Journal of Danish Archaeology vol. 11, 1992-93, pp 39 - 56

Prehistoric Settlement and Landscape Development in the Sandhill Belt of Southern Thy

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INTRODUCTION

Along most of the east coast of the North Sea, and not least in Denmark, runs a wide belt of blown sand. In some places this is being eaten away by erosion as the breakers cut into the low sandy cliffs. The present article is about investigations carried out since 1965 along a 14 kilometre stretch of coast immediately north of the western opening to the Limfjord, from Fladesø in the south to Stenbjerg in the north in the part of Denmark known as Thy (fig. 1). Along this stretch of coast prehistoric settlements regularly come to light in the course of erosion. They appear in the steep sand cliff above the beach, in which a constantly rejuvenated section can be studied. North and south of the study area the deposits now being eroded are not ancient enough to contain prehistoric remains.

In theory it should be possible to find all traces of earlier settlement as they emerge, and thus to obtain a complete cross-section of settlement history. At the same time the environmental evidence for the evolution of the landscape is unusually varied and well preserved. The aim of the present paper is to give a preliminary account of both archaeological and environmental aspects of these investigations, and indicate some of the future potential (1).

GEOLOGICAL AND GEOGRAPHICAL BACKGROUND

Earlier research and the historical sources

Not a great deal has been published on the geography or recent geology of the study area. The best account is still in many ways Axel Jessen's paper on the Litorina transgression in north Jutland (Jensen 1920). In this some very important points are made. The western end of the Limfjord has never been directly open to the North Sea, for the raised beach deposits in it are of types formed in sheltered water, and the shells from old bottom deposits are thinner walled than those from open coasts. Generally the original west coast of Thy lay further east than the present one, which been moved westwards by the deposition of large quantities of beach and aeolian sand. Jessen saw the first deposition of blown sand as going back to the *Litorina* transgression, and its big extension inland as being a result of the destruction of the forest. These conclusions still stand, but we now know that the destruction of the forest took place much earlier than Jessen thought.

With regard to the western entrance to the Limfjord, Liversage and Robinson (1988) pointed out that the boulder clay areas, that must once have existed west of the present entrance to the Limfjord and kept surf out, are likely to have been fairly extensive because coastal erosion in the region is so severe. This barrier was not so continuous as to hold salt water out altogether, for investigations by K. Strand Petersen (1983, 75) showed that salt water entered the present basin of Nissum Bredning at about the Boreal/Atlantic transition. K. Strand Petersen's most recent work (1994) shows that sheltered waters protected by an undulating landscape resembling the Limfjord with islands and fjords once existed as far as 75 km west of Agger Tange.

There is much scattered literature about the formation of the belt of blown sand, especially historical literature, but not much precise field observation. Two questions have to be addressed and ought to be kept separate. They are the evolution of the coast, and the chronology and causes of dune formation. The opinions expressed tend to be rather conjectural, and the new research described in this article fills something of a lacuna.

Brüel (1918) quotes several interesting unpublished descriptions, but comes too easily to the conclusion that dune formation began as a result of 16th century forest clearance and the removal of marram grass and other dune vegetation for fodder and binding materials.

Somewhat more scholarly, is a paper by Viggo Hansen (1957). Here the beginning of dune formation is placed in the Iron Age, following an undocumented assertion that Bronze Age pottery had been found at an unspecified place in northern Jutland in "*martørv*" or primary sandy peat under the blown sand. Hence he generalizes that the blown sand as a whole was deposited after the Bronze Age. He sees a second phase of dune formation in late and post-Medieval times, and writes "it is now reasonably well established that abuse of the dune vegetation was the primary cause of the late Medieval period of dune formation, which lasted until about 1750". This paper often gives the impression that we know more than we really do. It must be the source of the statement by H. Kuhlman in "Danmarks Natur" (1975) that the coastal dune belt originated in the Iron Age.

