.veenpl zegg
170		V3	plr	br										mosv.valt uit guts.veenpl zegg
180		V3	plr	br										mosv.valt uit guts.veenpl zegg
190		V3	plr	br										mosv.valt uit guts.veenpl zegg
200		V3	plr	br										mosv.valt uit guts.veenpl zegg
210		V3	plr	br										mosv.valt uit guts.veenpl zegg
220		V3	plr	br										mosv.valt uit guts.veenpl zegg
230		V3	plr	br										mosv.valt uit guts.veenpl zegg
240		V3	plr	br										mosv.valt uit guts.veenpl zegg
250		V3	plr	br										mosv.valt uit guts.veenpl zegg
260		V3	plr	br										mosv.valt uit guts.veenpl zegg
270		V3	plr	br										mosv.valt uit guts.veenpl zegg
280		V3	plr	br										mosv.valt uit guts.veenpl zegg
290		V3	plr	br										mosv.valt uit guts.veenpl zegg
300		V3	plr	br										mosv.valt uit guts.veenpl zegg
310		V3	plr	br										mosv.valt uit guts.veenpl zegg
320		V3	plr	br										mosv.valt uit guts.veenpl zegg
330		V3	plr	br										mosv.valt uit guts.veenpl zegg
340		V3	plr	br										mosv.valt uit guts.veenpl zegg
350		V3	plr	br										mosv.valt uit guts.veenpl zegg
360		V3	plr	br										mosv.valt uit guts.veenpl zegg
370		V3	plr	br										mosv.valt uit guts.veenpl zegg
380		V3	plr	br										mosv.valt uit guts.veenpl zegg
390		V3	plr	br										mosv.valt uit guts.veenpl zegg
400		V3	plr	br										mosv.valt uit guts.veenpl zegg
410		V3	plr	lbr										zegge
420		V3	plr	dgrbr										zegge
430		V3	plr	dgrbr										zegge
440		V3	plr	dgrbr										zegge
450		V3	plr	dgrbr										zegge
460		V3	plr	dgrbr										zegge
470		V3	plr	orbr										mosveen.btj zegge
480		V3	plr	orbr										mosveen.btj zegge
490		V3	plr	orbr										zeggeveen
500		V3	plr	dgrbr										homogeen. weinig plr
510		V3	plr	dgrbr										homogeen. weinig plr
520		V3	plr	dgrbr										homogeen. weinig plr
530		V3	plr	dgrbr										homogeen. weinig plr
540		V3	plr	dgrbr										homogeen. zachter/smeerbr
550		V3	plr	dgrbr										homogeen. zachter/smeerbr
560		V3	plr	dgrbr										homogeen. zachter/smeerbr
570		V3	plr	dgrbr										homogeen. zachter/smeerbr
580		V3	plr	dgrbr										homogeen. zachter/smeerbr
590		V3	plr	dgrbr										homogeen. zachter/smeerbr
600		V3	plr	dgrbr										homogeen. zachter/smeerbr

Boring: 201107049

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
610		V3	plr	dgrbr										homogeen. zachter/smeerbr
620		V3		lbr										gy-achtig.iets zandig.
630		V3	plr	lbrgr										ietz zandig. homogeen. stug
640		V3		lbrgr										ietz zandig. homogeen. stug
650		V3	plr	dbr										smeerbaar zacht
660		V3	plr	dbr										einde boring.verlengstukken op

Base of borehole: 201107049

Borehole: 201107050 Names: A&R Year: 2011 Group: 07 Date: 22-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
337879	541718	RD	0	110

MAP LEGEND CODE	Geomorphogenetical map: Laagte
Geological map:	Groundwaterstep:
Vegetation-map: Bos	Soilmap:

Emstekerfeld. Zelfs door leem lijkt soms aarde te zitten. Geroerd/opgebracht? va 50cm: grootte grind varieert, binnen elk sample alles door elkaar

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		zwbr										zandig, veraard, doorw
20		V1		zwbr										zandig, veraard, doorw
30		V1		lbr										zandig, veraard, doorw
40		V1		lbr										zandig, veraard, doorw
50	L			lgrbr										5% grind +/-2mm
60	L			lgrbr										zelfde, Fe vlekken, grind 5cm
70	L			lgrbr										zelfde, wortel
80	L			lgrbr										zelfde
90	L			lgrbr										zelfde
100	L			lgrbr										zelfde
110	L			lgrbr										zelfde

Base of borehole: 201107050

Borehole: 201107051	Names: R&A	Year: 2011	Group: 07	Date: 22-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 140	
337887	541708	RD	0	220	Vegetation-map: Bos	Soilmap:	

Emstekerfeld.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		dbr										zandig,veraard
20		V1		dbr										zandig,veraard
30		V1		lbr										zandig,veraard
40	ZL			lbrgr		2								zandig(150-210).
50	ZL			lbrgr		2								zandig(150-210), grindje 2cm
60	ZL		plr	lbrgr		2								zandig(150-210).
70	ZL		plr	lbrgr		2								zandig(150-210).
80	ZL		plr	lbrgr		2								zandig(150-210).
90	ZL		plr	lbrgr		2								zandig(150-210).
100	MZ		plr	lgrbr		2	210-300		2					lemig.beetje oranje
110	MZ		plr	lgrbr		2	210-300		2					lemig.beetje oranje
120	MZ		plr	lgrbr		2	210-300		2					lemig.beetje oranje
130	MZ		plr	lgrbr		2	210-300		2					lemig.beetje oranje
140	ZL			gr		2			2					zandig(150-210)
150	ZL			gr		2			2					zandig(150-210)
160	ZL			gr		2			2					zandig(150-210)
170	ZL			gr		2			2					zandig(150-210)
180	ZL			dgr		2			2					geplette steentjs zndg(150-210
190	ZL			dgr		2			2					geplette steentjs zndg(150-210
200	ZL			dgr		2			2					geplette steentjs zndg(150-210
210	ZL			dgr		2			2					geplette steentjs zndg(150-210
220	ZL			dgr		2			2					einde boring

Base of borehole: 201107051

Borehole: 201107052	Names: R&A	Year: 2011	Group: 07	Date: 22-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
337907	541651	RD	0	660

MAP LEGEND CODE	
Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 50
Vegetation-map: Bos	Soilmap:

Emstekerfeld. Pollen monsters genomen rondom 450.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										veenpluis
20		V3	plr	dbr										veenpluis
30		V3	plr	dbr										veenpluis
40		V3	plr	dbr										veenpluis
50		V3	plr	br										veenpluis/heide/mos
60		V3	plr	br										veenpluis/heide/mos
70		V3	plr	br										veenpluis/heide/mos
80		V3	plr	br										veenpluis/heide/mos
90		V3	plr	br										veenpluis/heide/mos
100		V3	plr	br										veenpluis/heide/mos
110		V3	plr	br										veenpluis/heide/mos
120		V3	plr	br										veenpluis/heide/mos
130		V3	plr	br										veenpluis/heide/mos
140		V3	plr	br										veenpluis/heide/mos
150		V3	plr	br										veenpluis/heide/mos
160		V3	plr	br										veenpluis/heide/mos
170		V3	plr	br										veenpluis/heide/mos
180		V3	plr	br										veenpluis/heide/mos
190		V3	plr	br										veenpluis/heide/mos
200		V3	plr	br										idem+ >mos. geliger
210		V3	plr	br										idem+ >mos. geliger
220		V3	plr	br										idem+ >mos. geliger
230		V3	plr	br										idem+ >mos. geliger
240		V3	plr	br										idem+ >mos. geliger
250		V3	plr	br										idem+ >mos. geliger
260		V3	plr	br										idem+ zegge/veenpluis
270		V3	plr	br										idem+ zegge/veenpluis
280		V3	plr	br										idem+ zegge/veenpluis
290		V3	plr	br										idem+ zegge/veenpluis
300		V3	plr	br										idem+ zegge/veenpluis
310		V3	plr	br										idem+ zegge/veenpluis
320		V3	plr	br										idem+ zegge/veenpluis
330		V3	plr	br										idem+ zegge/veenpluis
340		V3	plr	br										idem+ zegge/veenpluis
350		V3	plr	br										idem+ zegge/veenpluis
360		V3	plr	br										idem+ zegge/veenpluis
370		V3	plr	br										idem+ zegge/veenpluis
380		V3	plr	br										idem+ zegge/veenpluis
390		V3	plr	br										idem+ zegge/veenpluis
400		V3	plr	lgrbr										monster. homogeen
410		V3	plr	lgrbr										homogeen. smerig.natter
420		V3	plr	lgrbr										homogeen. smerig.natter
430		V3	plr	lgrbr										homogeen. smerig.natter
440		V3	plr	lgrbr										homogeen. smerig.natter
450		V3	plr	lgrbr										monster
460		V3	plr	lgrbr										homogeen. smerig.natter
470		V3	plr	lgrbr										homogeen. smerig.natter
480		V3	plr	dgnbr										grof detr.gy. potamogeton.
490		V3	plr	dgnbr										grof detr.gy. potamogeton.
500		V3	plr	dgnbr										grof detr.gy. potamogeton.
510		V3	plr	dgnbr										grof detr.gy. potamogeton.
520		V3	plr	dgnbr										grof detr.gy. potamogeton.
530		V3	plr	dgnbr										grof detr.gy. potamogeton.
540		V3	plr	dgnbr										grof detr.gy. potamogeton.
550		V3	plr	dgnbr										grof detr.gy. potamogeton.
560		V3		dgnbr										fijn detr.gy. potamogeton.
570		V3		dgnbr										fijn detr.gy. potamogeton.
580		V3		dgnbr										fijn detr.gy. potamogeton.
590		V3		dgnbr										fijn detr.gy. potamogeton.
600		V3		dgnbr										fijn detr.gy. potamogeton.

Boring: 201107052

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
610		V3		dgnbr										fijn detr.gy. potamogeton.
620		V3		dgnbr										fijn detr.gy. zandnesten.
630	UFZ			dgrbr			75-105							lemig. org meter. org. mat.
640	UFZ			dgrbr			75-105							lemig. org meter. org. mat.
650	UFZ			dgrbr			75-105							lemig. org meter. org. mat.
660	FZ			dgrbr			150-210							einde boring. zand onderin

Base of borehole: 201107052

Borehole: 201107053 Names: A&R Year: 2011 Group: 07 Date: 22-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
337924	541609	RD	0	580

MAP LEGEND CODE	
Geological map:	Geomorphogenetical map: Pingo
Vegetation-map: Bos	Groundwaterstep: 40
	Soilmap:

Emstekerfeld. Langere gy dan in midden --> ingewaaid zand in rand?

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	br										
20		V3	plr	br										
30		V3	plr	br										
40		V3	plr	lbr										
50		V3	plr	br										prut, mos,zegge,hout,pluismat
60		V3	plr	br										prut, mos,zegge,hout,pluismat
70		V3	plr	br										prut, mos,zegge,hout,pluismat
80		V3	plr	br										prut, mos,zegge,hout,pluismat
90		V3	plr	br										prut, mos,zegge,hout,pluismat
100		V3	plr	br										prut, mos,zegge,hout,pluismat
110		V3	plr	br										prut, mos,zegge,hout,pluismat
120		V3	plr	br										prut, mos,zegge,hout,pluismat
130		V3	plr	br										prut, mos,zegge,hout,pluismat
140		V3	plr	br										prut, mos,zegge,hout,pluismat
150		V3	plr	br										prut, mos,zegge,hout,pluismat
160		V3	plr	br										prut, mos,zegge,hout,pluismat
170		V3	plr	br										prut, mos,zegge,hout,pluismat
180		V3	plr	br										prut, mos,zegge,hout,pluismat
190		V3	plr	br										prut, mos,zegge,hout,pluismat
200		V3	plr	br										prut, mos,zegge,hout,pluismat
210		V3	plr	br										prut, mos,zegge,hout,pluismat
220		V3	plr	br										prut, mos,zegge,hout,pluismat
230		V3	plr	br										prut, mos,zegge,hout,pluismat
240		V3	plr	br										prut, mos,zegge,hout,pluismat
250		V3	plr	lbr										mos, zegge, veenpluis
260		V3	plr	lbr										mos, zegge, veenpluis
270		V3	plr	lbr										mos, zegge, veenpluis
280		V3	plr	lbr										mos, zegge, veenpluis
290		V3	plr	lbr										mos, zegge, veenpluis
300		V3	plr	lbr										mos, zegge, veenpluis
310		V3	plr	lbr										mos, zegge, veenpluis
320		V3	plr	lbr										mos, zegge, veenpluis
330		V3	plr	lbr										mos, zegge, veenpluis
340		V3	plr	lbr										mos, zegge, veenpluis
350		V3	plr	lbr										mos, zegge, veenpluis
360		V3	plr	lbr										mos, zegge, veenpluis
370		V3	plr	lbr										mos, zegge, veenpluis
380		V3	plr	lbr										mos, zegge, veenpluis
390		V3	plr	lbr										mos, zegge, veenpluis
400		V3		dgnbr										grof detr. gy
410		V3		dgnbr										grof detr. gy
420		V3		dgnbr										grof detr. gy
430		V3		dgnbr										grof detr. gy
440		V3		dgnbr										grof detr. gy
450		V3		gnbr										fijn detr. gy, potamogetonzaad
460		V3		gnbr										fijn detr. gy, potamogetonzaad
470		V3		gnbr										fijn detr. gy, potamogetonzaad
480		V3		gnbr										fijn detr. gy, potamogetonzaad
490		V3		gnbr										fijn detr. gy, potamogetonzaad
500		V3		gnbr										fijn detr. gy, potamogetonzaad
510		V3		gnbr										fijn detr. gy, potamogetonzaad
520		V3		gnbr										fijn detr. gy, potamogetonzaad
530		V3		gnbr										fijn detr. gy, potamogetonzaad
540		V3		gnbr										fijn detr. gy, potamogetonzaad
550		V3		gnbr										fijn detr. gy, potamogetonzaad
560		V3		gnbr										fijn detr. gy, potamogetonzaad
570		V3		gnbr			75-105							zeer zandig fijn detr. gy
580		V3		gngr										einde boring

Base of borehole: 201107053

Borehole: 201107054 Names: A&R Year: 2011 Group: 07 Date: 22-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
337935	541598	RD	0	480

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 50	
Vegetation-map: Bos	Soilmap:	

Emstekerfeld 360 kleur lbrgr of lbrgr??? grenzen afgerond. 407-410 zandig laagje, 450 zandig laagje 0.5cm 105-150

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										
20		V3	plr	dbr										
30		V3	plr	dbr										
40		V3	plr	dbr										
50		V3	plr	br										scheef gelaagd, 20grad dipt N
60		V3	plr	br										scheef gelaagd, 20grad dipt N
70		V3	plr	br										scheef gelaagd, 20grad dipt N
80		V3	plr	br										scheef gelaagd, 20grad dipt N
90		V3	plr	br										scheef gelaagd, 20grad dipt N
100		V3	plr	br										scheef gelaagd, 20grad dipt N
110		V3	plr	br										scheef gelaagd, 20grad dipt N
120		V3	plr	br										scheef gelaagd, 20grad dipt N
130		V3	plr	br										scheef gelaagd, 20grad dipt N
140		V3	plr	br										scheef gelaagd, 20grad dipt N
150		V3	plr	br										scheef gelaagd, 20grad dipt N
160		V3	plr	br										scheef gelaagd, 20grad dipt N
170		V3	plr	br										scheef gelaagd, 20grad dipt N
180		V3	plr	br										scheef gelaagd, 20grad dipt N
190		V3	plr	br										scheef gelaagd, 20grad dipt N
200		V3	plr	br										scheef gelaagd, 20grad dipt N
210		V3	plr	br										scheef gelaagd, 20grad dipt N
220		V3	plr	br										scheef gelaagd, 20grad dipt N
230		V3	plr	br										scheef gelaagd, 20grad dipt N
240		V3	plr	br										scheef gelaagd, 20grad dipt N
250		V3	plr	br										scheef gelaagd, 20grad dipt N
260		V3	plr	br										scheef gelaagd, 20grad dipt N
270		V3	plr	br										scheef gelaagd, 20grad dipt N
280		V3	plr	br										scheef gelaagd, 20grad dipt N
290		V3	plr	br										scheef gelaagd, 20grad dipt N
300		V3	plr	br										scheef gelaagd, 20grad dipt N
310		V3		dgr										grof detr. gy
320		V3		lgngr										fijndetr. gy, scherpkleuroverg
330		V3		dgngr			150-210							fijndetr. gy, zandig
340		V3		dgngr			150-210							fijndetr. gy, zandig
350		V3		dgngr			150-210							fijndetr. gy, zandig
360		V3		lbrgn			150-210							fijndetr. gy, zandig
370		V3		lbrgn			150-210							fijndetr. gy, zandig
380		V3		lbrgn			150-210							fijndetr. gy, zandig
390		V3		dbr										zandig, gy
400		V3		br										zandig, gy
410		V3		br										zandig, gy
420	ZL			gr										laminae
430	ZL			gr										laminae
440	ZL			gr										laminae
450	ZL			gr										laminae
460	ZL			gr										300-420
470	MZ			dgr			210-300							zeer lemig
480	MZ			dgr			210-300							zeer lemig, einde boring steen

Base of borehole: 201107054

Borehole: 201107055	Names: A&R	Year: 2011	Group: 07	Date: 22-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
337935	541585	RD	0	260

MAP LEGEND CODE		Geomorphogenetical map:	Pingo
Geological map:		Groundwaterstep:	
Vegetation-map: Bos		Soilmap:	