The actual historical sources from the 15th – 19th centuries are more interesting. Some of them relate to the history of dune formation, others to the question of possible now vanished land masses west of the Limfjord. They show that even as late as the 19th century the remains of a boulder clay area survived west of Agger and Fladesø. An account by Andresen in 1861, quoted by Jessen (1920), reports that a continuous morainic cliff ran from Agger to the northern end of Lodbjerg parish, interrupted only for a couple of hundred metres at Aalum. The gap had opened to a kilometre by Jessen's day (Jessen 1920), and there is now no sign at all of any boulder clay west of Fladesø lake. Further evidence of a now-vanished morainic area is an account by A. Østerbøll (1878), that the villages of Agger and Vester Aalum had originally been "on the mount" (described by Andresen as stony clay – *rullestensler*) but had by then been moved to lower land further east. Østerbøll also writes that the bones of a "wild ox" were found in "martorv", and as bones only survive here in contact with till, this also shows that there was till where none survives today.

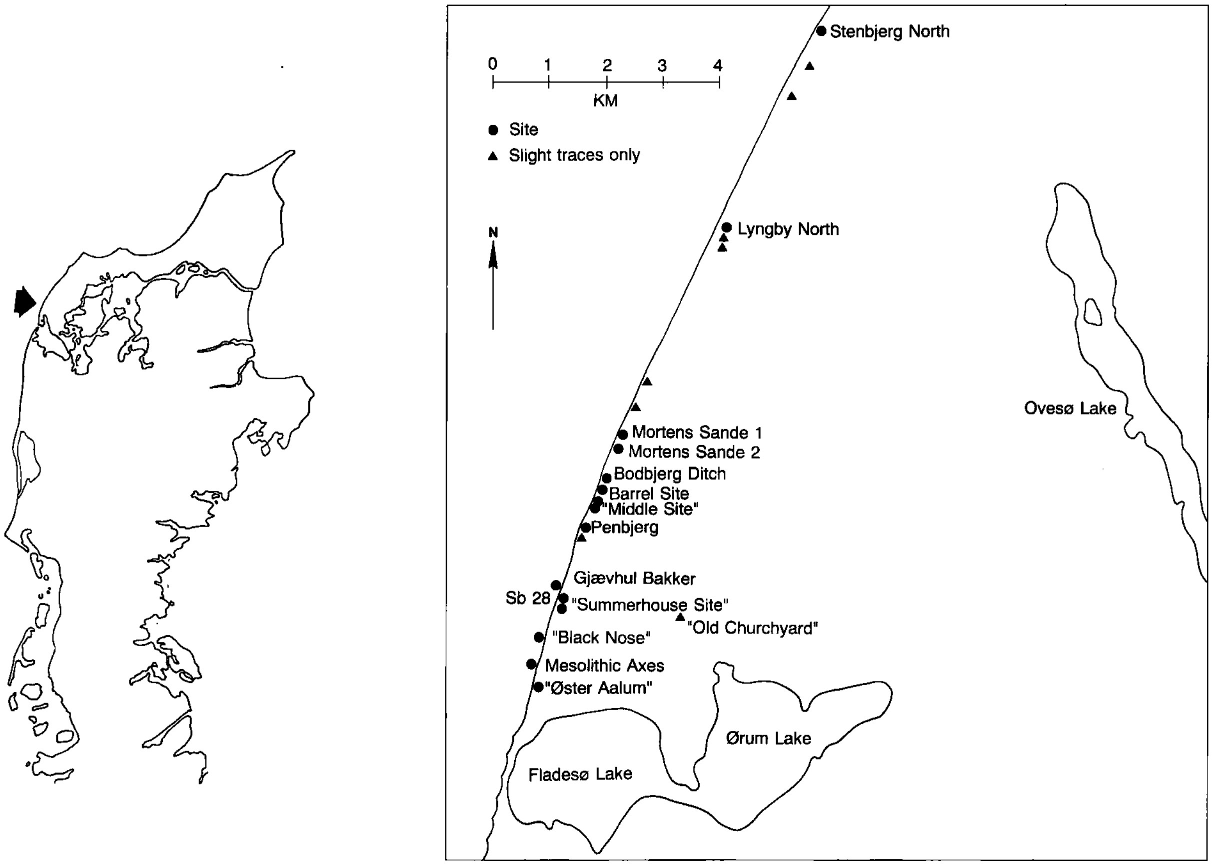

Fig. 1. Map of the area, showing the present extent of the dune belt and the position of the sites along the coast.

An interesting, but more speculative point concerning these land masses is the statement by Pontoppidan (1761) that the inhabitants of Agger spoke a dialect different from that of other people in Thy. It is tempting to see this as evidence that "the mount" which survived west of Agger and Fladesø was the remnant of an area that originally was large enough to have dialect of its own, which still survived in the 18th century.

The historical sources on dune formation are summarized by Hansen (1957) and concern the extension of the dune belt into agricultural land, which could be a disaster for those affected. They begin with a clerical petition from the 15th century and give the impression that sand blowing was at its worst in the 16th-17th centuries and became less of a problem in the 18th. This last point is disputed by Fuglsand. He admitted that the petitions from clerics ceased by about 1750, but thought it was only at the end of the century, when organized measures were taken to anchor the sand with vegetation, that there was any real improvement (Fuglsand 1949).

The dunes are now of course anchored and watched, and natural sand blowing is not allowed. It would help us to know whether this is really necessary, if we could establish whether the dunes started being anchored in the 18th century spontaneously, or only when organized measures were taken to plant them with marram grass (*Ammophila arenaria*). Unfortunately the historical sources are not precise on this point and tend to be partial. Similarly we would like to know whether the problem starts being mentioned in the late Middle Ages because a real deterioration took place, or only because of increasing literacy and the hope of receiving a little help from central government. The fact is we do not know whether there from time immemorial have always been alternating periods of dune advance and dune stability, or whether the sort of conditions that prevailed before artificial measures were applied to restrict sand blowing have always been typical, only becoming more severe as the size of the dune belt increased. It is therefore not possible to judge whether the measures do more than prevent the natural rejuvenation of the landscape through the formation of new dunes close behind the coast, where the existing ones are now disappearing into the sea.

Contemporary observers have always favoured anthropic explanations. Sand blowing was attributed to cutting firewood, using marram grass, etc., and royal decrees were promulgated to protect the local environment from the kinds of use it no doubt had been subject to for millennia. In the demographic perspective, the theory of anthropic degradation is not particularly likely. The 15th-17th century, when sand blowing appears

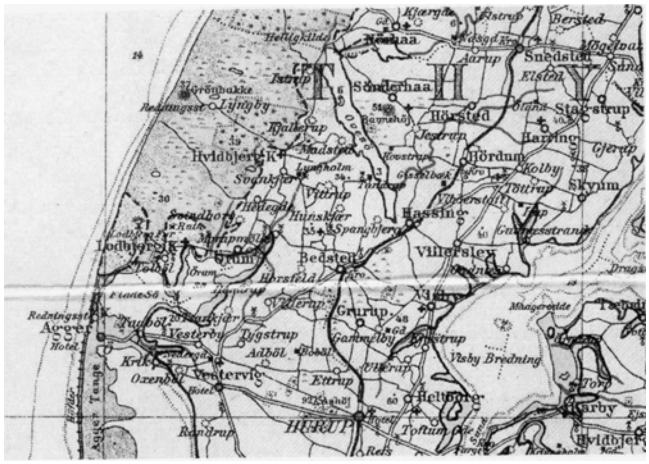

Fig. 2. Axel Jessen's map of the maximum extension of the sea in our area.

Fig. 3. The withdrawal of the coast since c.1790. The present coastline superimposed on Videnskabernes Selskab's map.

Fig. 4. Typical view of the cliff in the area of study, showing the alternation between organic layers and blown sand.

to have been at its worst, was generally a time of low population, when the pressure by the local people on the dune vegetation can be expected to have been less than either earlier, before the Black Death, or later, as populations rose in the 18th century.

New field observations and deductions

Modern and historical work is thus restricted and sometimes directly misleading. More can be learned from the field evidence. This includes present surface indications, the stratigraphy visible in the erosion cliff, borings (for wells) shown on the basis data maps issued by the Danish Geological Survey and further information in the archives of the Geological Survey.

Fig. 2 reproduces A. Jessen's estimate of the course of the shoreline at the Litorina maximum, and though it cannot be accurate, it gives a good impression. Two islands are seen north of Fladesø, and north of them the coastline ran some 5-6 km east of the present coast, with Ovesø lake as an arm of the sea, as is confirmed by a modern sediment core taken from the lake bed for pollen analysis (Andersen et al. 1991).