Emstekerfeld. versimpelde kernbeschrijving, voor detail zie origineel

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V3	plr	dbr										
20		V3	plr	dbr										
30		V3	plr	dbr										
40		V3	plr	dbr										
50		V3	plr	dbr										
60		V3	plr	dbr										
70		V3	plr	dbr										
80		V3	plr	br										zegge, veenpluis
90		V3	plr	br										zegge, veenpluis
100		V3	plr	br										zegge, veenpluis
110		V3	plr	br										zegge, veenpluis
120		V3	plr	br										zegge, veenpluis
130		V3	plr	br										zegge, veenpluis
140		V3	plr	dgnbr										grof.detr.gy
150		V3	plr	dgnbr										grof.detr.gy
160		V3	plr	gnbr										grof.detr.gy, YD deel 2
170		V3	plr	gnbr										grof.detr.gy, YD deel 2
180		V3		dgnbr										fijn detr. gy, YD deel 1
190		V3	plr	dgnbr										fijn detr. gy, Allerod
200		V3	plr	lgnbr										zandig, Oude Dryas/Bolling
210	ZL													zandig 150-210, Oudste Dryas
220	ZL													zandig 150-210, Oudste Dryas
230	FZ			dgr			150-210							lemig
240	FZ			lbrgr			150-210							langzaam groffer, laminae
250	MZ			lbrgr			210-300							zelfde
260	MZ			lbrgr			300-420							zelfde, einde boring

Base of borehole: 201107055

Borehole: 201107056 Names: R&A Year: 2011 Group: 07 Date: 22-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
337939	541561	RD	0,5	100

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep: 60
Vegetation-map: Gras	Soilmap:

Emsterkerfeld. Op zoek naar randwal.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	dbr										doorw. veraard
20		V1	plr	dbr										doorw. veraard
30		V1	plr	dbr										doorw. veraard
40		V3	plr	br										zandig
50	ZFZ			lbr			105-150							lemig. humeus
60	ZFZ			lbr			105-150							lemig. humeus
70	ZFZ			lbr			105-150							lemig. humeus
80	ZFZ		plr	lbr			105-150							leem/loess. homogeen. zandig
90	L			lbr		15								leem/loess. grind tot 2cm
100	L			lbr		15								leem/loess. einde boring.

Base of borehole: 201107056

Borehole: 201107057 Names: R&A Year: 2011 Group: 07 Date: 22-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
337942	541560	RD	0,6	70

MAP LEGEND CODE	Geomorphogenetical map: Pingo
Geological map:	Groundwaterstep:
Vegetation-map: Mais	Soilmap:

Emstekerfeld. Op zoek naar randwal. Niet gevonden.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1		zwbr										zandig. GER.
20		V1		zwbr										zandig. GER.
30		V1		zwbr										zandig. GER.
40		V1		zwbr										zandig. GER.
50	L			br										loess
60	ZFZ			lbr		2	105-150							lemig. grind gevoeld.
70	ZFZ			lbr		2	105-150							einde boring. steen.

Base of borehole: 201107057

Borehole: 201107058 Names: R&A Year: 2011 Group: 07 Date: 23-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep: 60	
334830	540550	RD	0	490	Vegetation-map: Bosje	Soilmap:	

Sevelte. Depressie 14 zie beschrijving. Boring naast een vijvertje (wss uitgegraven) +/- 5 m van de rand van het bosje. Monster op 345, 403, 458 en 482 cm.

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10		V1	plr	br										zandig (150-210). doorw.
20		V1	plr	br										zandig (150-210). doorw.
30		V1	plr	br										zandig (150-210). doorw.
40	FZ		plr	lbr			150-210		1					humeus. geroerd.
50	FZ		plr	lbr			150-210		1					humeus. geroerd. lemig
60	FZ		plr	lbr			150-210		1	GW				humeus. geroerd. lemig
70	FZ		plr	lbr			150-210		1					humeus. geroerd. lemig
80		V1	plr	dbr										doorw. zandig(150-210) veenpl
90		V1	plr	dbr										veenpluis
100		V1	plr	dbr										doorw. zandig(150-210) veenpl
110		V1	plr	dbr										doorw. zandig(150-210) veenpl
120		V1	plr	dbr										doorw. zandig(150-210) veenpl
130		V1	plr	dbr										doorw. zandig(150-210) veenpl
140		V1	plr	dbr										doorw. zandig(150-210) veenpl
150		V1	plr	dbr										doorw. zandig(150-210) veenpl
160		V3	plr	orbr										mos/zegge/veenpl breekt scheef
170		V3	plr	orbr										mos/zegge/veenpl breekt scheef
180		V3	plr	orbr										mos/zegge/veenpl breekt scheef
190		V3	plr	orbr										mos/zegge/veenpl breekt scheef
200		V3	plr	orbr										mos/zegge/veenpl breekt scheef
210		V3	plr	orbr										mos/zegge/veenpl breekt scheef
220		V3	plr	orbr										mos/zegge/veenpl breekt scheef
230		V3	plr	orbr										mos/zegge/veenpl breekt scheef
240		V3	plr	orbr										mos/zegge/veenpl breekt scheef
250		V3	plr	dgrbr										homogeen smeerbaar. gy-acht.
260		V3	plr	dgrbr										homogeen smeerbaar. gy-acht.
270		V3	plr	dgrbr										homogeen smeerbaar. gy-acht.
280		V3	plr	dgrbr										homogeen smeerbaar. gy-acht.
290		V3	plr	dgrbr										homogeen smeerbaar. gy-acht.
300		V3	plr	dgrbr										homogeen smeerbaar. gy-acht.
310		V3	plr	dgrbr										homogeen smeerbaar. gy-acht.
320		V3	plr	dgrbr										homogeen smeerbaar. gy-acht.
330		V3	plr	dgrbr										homogeen smeerbaar. gy-acht.
340		V3	plr	dgrbr										homogeen smeerbaar. gy-acht.
350		V3	plr	dbrgr										grof detr. gy
360		V3	plr	dbrgr										grof detr. gy
370		V3	plr	dbrgr										grof detr. gy
380		V3	plr	dbrgr										grof detr. gy
390		V3	plr	dbrgr										grof detr. gy
400		V3		brgr										fijn detr. gy. iets zandig
410		V3		brgr										fijn detr. gy. iets zandig
420		V3		brgr										fijn detr. gy. iets zandig
430		V3		gngr										gy. zaadjes
440		V3		gngr										gy. zaadjes
450		V3		gngr										gy. zaadjes
460		V3		dgngr										gy. gummie
470		V3		dgngr										gy. gummie
480		V3		dgngr										gy. gummie
490		V3		dgngr										einde boring. guts vast.

Base of borehole: 201107058

Borehole: 201107059	Names: R&A	Year: 2011	Group: 07	Date: 23-9-2011

Coordinates			Elevation	Depth
XCO	YCO	Coord. sys		[cm]
334752	540550	RD	1,5	370

MAP LEGEND CODE	Geomorphogenetical map:	Pingo
Geological map:	Groundwaterstep: 150	
Vegetation-map:	Soilmap:	

Sevelten - op de randwal, z is geschat. Monster op 130, 210 290-295 dbr v3 gy 295-300 grbr v3 gy 320-325 groot stuk hout grenzen afgerond, zie aantekeningen voor precieze grenzen 2 gootjes: 360-325 en 323-280

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	MZ		plr	dbr			210-300							geroerd, humeus
20	MZ			gebr			210-300							bontgekleurd, vlekken d en l
30	MZ			gebr			210-300							bontgekleurd, vlekken d en l
40	MZ			gebr			210-300							bontgekleurd, vlekken d en l
50	MZ			gebr		2	210-300							zelfde, grind tot 5mm
60	MZ			gebr			210-300							brro leemblokken tot 30mm
70	MZ			gebr		2	210-300							dogr leemblokken tot 30mm
80	L			brgr		5								zeer zandig 150-210
90	L			brgr		5								zeer zandig 210-300
100	L			brgr		5								zeer zandig 210-300
110	L			brgr		5								zeer zandig 210-300
120		V1		dbr										zeer zandig, rand boor 420-600
130		V1		dbr										zeer zandig, rand boor 420-600
140	FZ			gebr			150-210							redelijk schoon
150	FZ			gebr			150-210							redelijk schoon
160	FZ			gebr			150-210							redelijk schoon
170	L			gr										zandig, 105-150, mix grbr zand
180	L			gr										zandig, 105-150, mix grbr zand
190	L			gr										zandig, 105-150, mix grbr zand
200	FZ			grbr			150-210							zandig
210		V3	plr	dbr										zegge, grbr zandbrokken...
220		V3	plr	dbr										idem .....zelfde als door leem
230		V3	plr	dbr										idem ....van boven?
240		V3	plr	dbr										idem
250		V3	plr	dbr										idem, fonteinkruidzaadje
260		V3	plr	br										zandig, grof detr. gy?
270		V3	plr	br										zandig, grof detr. gy?
280		V3	plr	br										zandig, grof detr. gy?
290		V3	plr	dbr										zandig, fijne gy, dbr-grbr
300		V3		gngr										gnbrgr, fijne gy
310		V3		gngr										gnbrgr, fijne gy
320														geen monster - boom!
330		V3	plr	br										fijne gy
340		V3	plr	br										fijne gy
350		V3	plr	br										fijne gy
360	ZFZ		plr	grbr			105-150							laminae 3mm zand br/gr 105-150
370		V3	plr	gebr										einde boring zand

Base of borehole: 201107059

Borehole: 201107060 Names: A&R Year: 2011 Group: 07 Date: 27-9-2011

Coordinates			Elevation	Depth	MAP LEGEND CODE	Geomorphogenetical map:	Pingo
XCO	YCO	Coord. sys		[cm]	Geological map:	Groundwaterstep:	
334721	540589	RD	0	130	Vegetation-map:	Soilmap:	

Sevelten

Depth	Texture	Org	Plr	Colour	RedOx	Gravel	M50	Ca	Fe	GW	M	LKL	Strat	Miscellaneous observations
10	ZFZ			gr			105-150		2					iets lemig, or vlekken
20	ZFZ			gr			105-150		2					iets lemig, or vlekken
30	ZFZ			gr			105-150		2					iets lemig, or vlekken
40	ZFZ			gr		5	105-150		2					idem,grind tot 2mm
50	ZFZ			gr			105-150							iets lemig, or vlekken
60	L			or										mix met or en ro zand 210
70	L			or										mix met or en ro zand 210
80	L			or										mix met or en ro zand 210
90	L			or										1,5 cm grindje
100	L			or										mix met or en ro zand 210
110	L			or										mix met or en ro zand 210
120	L			or										mix met or en ro zand 210
130	L			or										einde boring. teveel tehard.