Naturally no map can be reconstructed of the areas that must have been eroded away west of the present coastline, but there is reason to think the differences from the present situation were much more dramatic than suggested by Jessen's map (for example Strand Petersen's new work (Petersen 1994). Some idea of what can be expected can be obtained from the rate of coastal erosion, which can be accurately determined for the past two centuries and projected backwards.

The earliest cartographically correct survey is Videnskabernes Selskab's map, surveyed in the 1790's. The original hand-drawn version of this survey was drawn at the same scale of 1:20,000 that was in use until the 1970's for normal map cover, and as church steeples were used as trigonometric points, accurate comparison is simple. Unfortunately the present coastline first appears on the new 1:25,000 maps, but the problem of transferring the present coast to the 1:20,000 maps was solved through the kindness of the Danish Ordnance Survey, so that it could be superimposed on Videnskabernes Selskabs map, using the churches to link them together. The result is shown in fig. 3, where however the printed version of the old map has been substituted for the hand-drawn original, which is not suitable for reproduction on so small a scale.

It was found that at Agger the coast has retreated 1200 metres in two centuries. The amount of retreat decreases northwards, and near the site of Lyngby North (fig.1) was only about 250 m. Agger Bar itself has been moved up to 2 kilometres eastwards, and now bends inwards as two horns, when in 1790 it passed across in a straight line from Thy to the nearest part of the mainland.

The speed of retreat agrees well enough with modern observations. For instance at the site of Mortens Sande 2 the coast withdrew 16 metres in 1983-1992, giving an average of a little over 2 metres a year. With this evidence before us it is not difficult to appreciate that the west coast of Jutland can have been retreating at a rate of 2-3 kilometres every thousand years, and could have retreated 12-18 km since the Neolithic, and considerably more since the sea reached its present level in early Atlantic times. There can be no problem in accepting the existence of large land masses west of Agger, which sheltered the original western end of the Limfjord from heavy surf, giving a pattern of land and sea radically different from that which we find today.

We may now turn to the other factor in the development of the present landscape – the formation of the dune belt.

The original bays east of the present coastline must have begun to fill immediately with sand derived from the erosion of the more exposed parts of the original coast. Beach deposits of sand with water-worn stones up to the size of a fist have been observed below the blown sand in the cliff and must be part of the original bay filling, and there is certainly also stone-free beach sand.

Higher up in the profile there is wind-blown sand everywhere. The highest dunes rise to over 40 m above sea level. Up to about 12 m the blown sand is interbedded with numerous organic layers, which show as dark brown horizons in the cliff above the beach. These are old surfaces, often with remains of the original vegetation surviving on them. An impression of the situation is given by fig. 4. In some places they are associated with remains of human settlements, of which about 23 have been found since 1965 (fig. 1). Some very minor finds of pottery or flint are not shown on this map. In many places old surfaces are absent owing to "blowouts", where wind erosion has cut through the layers described above almost to present beach level. The largest blowout is about a kilometre wide. Many of the blowouts are recent, but they have been completely refilled with blown sand, which can rise in them to high dunes. If the old surfaces give the impression of running for long distances, this is something of an optical illusion because so much of the scarp in reality is covered by talus and sandslips. It is impossible to clean a long enough section to see how the blown sand is really built up, but it seems that most of the individual turf lines only run a few hundred metres before ending in blown sand. It should be pointed out that the sand belt is a cumulative phenomenon. Sand is added, but not removed. Originally only quite modest amounts of blown sand were present, but the amount has been steadily increasing. It is clear that the larger the dune belt and the more sand it contains, the more dramatic will be the effect if the dunes become active and invade the land behind them. Each invasion could be expected to be more extreme than the one before.

ARCHAEOLOGICAL SITES

As well as helping to date the blown sand, the archaeological sites produce valuable closed assemblages of artifacts. These closed finds are particularly well segregated and stratigraphical sequences occur. As only a selection of the material has been published so far, the opportunity can be taken to sum up the results of 28 years' archaeological fieldwork. The location of the sites is shown in fig. 1. The emphasis has changed during these 28 years gradually from obtaining closed finds to illuminate the development of material equipment, to examining the relation between the sites and their environment.

Mesolithic

The only certain evidence pointing to the Mesolithic was the discovery by the Hirsch family in 1971-76 of 9 core axes, some incomplete, at the point marked "mesolithic site" in fig. 1. The site cannot have been a normal settlement, as there were no other tools and very little chipping waste.

Funnel Beaker Culture

There are three sites from the Funnel Beaker Culture, all on the till under the blown sand, and therefore older than the beginning of dune formation along the present coast. The pottery at all three sites was from the late EN or the beginning of the MN.

At the first site (fig. 1 "Black Nose") there were two small pits and a little pottery. The second site (fig. 1, sb.28) lay by a depression in the moraine which there were deposits from a pond that existed before the blown sand was deposited. A column of peat was taken from it and preserved for possible future study. A pit in the till not far away, which contained animal bones only, may have been from this settlement. The old surface under the dunes was compressed and exceedingly hard, making all excavation very difficult.

Much the most important of the three Funnel Beaker sites was Penbjerg. Thanks to the perseverance of Harald Holm a valuable assemblage of artifacts of pottery, flint and amber was found. The flint was described by Liversage and Singh (1985), and some of the amber by Hirsch and Liversage (1987).

Only TRB settlements from around the EN/MN transition have been found. If there was settlement from other phases of the culture, it has yet to emerge. At the beginning of the Middle Neolithic deposition of blown sand had not begun, or at least had not yet reached the line of the present coast.

Single Grave Culture/Late Neolithic /Earliest Bronze Age

The settlement remains from these periods were much more substantial, and the population must have increased. The earliest material is from the Ground Grave period, when the Single Grave Culture first appeared north of the Limfjord, and thereafter there are so many sites that we may assume that the blown sand area was being more or less continuously exploited as part of the subsistence strategy of the inhabitants, a conclusion supported by the pollen diagram from Gjævhul Lake (fig. 8). The occupation layers now had blown sand below them as well as above them, showing that dune formation had begun, but the sand layers were still thin, and out of them rose morainic hills, crowned by barrows, some of which still emerge through the dunes today. Some information and photographs from this settlement phase has been given earlier (Liversage 1989).

Single Grave Culture. This was represented at Mortens Sande 2, the only Stone Age site that was excavated extensively enough for comprehensible structures to be uncovered. It has been fully published (Liversage 1988). There were traces of three of four consecutive structures. Each had one substantial post and a double rows of stakes. Though regarded as shelters of some kind, it is hard to be specific about their original appearance. The site produced a good closed assemblage of pottery and flint, as well as remains from amber working.

Mortens Sande 2 was a stratified site with overlapping strata from the Single Grave and Bell Beaker cultures. More Single Grave settlements certainly exist, for isolated Single Grave potsherds have appeared at two other locations along the coast.

The next developmental stage is represented by layers with Bell Beaker pottery, sometimes associated with flat-flaked tanged and barbed arrowheads and/or flint dagger fragments. Four distinct Bell Beaker strata have been found (fig. 1). They are Mortens Sande 1, the upper layer at Mortens Sande 2, the lower of two occupation layers at Bodbjerg Ditch, and the lower of two layers at the Barrel Site. There are also faint signs of Bell Beaker settlement at the Viking site of Øster Aalum. There must have been structures at some of these sites, as pits and stakeholes have been observed, but only small areas could be excavated, and nothing definite can be said about the structures.

There were also occupation layers with pottery with degenerate or residual Bell Beaker traits. There are three occurrences of this kind, all small. They are the upper layer at the Barrel Site, Middle Site A, and the lower of two layers at Gjævhul Bakke.

The final site in this series (the upper layer at Gjævhul Bakker) produced coarse thick pottery from period I of the Bronze Age. Part of a type VI flint dagger was found on the surface at this site, and may be supposed to be derived from this layer.