Base of borehole: 201107060

Appendix E1a. Core descriptions Timmelteich

Timmelteich I

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
100	128		geen monster			
128	142	dbr	veen		kleine plr	
142	154	br/dbr gevlekt	veen		plr	baksteentje
154	168	br	veen	zandig		stukjes baksteen, zandnesten

Timmelteich II

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
168	178	grbr	veen	iets zandig		dunne holle laagjes, onderste 3cm
178	189	grbr	V3		iets plr	bovenste 5cm iets gelaagd
189	196	dgrbr	bosveen		plr	twee takken (1.5cm)
196	202	br	V3		plr	iets gelaagd

Timmelteich III

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
214	215	br	V3	-	plr	doorworteld, niet verstoord
215	238	br	V3	-	plr	iets dun gelaagd (door snijder?)
238	248	br	V3	-	plr	doorworteld
248	280	dbr	V3		plr, zaadjes, houtje	iets (dikker) gelaagd

Timmelteich IV

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
279	280	dbr	V3		grote plr	losser dan hieronder, 278 baksteen
280	290	dbr	V3		grote plr	ruwer, minder compact dan onder
290	327	dbr	V3	iets zandig	kleine plr	laagjes, mosbandjes, 300: zegge
327	365	dbr	V3	iets zandig	plr	laagjes, mosbandjes

Timmelteich V

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
374	376	dbr	grof gy	iets zandig	grote plr	
376	386					zelfde als onder, lastig opensnijden
386	403	dbr	grof gy	zandig	iets plr	zelfde als onder, minder moslaagjes
403	423	dbr	fijne gy	zandig	kleine plr	gelaagdheid, lange plr bovendoor
423	433	dbr	fijne gy (iets minder fijn)	iets zandig	iets kleine plr	iets gelaagd
433	435	dbr	grof gy?		plr, mos?	gelaagd
435	436.5	dbr	fijner detritisch bandje gy	-	minder kl. plr	
436.5	443	dbr	iets groffer detr gy	iets zandig	veel kl. plr. mos?	laagjes
443	455	dbr	fijn gy	iets zandig	niet heel, zaadje	o.grens niet horizontaal!
455	462	gnbr	fijn gy	zeer zandig	niets herkenbaar	YD?
462	466	lgnbr	gy	zeer zandig		gelaagd, niet netjes; zandnesten
466	469	gnbr	gy	zeer zandig	plr: takje?	gelaagd
469	470	dgnbr	fijn gy	zeer zandig	geen duidelijk	

Timmelteich VI

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
478	500	dbr		zandig		84: zandnestje, 99: zegge
500	501	dgnbr	organisch			o/b grens vaag, dunne laagjes
501	503	gngr		zandig		org. pikkels, rommelige laagjes
503	504	dgnbr		zandig		gelaagd, meer org. mat dan onder
504	507.2	gngr		zandig		organische spikkels, zandnestje bovenop
507.2	507.6	lgngr				zandlaagje?
507.6	513	dgngr	gelaagd	zandig	-	organische spikkels
513	513.3	lgngr	zandlaagje	zand	-	-
513.3	516	dgngr	gelaagd	zandig	-	organische spikkels
516	519.7	gngr	gelaagd gyttja	zandig	-	organische spikkels
519.7	520	lgngr			-	bandje
520	525.2	gngr		zandig	macro	organische spikkels
525.2	526	lbrgr	gyttja		-	bandje
526	527	grbr	organische resten		macro	scherpe grens (boven of onder?)
527	541	gr	lemig zand	zand	-	bont grind, hoekig, 1 van 3cm geleidelijke grens
541	547	dgr	lemig zand	zand	-	witte (spikkels)/ grindjes

Appendix E1b. Core photographs Timmelteich

Appendix E2a. Core descriptions Emstekerfeld

Emstekerfeld I

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
358	365	dbr	(gyttja?) veen	zandig	plr	
365	375	dgngr	gyttja	heel zandig		
375	393	gnbr	??? gelaagd	zandig	beetje plr	
393	400	dgnbr	gyttja veen	zandig		400: takje
400	409	gnbr	fijne gyttja, gelaagd	zandig	iets plr	404: 2 cm zwart laagje
409	414	dgngr	fijne gyttja, gelaagd	zandig	miss plr	
414	419	gngr	fijne gyttja (lemig veen)	zandig		
419	438	gr	leem			
438	450	dgr	leem			

Emstekerfeld II

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
342	354	dbr	veen gyttja	zandig		
354	355	hnbr	veen gyttja	zandig		
355	366	dgnbr	veen gyttja	zandig		grote overgang in kort interval
366	372	lgnbr (grijzig)	veen gyttja	zandig		grote overgang in kort interval
372	378	gnbr (grijzig)	veen gyttja	zandig		
378	383	dgnbr (grijzig)	veen gyttja	zandig		
383	392	gnbr (grijziger)	veen gyttja	zandig		
392	400	dgnbr	veen gyttja	zeer zandig		
400	410	gnbr	veen gyttja	zeer zandig		408: zaadje

Appendix E2b. Core photographs Emstekerfeld

Emstekerfeld I

Emstekerfeld II - photographs not available

Appendix E3a. Core descriptions Sleenerstroom I

Sleenerstroom I (borehole A)

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
146	149	br	veen	zandig		naval
149	155	br	veen	zandig		
155	165	lbr	veen	zandig		bovengrens niet horizontaal
165	168	dbr	veen	zandig		
168	169.5	br	veen	zandig		
169.5	170	dbr	veen	zandig		
170	172	lbr	veen	zandiger		
172	176	br	veen	zandig		vlekkerig
176	180	dbr	veen	zandig		
180	186	br/dbr	veen	zandig		verkleuring door oxidatie en zandigheid
186	190	br/lbrgr	veen	zandig		gelaagd met lbrgr zand, laagjes 2 a 3 mm en 1 dikkere laag van 187-186

Sleenerstroom II (borehole A)

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
197	215	br	veen	zeer zandig		zandlaagjes: 212-211.5, 210-208.5, 208-207,206, 203.5-202.5, 200-199.5
215	240	dbr	veen	zeer zandig		zandlaagjes: 239.6-239.4, 239-238.5, 238.4-238, 235, 222-220.5, 219.5-218.5, 217-216

Sleenerstroom III (borehole A)

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
244	256	br	veen	iets zandig		losse prut
256	290	br	veen	iets zandig		geoxideerd, compact, vivianiet op 273, witte pikkels 276-272

Sleenerstroom IV (borehole A)

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
289	295	br	veen			laagjes, mos? Minder compact
295	305	br	veen			laagjes, mos?

Sleenerstroom V (borehole A)

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
307	335	dbr	veen			moslaagjes

Sleenerstroom VI (borehole A) - genomen met guts

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
334	348	dbr	veen (fijne gy?)	zandig		zandige bijmenging, zandlaagjes
348	410	dbr	grof gy			vivianiet van 371-368

Sleenerstroom VII (borehole B) - genomen met guts

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
400	470	dbr	grof gy		kleine plr	plr onherkenbaar

Sleenerstroom VIII (borehole B) - genomen met guts

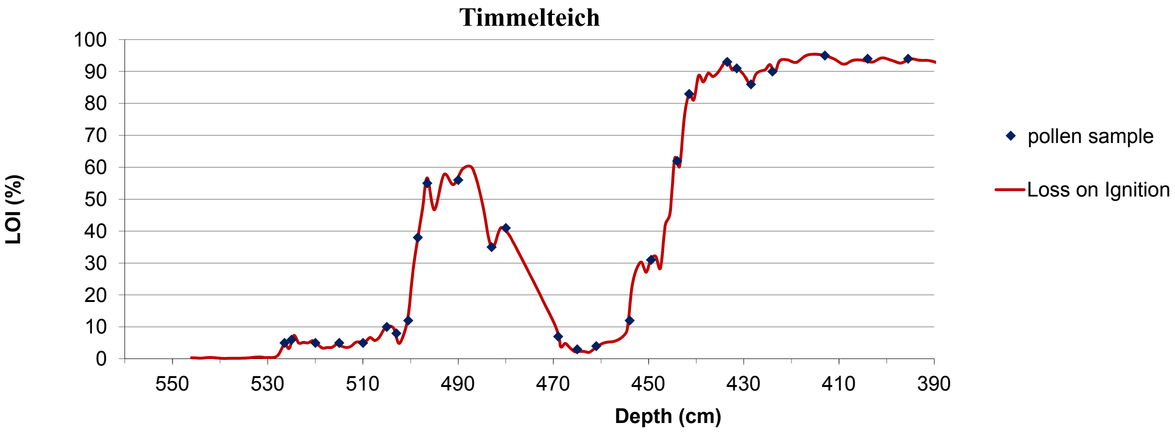
bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
477	480	dgrbr	fijne gy			gele vlek ~480, vivianiet op 484 en 483

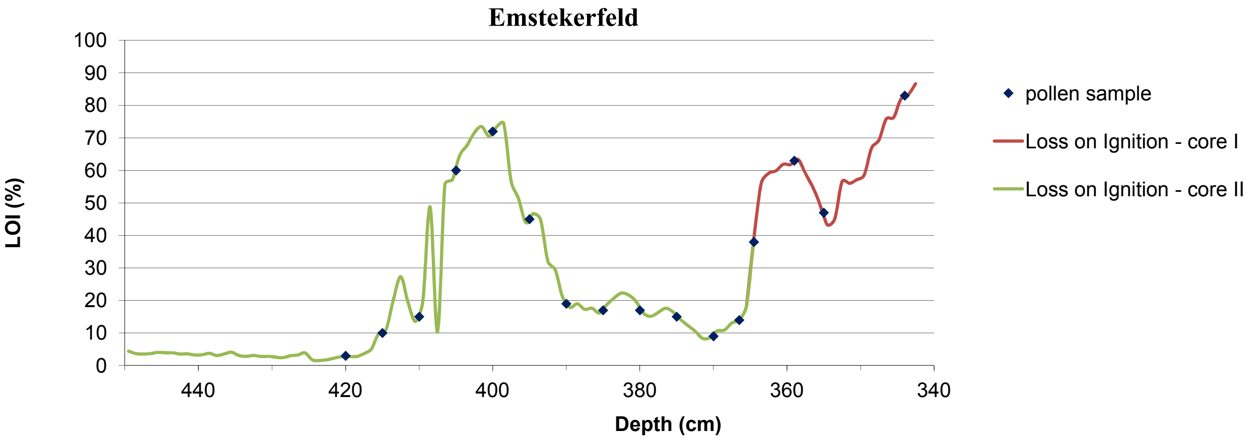
Sleenerstroom IX (borehole B) - genomen met guts

bovengrens	ondergrens	kleur	beschrijving	zandig?	plr	opmerking
480	498	mix br en gn	fijne gy	iets zandig		vivaniet op 484
498	526	gnbr	fijne gy			laminae, vivianiet op 523
526	548	mix gn en br	fijne gy	zandig		vage overgang naar onder, erboven 'stukken' zand
548	555	lbrgr	zand			humeus

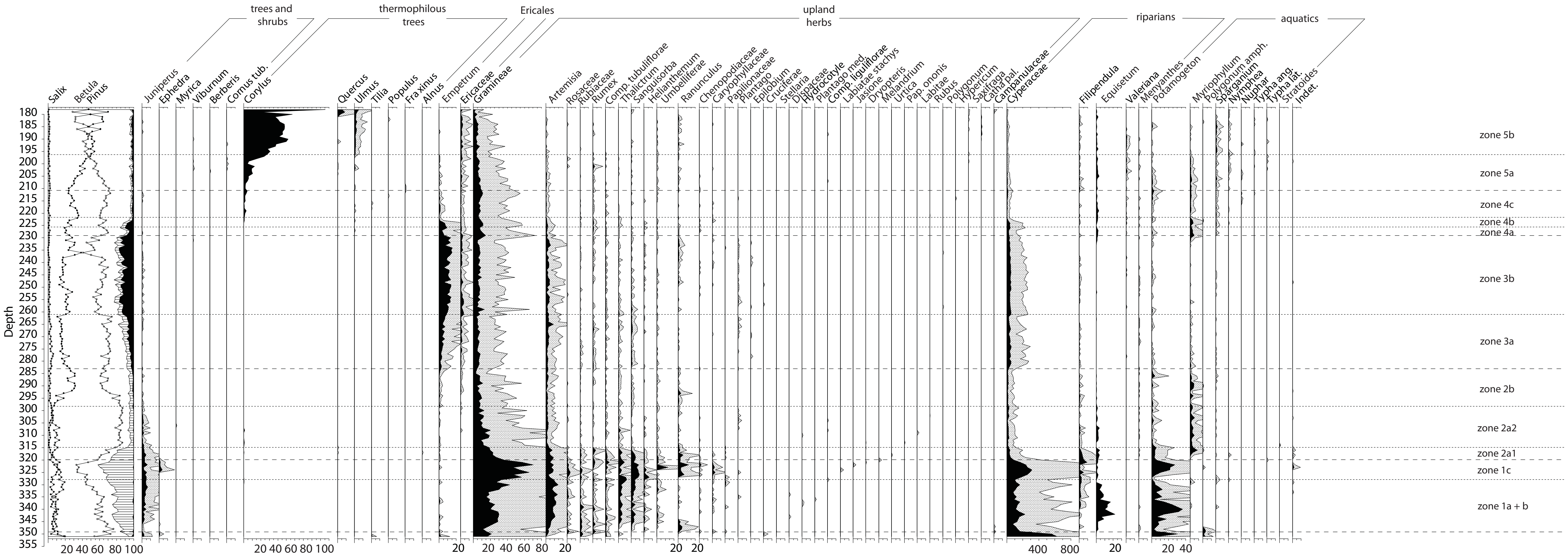
Appendix E3b. Core photographs Sleenerstroom I

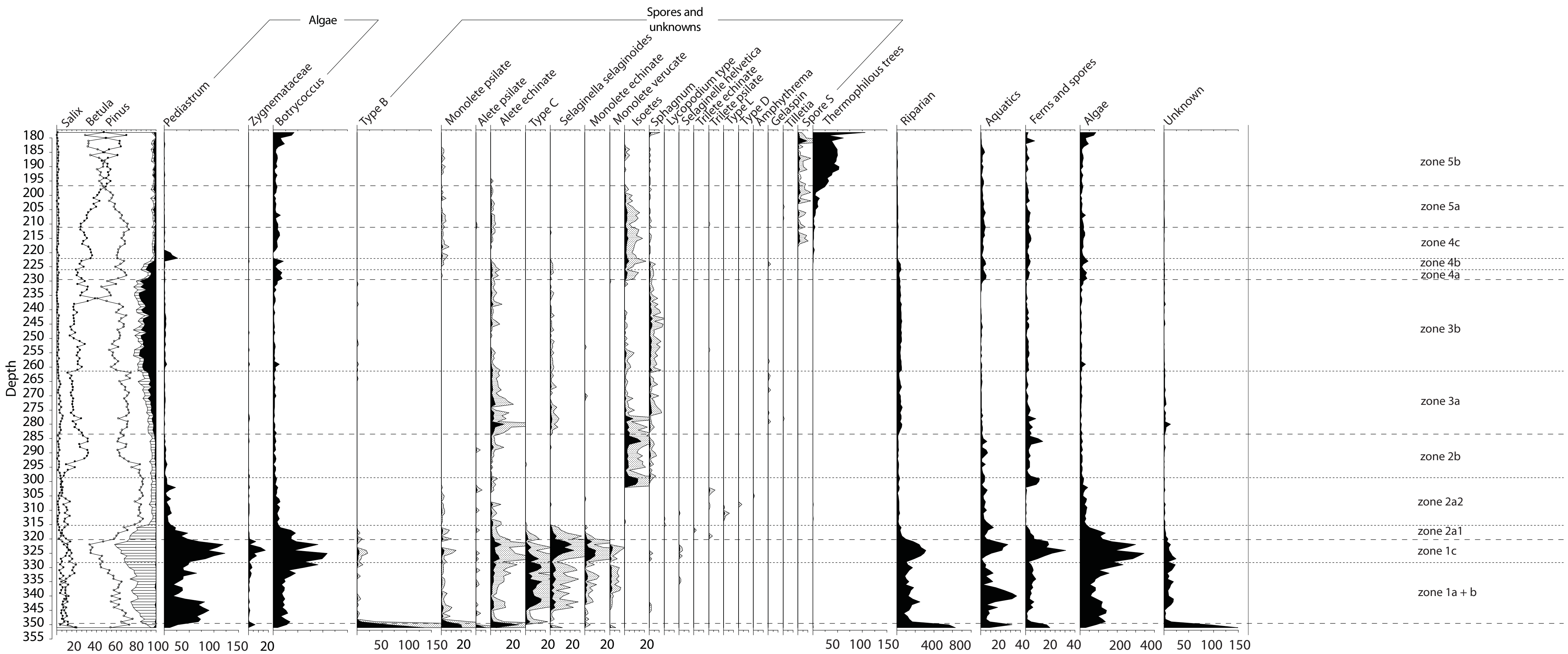
Appendix F1. Depth of pollen samples Timmelteich and Emstekerfeld