All these Single Grave/Late Neolithic sites were rather alike. They comprised spreads of charcoal, flint implements, chipping waste, and pottery, and usually amber (Hirsch & Liversage 1987). Stake structures would certainly have been found if the sites could have been excavated in the same way as Mortens Sande 2. Their size can be roughly estimated from their extension along the cliff, which suggests a typical diametre seldom or never exceeding 10 m. The flimsiness of the structures, the small extent of the occupied area, and the limited amount of finds all suggest that these sites were temporary camps rather than permanent settlements. It seems likely that they were inhabited seasonally by herdsmen, whose permanent settlements lay elsewhere, but who exploited the dune belt for grazing, probably on a seasonal basis. The permanent settlements were no doubt similar to some of those excavated by the Thy-project on higher land east of Ovesø lake, and could even be the same settlements. It was never possible to recover the total material of a site, and it is clear that a great deal has been lost to the sea. Nevertheless the excavations give quite a good idea of the range of pottery that was in use in different phases and how it developed from phase to phase, and this is supported by stratigraphical evidence. At some sites polished flint was present. Amber was extensively worked. At Mortens Sande 2 the complete flint chipping inventory of a Single Grave community was recovered, and found to be so unusual that it supports the theory that these people lacked experience and skill in dealing with flint (Liversage 1988).

Early Bronze Age (period II onwards)

Period I in the upper layer at Gjævhul Bakker belongs to the Single Grave/Late Neolithic cycle. The next in chronological order must be Lyngby North (see fig. 1). It was a difficult site to date, because the pottery was atypical and rather sparse. The pottery must in all events be later than the coarse pottery from the upper layer at Gjævhul Bakke, while the presence of a little flat-flaked flint shows that the settlement can hardly be later than the early Bronze Age. The finds included a glass bead, which though found on the surface is most unlikely to be intrusive.

Late Bronze Age

Basically there are two types of site. The first are sparse scatters of sherds and flint accompanied by a little charcoal. The second have abundant finds, especially of pottery, and numerous postholes are found. These were much larger than any from the Late Neolithic, and certainly represent year-around settlements lasting decades.

The three rich LBA sites were in chronological order the Middle Site B and C (which may be from the same settlement), Stenbjerg North, and Bodbjerg Ditch (fig. 1). There were indications that settlement activities had been spread over quite a large area. Thus at the Middle Site there were two middens, so far as we can judge from the pottery both of about of the same age, lying about 100 m apart, and at Bodbjerg Ditch apparently similar pottery was found in a blowout some scores of metres from the main discovery. The midden deposits were characteristically about or in one place over a metre thick, and consisted of streaky blown sand variously coloured by ash, in which there was much pottery, fire-shattered stones ("potboilers"), and food debris in the form of carbonized plant remains and decomposed ruminant teeth representing the cattle, and sheep or goats eaten by the inhabitants. Adjacent to one of the middens at the Middle Site was an area with numerous, often fairly large postholes. Many were cut into one another, showing that the buildings had been rebuilt or repaired at the same location, which indicates that the settlement must have been in use for a substantial time.

The third major Bronze Age site was Stenbjerg North. Here there were the remains of a house, which will be described on p.52.

On the basis of the pottery, and to some extent supported by radiocarbon dates, the Middle Site can be dated to period IV, Stenbjerg North to period V, and Bodbjerg Ditch to period VI of the Bronze Age. They provide closed assemblages showing the full range of pottery in local use at these stages. Chipped flint is still present, and if anybody wants a pure and uncontaminated sample showing how flint was treated in the LBA, it is available here. Amber was no longer being worked and there is no indication that it was used.

A particularly important feature of the Late Bronze Age settlement is that old plough soils start appearing. They are recognizable first as homogeneous greyish strata 10-20 cm thick. The identification is confirmed if the criss-cross grooves caused by ploughing with the ard can be found at the transition to the underlying deposit. The plough layers will be considered below p.51.

The sparse type of Bronze Age occurrences have been harder to study. Several occurrences were found in the early years of the project, but no sites of this kind have been found recently. It is quite likely that they were diffuse artifact scatters associated with plough layers, and most of them were found in the northern two thirds of the research area, on what was at the time a level plain some metres above sea level. Together they suggest a considerable amount of Late Bronze Age settlement, but they are very difficult to study.