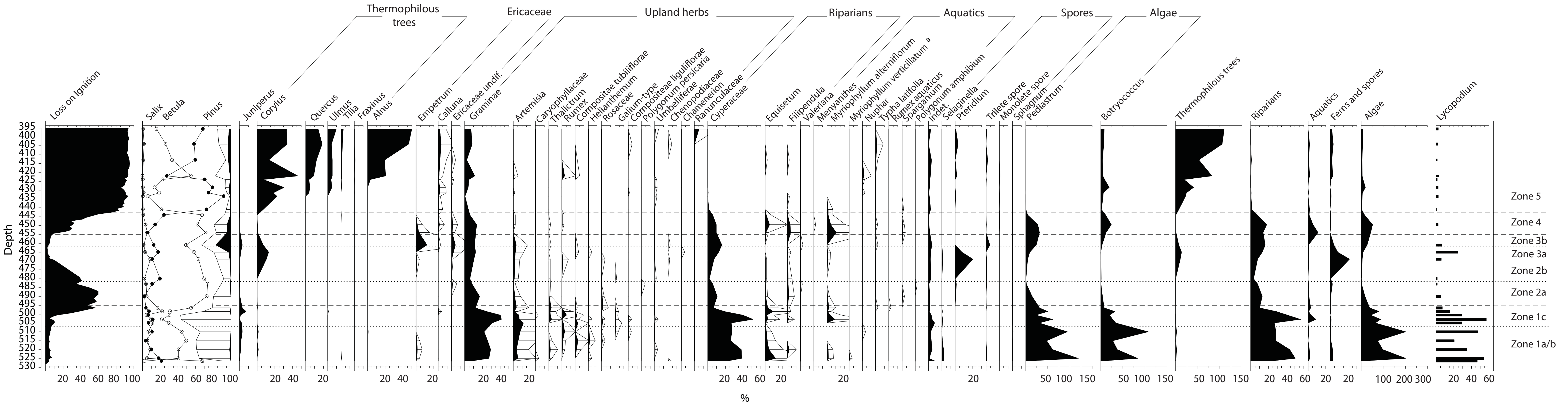


Appendix F2. Complete pollen diagram Uteringsveen II

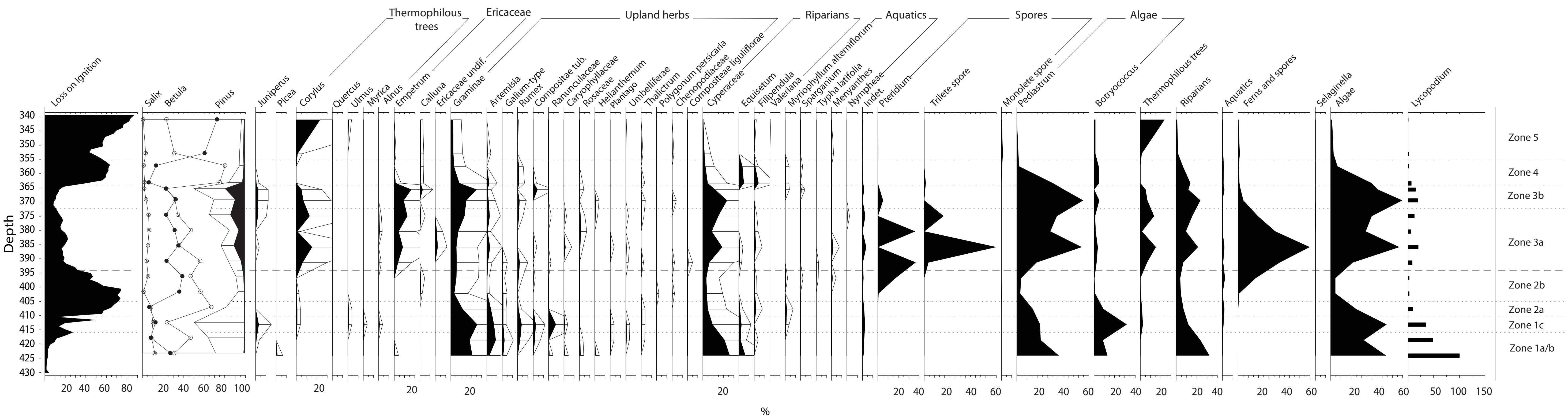




Appendix F3a. Complete pollen diagram Timmelteich



Appendix F3b. Complete pollen diagram Emstekerfeld



Appendix F4a. Pollen results Timmelteich

Depth (cm)		395.5	404	413	422	424	428.5	431.5	433.5	441	444	449.5	454	461	465	469	480	483	490	496.5	498.5	500.5	503	505	510	515	520	525	526.5
Pollen (%)	Group																												
Betula	Trees and shrubs	15.8	26.3	33.6	54.9	22.8	13.9	19.0	6.0	21.5	67.6	62.3	71.6	49.2	58.1	63.4	69.8	73.8	72.8	55.0	31.4	30.7	22.0	29.8	44.5	49.6	40.8	40.7	2.4
Pinus	Trees and shrubs	68.4	58.5	59.9	27.7	70.5	79.2	75.0	92.0	72.5	24.4	14.4	6.0	12.8	17.8	11.2	19.9	11.1	2.2	4.0	7.4	6.7	11.8	6.9	10.9	3.9	10.2	18.5	21.6
Salix	Trees and shrubs	0.9	1.7	0.9	0.0	0.5	0.6	1.5	0.5	0.7	0.9	3.7	5.2	1.6	3.1	9.0	2.2	4.1	4.9	17.0	22.3	4.5	9.8	11.5	6.8	5.5	8.8	5.2	67.8
Juniperus	Trees and shrubs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.7	3.2	1.6	0.4	0.0	0.0	0.5	3.0	7.4	1.3	0.0	2.3	3.0	1.6	1.4	0.0	0.0
Alnus	Thermophilous trees	50.0	46.6	19.6	20.5	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.7	0.0	0.0
Corylus	Thermophilous trees	33.3	33.9	13.5	46.2	7.1	30.6	18.4	22.4	7.0	0.0	0.5	0.7	7.0	13.2	10.4	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	1.5	0.0	1.4	0.0	0.0
Quercus	Thermophilous trees	14.0	18.6	12.1	9.2	3.8	4.6	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ulmus	Thermophilous trees	9.6	4.2	5.1	5.1	3.8	4.6	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tilia	Thermophilous trees	2.6	1.7	0.9	1.0	0.5	0.6	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0
Fraxinus	Thermophilous trees	0.0	0.0	0.9	0.0	0.5	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Empetrum	Ericaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	3.0	12.3	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.4	0.7	0.0
Calluna	Ericaceae	1.8	3.4	1.9	1.0	0.5	1.7	1.8	0.5	1.0	0.0	1.4	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ericaceae undif	Ericaceae	0.0	0.0	0.9	0.0	0.5	0.0	0.0	0.0	0.0	0.4	1.4	0.7	4.3	2.3	0.4	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gramineae	Upland herbs	7.0	8.5	2.3	11.3	4.8	4.0	1.8	0.5	4.3	5.8	13.5	12.7	11.2	12.4	10.4	5.9	8.2	16.8	12.0	24.8	40.3	41.6	31.3	21.9	26.0	29.3	27.4	7.3
Artemisia	Upland herbs	0.0	0.0	0.0	1.0	0.0	0.0	0.3	0.0	0.0	0.4	0.5	0.0	3.2	2.3	1.5	1.1	0.4	1.6	3.5	0.8	6.4	6.5	11.5	7.5	5.5	3.4	5.2	0.0
Caryophyllaceae	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.7	0.0
Chenopodiaceae	Upland herbs	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Asteraceae liguliflorae	Upland herbs	0.0	0.8	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.8	0.0	0.0	0.0	0.0
Asteraceae tubiliflorae	Upland herbs	0.0	0.0	0.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.8	0.0	0.0	0.0	0.0	0.5	0.0	1.9	0.8	3.1	0.0	3.1	1.4	0.0	0.0
Galium-type	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.5	0.8	0.6	0.8	1.5	0.8	0.0	0.0	0.0	0.0
Helianthemum	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.8	1.6	0.0	0.7	0.0
Ranunculaceae	Upland herbs	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rosaceae	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.5	1.5	0.0	0.0	0.8	0.8	0.0	0.8	0.0	0.0	0.0
Rumex	Upland herbs	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.4	0.5	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	2.5	5.1	0.0	1.5	3.0	0.8	0.7	0.0	0.0
Thalictrum	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.4	0.4	0.4	0.5	3.0	1.7	1.9	3.3	0.0	0.0	0.8	2.0	0.7	0.0
Umbellifereae	Upland herbs	0.9	0.0	0.0	0.0	0.5	0.6	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.7	0.0	0.0
Chamenerion	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygonum persicaria	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyperaceae	Riparian	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	1.3	5.8	9.8	9.7	16.0	12.4	7.1	1.9	5.7	10.9	6.5	19.0	39.6	51.4	26.7	27.2	26.0	38.1	38.5	22.0