Iron Age

A site from the middle of the Pre-Roman Iron Age at a point now far out in the breakers is indicated by a box of sherds at the National Museum from an unspecified place in the sand dunes in Lodbjerg parish.

Only one Iron Age settlement has been found since 1965. It is the "Summerhouse Site", which has been thoroughly studied and published by an international team (Liversage *et al.* 1987). Primarily it was a ploughsoil with ard marks. This was bounded on the south by a broad, very low bank of wind-blown sand. A narrower bank running through the ploughed area had signs of cultivation underneath it, showing it did not date from the earliest use of the field. Pottery, flint, and charcoal indicate settlement, and a sunken clay layer must be interpreted as a house floor. It was cut by ard marks showing that there had been cultivation after demolition of the building. The interesting botanical and pedological studies will be discussed in the next section. The pottery dated the site to an early part of the Pre-Roman Iron Age. In 1992 it was found that the field had entirely disappeared into the sea.

Later settlement

After the early Pre-Roman Iron Age there seems to be a gap in settlement, so that the late Pre-Roman, Roman, and Post-Roman periods are unrepresented in the archaeological material.

The youngest site found has been named "Øster Aalum" after the Nørre Aalum shown on old maps and washed away by the sea in the last century. "Øster Aalum" was a Viking Age farming settlement, and was placed at what was then the border between boulder clay and the innermost edge of the blown sand. There was evidence of cultivation on both substrates, and there may have been good agricultural reasons for choosing the situation at the transition between two soil types. Thus Øster Aalum is not really a true dune site, and it can be said that as far as our present evidence goes settlement on the blown sand ended in the Pre-Roman Iron Age and was never revived. The erosion of the coast at Øster Aalum is particularly severe, and over the years postholes, a hearth, various pits including what probably was a pithouse, a palisade or house wall, and a great deal more, have been washed into the North Sea. Features connected with agriculture at this site were a cultivation layer, a field bank, and some small trenches, which were probably field drains. As well as a little Viking pottery the site has produced archaeobotanical material, and there are faint traces of earlier settlement from pre-Roman and Bell Beaker times.

Summary

At all these sites only a small fraction of the finds could be salvaged, but the material is interesting and its validity as closed finds is ensured by the thick separating layers of blown sand. The assemblages add usefully to our knowledge of the development of material equipment. Among other things they provide good evidence of technology of chipped flint over a long period, and provide the best opportunity we have for examining the character of the flint work in Late Bronze Age and Pre-Roman Iron Age times. In several cases direct superposition of cultural layers provides stratigraphical sequences of a type that rarely occurs before the stratified Iron Age settlements.

THE ENVIRONMENTAL EVIDENCE

Introduction

At the outset, the first priority of this project was the archaeology of the finds and structures which emerged from the eroding dunes. After a while it was realised that there was also a very significant natural archive preserved in the layers which the sea was relentlessly exposing. Over the boulder clay and under the dunes there are buried mineral soils capped by organically-rich vegetation layers, and peat and gyttja deposits accumulated under the wetter conditions found in small hollows, ponds and lakes, similar to those seen today on the flats behind the dunes. In some areas the dunes were stable sufficiently long for vegetation cover to establish and soils to develop before another layer of blown sand was deposited. In some places, gleying, podsolisation and iron pan formation in the layers of blown sand, led to local waterlogging. These processes were aided by a general rise in the watertable linked to the rise in the ground surface as successive layers of blown sand were deposited, and even well-drained deposits eventually became waterlogged. As a consequence, peat and gyttja deposits can be found in the blown sand high above the glacial till. Due to the waterlogging and the protective effect of the sand, many of these deposits contained well-preserved carbonized and uncarbonized organic material in the form of pollen, seeds, fruits and other plant remains, insect remains and occasionally bones.

The vast majority of the deposits found in the erosion cliffs are natural and devoid of artifacts. In a small number of cases the deposits have either been modified by being on the fringes of human settlements or have been directly created by human activity. Analyses of the botany, pedology, geology and micromorphology of natural, semi-natural and man-made deposits can give us a great deal of information about the local natural environment and the development of the landscape, and the part which successive human populations played in this process.