Valeriana	Riparian	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Equisetum	Riparian	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	1.3	5.1	0.7	0.0	0.0	0.4	0.4	0.4	0.5	3.0	9.1	1.9	3.3	0.0	1.5	2.4	4.1	11.9	0.8
Filipendula	Riparian	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5	0.0	0.4	3.3	3.7	0.0	0.8	0.4	1.1	1.2	1.6	0.5	0.8	0.0	1.6	0.0	0.0	0.0	2.0	0.0	0.0
Menyanthes	Aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Myriophyllum alt.	Aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.3	4.2	10.4	0.0	0.8	0.7	0.0	0.0	0.5	2.0	0.8	3.2	9.0	0.0	0.0	0.0	1.4	1.5	0.0
Myriophyllum vert.	Aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0
Nuphar	Aquatic vascular plants	0.0	0.0	0.0	2.1	0.5	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Nymphaea	Aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rumex Aquaticus	Aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygonum amfibium	Aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sparganium	Aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.5	0.7	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Typha latifolia	Aquatic vascular plants	0.0	1.7	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lycopodium	Added in laboratory	2.6	1.7	1.4	3.1	1.4	2.3	0.0	2.5	0.3	0.0	2.3	0.0	6.4	24.8	6.0	1.3	1.4	5.4	7.0	15.7	29.1	56.7	29.0	47.5	20.5	34.7	53.7	46.5
Selaginella	VACR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.1	0.0	0.0	0.0	0.0	0.8	0.0	1.2	0.8	0.0	0.8	2.0	2.2	1.6
Pteridium	VACR	0.9	3.4	0.0	2.1	0.0	0.0	0.6	0.5	0.0	0.0	0.0	0.0	0.0	7.8	20.1	0.0	1.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trilete spore	VACR	0.9	0.0	1.9	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.5	0.0	4.3	0.0	0.7	0.7	0.8	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.8
Monolete spore	VACR	0.0	0.0	0.0	1.0	0.5	0.0	0.3	0.5	0.0	0.9	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphagnum	VACR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Pediastrum	Algae	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	4.5	27.4	31.3	24.1	9.3	4.1	0.4	1.2	14.1	31.0	49.6	23.0	61.2	30.5	94.3	47.2	60.5	119.3	1.6
Botryococcus	Algae	7.9	6.8	4.2	5.1	8.6	19.1	6.0	5.5	1.7	11.2	24.2	11.9	3.2	0.0	0.7	1.1	0.8	3.8	8.0	32.2	20.4	26.9	34.4	107.9	27.6	37.4	83.7	2.4
Indet	Other	2.6	0.0	3.3	2.1	1.4	1.2	0.3	1.0	2.3	0.4	0.5	1.5	3.7	2.3	2.2	2.6	0.4	1.6	1.5	0.8	3.2	4.1	6.9	2.3	3.1	4.1	0.7	7.3
Trees and shrubs		85.1	86.4	94.4	82.6	93.8	93.6	95.5	98.5	94.7	92.8	80.9	83.6	66.8	80.6	84.0	91.8	88.9	80.4	79.0	68.6	43.1	43.7	50.4	65.3	60.6	61.2	64.4	91.8
Thermophilous trees		109.6	105.1	52.2	82.1	19.0	40.5	24.4	22.4	7.0	0.4	0.5	0.7	7.0	13.2	10.4	0.0	0.0	0.0	0.5	0.8	0.0	0.0	0.0	2.3	0.0	2.0	0.7	0.0
Ericales		1.8	3.4	2.8	1.0	1.0	1.7	1.8	0.5	1.0	0.4	4.2	3.7	17.1	2.3	1.1	0.0	1.2	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.8	1.4	0.7	0.0
Riparian		0.0	0.0	0.9	0.0	0.0	0.0	0.6	0.5	1.3	7.6	18.1	14.2	16.6	13.2	7.8	3.3	7.8	13.0	10.0	28.9	41.5	56.3	26.7	28.7	28.3	44.2	50.4	22.9
Upland herbs		13.2	10.2	2.8	16.4	5.2	4.6	2.7	1.0	4.3	6.7	14.9	12.7	16.0	17.1	14.9	8.2	9.8	19.6	21.0	30.6	56.9	56.3	49.6	34.7	38.6	37.4	34.8	8.2
Aquatics		0.0	1.7	0.5	2.1	0.5	0.0	0.6	0.0	1.7	1.3	5.6	11.2	0.5	0.8	0.7	0.0	0.4	1.1	3.0	0.8	3.2	9.0	0.0	0.8	0.0	1.4	2.2	0.0
Laboratory added		2.6	1.7	1.4	3.1	1.4	2.3	0.0	2.5	0.3	0.0	2.3	0.0	6.4	24.8	6.0	1.3	1.4	5.4	7.0	15.7	29.1	56.7	29.0	47.5	20.5	34.7	53.7	46.5
Ferns and spores		1.8	3.4	1.9	3.1	1.0	0.0	0.9	1.0	0.0	0.9	0.9	0.0	4.3	8.5	22.0	0.7	2.5	0.5	0.5	0.8	0.0	1.2	0.8	0.8	0.8	2.7	3.0	2.4
Algae		7.9	6.8	4.2	5.1	8.6	19.1	6.3	5.5	2.0	15.7	51.6	43.3	27.3	9.3	4.9	1.5	2.0	17.9	39.0	81.8	43.5	88.2	64.9	202.3	74.8	98.0	203.0	4.1
Other		2.6	0.0	3.3	2.1	1.4	1.2	0.3	1.0	2.3	0.4	0.5	1.5	3.7	2.3	2.2	2.6	0.4	1.6	1.5	0.8	3.2	4.1	6.9	2.3	3.1	4.1	0.7	7.3
Pollen sum (n)		114	118	214.5	97.5	210.5	173	332	201	302	223.5	215	134	187	129	268	269.5	244	184	200	121	156.5	122.5	131	132.5	127	147	135	122.5

Appendix F4b. Pollen results Emstekerfeld

Depth (cm)		344	355	359	364.5	366.5	370	375	380	385	390	395	400	405	410	415	420
Pollen (%)	Group																
Betula	Trees and shrubs	23.4	31.2	80.9	75.7	23.2	31.7	34.5	47.3	35.8	56.5	47.1	56.8	67.4	23.9	47.1	31.0
Pinus	Trees and shrubs	73.0	60.8	13.2	6.1	22.8	32.5	23.1	31.4	35.1	23.5	39.0	36.0	6.5	12.7	8.0	27.2
Salix	Trees and shrubs	0.6	3.0	1.1	2.0	1.7	3.3	5.8	6.4	5.2	4.0	5.4	1.0	8.4	10.0	8.7	12.1
Juniperus	Trees and shrubs	0.0	0.0	0.0	0.7	2.5	2.5	2.1	0.0	0.7	0.0	0.0	0.0	0.0	3.1	0.7	0.0
Myrica	Trees and shrubs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
Picea	Trees and shrubs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
Alnus	Thermophilous trees	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.7	0.0	0.5	0.0	0.0	0.0	0.8	0.0	0.0
Corylus	Thermophilous trees	22.8	1.1	0.0	0.0	5.0	6.7	12.7	0.7	14.9	6.0	0.0	0.5	0.8	0.8	0.0	0.0
Quercus	Thermophilous trees	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ulmus	Thermophilous trees	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.0	0.0
Tilia	Thermophilous trees	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Empetrum	Ericales	0.0	0.4	0.0	1.4	16.6	9.2	12.7	4.2	8.2	3.5	0.0	0.0	0.0	0.0	0.0	0.9
Calluna	Ericales	0.6	0.8	0.7	0.7	2.5	0.0	1.1	0.0	0.0	0.0	0.9	0.5	0.0	0.0	0.0	0.0
Ericaceae undif	Ericales	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gramineae	Upland herbs	2.1	2.3	2.9	8.1	24.9	15.0	13.3	7.1	5.2	5.5	5.4	3.3	11.5	25.5	18.1	20.7
Artemisia	Upland herbs	0.0	0.8	0.0	2.0	0.8	1.7	2.7	0.7	3.0	1.0	0.4	0.5	3.8	6.9	8.7	2.6
Caryophyllaceae	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	1.5	0.0	0.0	0.0	0.0	0.8	0.0	0.9
Chenopodiaceae	Upland herbs	0.0	0.4	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0
Asteraceae liguliflorae	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Asteraceae tubiliflorae	Upland herbs	0.0	0.0	0.0	0.7	4.1	0.0	0.0	0.0	0.7	0.0	0.4	0.0	0.0	2.3	1.4	0.0
Galium-type	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.4	1.0	0.8	0.8	2.2	0.9
Helianthemum	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.8	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Ranunculaceae	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.0	6.9	0.0	0.9
Rosaceae	Upland herbs	0.0	0.0	0.0	0.7	0.8	0.0	1.1	1.4	0.7	0.0	0.0	0.0	0.0	0.0	0.7	0.9
Rumex	Upland herbs	0.2	0.0	1.1	1.4	0.0	1.7	1.1	0.0	0.0	2.0	0.9	0.0	0.8	3.9	2.2	0.0
Thalictrum	Upland herbs	0.0	0.4	0.0	0.7	0.0	0.8	0.5	0.0	0.0	0.5	0.0	0.0	0.8	0.8	0.7	0.0
Umbellifereae	Upland herbs	0.2	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.7	0.5	0.0	0.0	0.0	0.8	0.7	0.0
Plantago	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.8	0.7	0.0
Polygonum persicaria	Upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Cyperaceae	Riparian	0.2	1.5	2.2	4.7	11.6	23.3	14.9	8.5	18.7	6.0	3.1	3.8	4.6	9.3	21.0	25.9
Valeriana	Riparian	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Equisetum	Riparian	0.0	0.0	3.3	4.7	0.0	0.0	0.0	0.0	0.7	0.5	0.0	0.0	0.8	2.3	1.4	6.0
Filipendula	Riparian	0.4	0.0	0.7	4.1	0.0	0.0	0.5	0.7	1.5	0.0	0.4	0.5	1.5	0.0	0.7	0.0
Menyanthes	Aquatic vascular plants	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.9	0.0	0.0	0.0	0.0	0.0
Myriophyllum alt.	Aquatic vascular plants	0.0	0.0	0.7	0.7	0.8	0.0	0.0	0.0	0.0	0.0	0.4	0.0	1.5	0.8	0.0	0.0
Myriophyllum vert.	Aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nuphar	Aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nymphaea	Aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sparganium	Aquatic vascular plants	0.0	0.0	0.4	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Typha latifolia	Aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.4	0.0	0.0	0.0	0.0	0.0
Lycopodium	Added in laboratory	0.7	2.3	1.3	6.8	14.9	19.2	12.7	6.4	20.1	8.8	2.5	2.4	9.2	35.5	48.2	100.4
Selaginella	Ferns and mosses	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pteridium	Ferns and mosses	0.0	0.4	0.0	0.0	1.7	5.0	0.0	36.0	0.0	36.5	17.0	0.5	0.0	0.0	0.0	0.0
Trilete spore	Ferns and mosses	0.0	0.0	0.0	1.4	0.8	0.0	18.6	0.0	69.4	4.0	0.0	0.0	0.0	0.0	0.0	0.0
Monolete spore	Ferns and mosses	0.4	1.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Pediastrum	Algae	0.0	1.5	2.2	35.1	45.6	64.2	38.7	32.5	62.7	19.0	4.0	3.3	15.3	22.4	23.2	40.5
Botryococcus	Algae	1.3	1.1	4.4	4.7	0.0	5.0	1.1	1.4	3.7	2.5	0.4	1.0	9.2	31.7	8.7	12.9
Indet	other	0.7	0.0	0.0	0.7	1.7	0.0	2.7	0.0	3.7	0.5	0.9	0.0	1.5	2.3	1.4	0.9
Trees and shrubs		97.0	95.1	95.3	84.5	50.2	70.0	65.5	85.2	76.9	84.0	91.5	93.8	82.4	50.6	64.5	71.6
Thermophilous trees		23.6	1.1	0.0	0.0	5.0	6.7	13.3	1.4	14.9	6.5	0.0	0.5	1.5	2.3	0.0	0.0
Ericales		0.6	1.1	0.7	2.0	19.1	9.2	13.8	5.7	10.4	3.5	0.9	0.5	0.0	0.0	0.0	0.9
Riparian		0.7	1.5	6.2	13.5	11.6	23.3	15.4	9.2	20.9	6.5	3.6	4.3	6.9	11.6	23.2	31.9
Upland herbs		2.4	3.8	4.0	13.5	30.7	20.8	20.7	9.2	12.7	12.5	7.6	5.7	17.6	49.4	35.5	27.6
Aquatics		0.0	0.4	1.1	0.7	1.7	0.0	0.5	0.0	1.5	0.5	2.2	0.0	1.5	0.8	0.0	0.0
Laboratory added		0.7	2.3	1.3	6.8	14.9	19.2	12.7	6.4	20.1	8.8	2.5	2.4	9.2	35.5	48.2	100.4
Ferns and spores		0.4	1.5	0.7	1.4	2.5	5.0	19.1	36.0	69.4	40.5	17.0	1.0	0.0	0.0	0.0	0.0
Algae		1.3	2.7	6.5	39.9	45.6	69.2	39.8	33.9	66.4	21.5	4.5	4.3	24.5	54.1	31.9	53.4
Other		0.7	0.0	0.0	0.7	1.7	0.0	2.7	0.0	3.7	0.5	0.9	0.0	1.5	2.3	1.4	0.9
Pollen Sum	TRSH;Ericales;UPHE	116.0	138.0	129.5	130.5	209.5	223.0	200.0	134.0	141.5	188.5	120.0	120.5	148.0	275.5	263.0	534.0

Appendix F5. Results pollen quickscans

Site		**Egypte**	**Sleenerstroom I**	**Vlierendijk**	**Brill**	**Brill**	**Wrokmoor**	**Mamburg**	**Sevelte**
Study area		Friesland (NL)	Drenthe (NL)	Drenthe (NL)	Ost-Friesland (G)	Ost-Friesland (G)	Ost-Friesland (G)	Ost-Friesland (G)	Clop./Visbek (G)
Pollen zone		**1c**	**1b**	**prior to 1 or 3b**	**prior to 1 or 1a/b**	**prior to 1**	**prior to 1**	**prior to 1**	**2b**
Equivalent age		**Older Dryas**	**Bølling**	**Pleniglacial / YD**	**Pleniglacial / Bølling**	**Pleniglacial**	**Pleniglacial**	**Pleniglacial**	**Allerød (second phase)**
LOI		-	12.88	3.56	2.72	4.43	1.74	19.61	40.61
Depth (cm)		270	546	465	291	288	508	208	483
Betula	trees and shrubs	39.4	63.5	4.8	34.4	8.5	11.8	5.1	57.6
Juniperus	trees and shrubs	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pinus	trees and shrubs	5.5	2.7	13.0	26.9	36.2	22.7	64.5	25.5
Salix	trees and shrubs	0.0	3.1	6.8	5.4	3.1	12.7	4.3	3.0
Abies	thermophilous trees	0.0	0.0	1.4	0.0	0.0	0.0	0.7	0.0
Alnus	thermophilous trees	4.6	0.0	0.0	20.4	0.8	2.7	5.8	0.0
cf. Cedrus	thermophilous trees	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0
Corylus	thermophilous trees	2.8	0.0	1.9	12.9	2.3	1.8	4.3	0.0
Picea	thermophilous trees	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0
Tilia	thermophilous trees	0.0	0.0	0.0	2.2	0.0	0.9	0.0	0.0
Ulmus	thermophilous trees	0.0	0.0	0.0	2.2	0.0	0.9	0.0	0.0
Calluna	Ericales	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0
Empetrum	Ericales	0.0	0.0	1.0	1.1	0.0	0.0	0.7	0.0
Ericaceae	Ericales	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0
Artemisia	upland herbs	15.6	5.5	3.9	4.3	1.5	2.7	4.3	0.0
Chenopodiceae	upland herbs	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0
Compositae lig	upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0
Compositae tub	upland herbs	0.9	1.6	0.0	0.0	0.0	1.8	0.0	0.0
Galium-type	upland herbs	1.8	1.6	1.9	1.1	0.0	0.9	0.0	0.0
Graminae	upland herbs	31.2	18.0	67.6	17.2	42.3	45.5	17.4	9.6
Lysimachia	upland herbs	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0
Plantago	upland herbs	0.0	0.0	1.0	0.0	1.5	0.0	0.0	0.0
Polygonum	upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7
Ranunculaceae	upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Rosaceae	upland herbs	0.0	0.8	0.0	0.0	0.8	0.0	0.0	0.0
Rumex	upland herbs	0.0	1.6	0.0	3.2	3.1	0.9	0.7	0.0
Thalictrum	upland herbs	1.8	1.6	0.0	0.0	0.0	0.9	0.0	0.0
Umbellifereae	upland herbs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Filipendula	riparian	0.0	0.0	0.0	0.0	2.3	0.0	0.7	2.2
Cyperaceae	riparian	46.8	55.7	45.4	33.3	70.0	27.3	60.1	4.4
Equisetum	riparian	0.0	3.1	1.9	4.3	6.2	16.4	13.0	0.7
Myiophyllum alt.	aquatic vascular plants	4.6	0.8	0.0	1.1	1.5	0.0	1.4	0.0
Nuphar	aquatic vascular plants	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0
Nympheae	aquatic vascular plants	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0
Sparganium	aquatic vascular plants	1.8	0.0	0.0	1.1	0.0	0.0	0.0	0.0
Typha latifolia	aquatic vascular plants	0.0	0.0	1.0	0.0	0.0	0.0	0.7	0.0
Monolete spores	ferns and mosses	0.0	0.0	0.0	1.1	0.8	0.0	0.0	0.0
Lycopodium	ferns and mosses	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0
Pteridium	ferns and mosses	0.0	0.8	0.0	16.1	1.5	0.0	0.0	1.5
Seliganella	ferns and mosses	0.0	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Trilete spores	ferns and mosses	0.0	0.0	0.0	2.2	0.0	2.7	0.0	0.0
Botryococcus	algae	0.0	39.2	83.1	28.0	32.3	72.7	26.1	4.4
Pediastrum	algae	41.3	149.8	423.2	78.5	140.0	280.0	20.3	5.2
Dinoflaggelates	other	0.0	0.0	0.0	1.1	1.5	1.8	2.2	0.0
Indet	other	2.8	0.8	0.0	8.6	0.8	0.0	3.6	2.2
Pollen sum (%)		100	100	100	100	100	100	100	100
Number of pollen counted		109	127.5	101.5	93	130	110	138	135.5