The analyses

The first palynological evidence came in 1972. A sample from an organic layer below the Bell Beaker occupation layer at Mortens Sande I was described by Svend Jørgensen of the National Museum as very humified organic material, containing fungal hyphae, charcoal dust and fine eolian sand, in a felted fibrous mass of woody and herbaceous root and stem fragments. Archaeological finds were absent from the layer, which must represent the pre-occupation environment. Despite the pollen being sparse and poorly preserved, Svend Jørgensen produced a pollen count (Table 1). The pre-occupation environment at Mortens Sande I was probably sheltered scrubby woodland, comprising oak *(Quercus)*, birch *(Betula)* and alder *(Alnus)*, and the influence of nearby dune and coastal vegetation can be clearly seen. Direct palynological evidence of human activity is minimal, although the openness of the woodland and the abundance of herb pollen (particularly grass, *Poaceae*) is indirect evidence of human influence. Heather pollen shows the heath formation had already begun locally in the area at this time, possibly both in the woodland and on the dunes.

The next step forward came in 1979, when an international team, comprising an archaeologist, a palynologist, two soil scientists and an archaeobotanist became involved in investigations at a Pre-Roman Iron Age locality – the "Summerhouse Site" (Liversage *et al.* 1987). The investigation included a section through the remains of cultivated fields, field banks, a house floor and uncultivated areas. Pollen and plant macrofossil analyses were carried out on plough soils and peat and gyttja deposits in the uncultivated areas immediately adjacent to the fields. The pedology and soil micromorphology

Table 1. Pollen analysis from Mortens Sande 1 – Svend Jørgensen 1971.

Pollen Type		Count	% total pollen + spores
Trees			
Fagus (Beech)		1	0.4
Quercus (Oak)		32	12.8
Fraxinus (Ash)		2	0.8
Tilia (Lime)		3	1.2
Ulmus (Elm)		2	0.8
Pinus (Pine)		15	6.0
Betula (Birch)		43	17.2
Alnus (Alder)		15	6.0
Shrubs			
Salix (Willow)		16	6.4
Corylus (Hazel)		26	10.4
Dwarf Shrubs			
Ericaceae		7	2.8
Herbs			
Poaceae (Grasses)		62	24.8
Cyperaceae (Sedges)		2	0.8
Galium (Bedstraw)		2	0.8
Liguliflorae (Composites)		5	2.0
Tubuliforae (Composites)		1	0.4
Melampyrum (Cow-Wheat)		2	0.8
Plantago maritima (Sea Plantain)		3	1.2
Plantago coronopus (Buck's-horn Plantain)		2	0.8
Potentilla (Tormentil etc.)		2	0.8
Scrophulariaceae (Figwort Family)		1	0.4
Vicia (Vetch)		1	0.4
Elymus (Lyme grass)		1	0.4
Ferns and mosses			
Polypodium	(Polypody)	3	1.2
Pteridium	(Bracken)	2	0.8
Dryopteris	(Buckler fern etc.)	2	0.8
Sphagnum	(Bog Moss)	2	0.8
Total pollen and spores		253	

of the various deposits including the remains of a house floor were also investigated. The botanical and stratigraphical analyses from the small pond north of the field are particularly useful in reconstructing events at the site, as the deposits consist primarily of gyttja formed under water, thus avoiding many of the interpretative problems associated with soil pollen analyses (Moore et al 1991, p.22). The analyses show that prior to the area coming under cultivation, the dominant vegetation was heather *(Calluna vulgaris)* heathland, with local wetland vegetation in the pond. Heather produces very large amounts of pollen, which tends to swamp the evidence for other vegetation types in the pollen spectra. Nevertheless, it is clear from the presence of various agricultural indicator species (albeit in relatively small amounts) that agriculture was being practised in the vicinity, prior to cultivation at this particular location. When cultivation and settlement commenced in the immediate vicinity, drastic changes occurred in the pollen spectra. These are partly due to the removal of the source of the heather pollen, but also very real changes in the vegetation are apparent. The pollen and plant macrofossil analyses reveal the presence of distinct vegetation types linked to the cultivated fields, the pond, and possibly the field bank or hedge associated with the fields. Some of the spectra from the plough soils are clearly a mixture of residual heather pollen and pollen of cereals, arable weeds, grasses and sedges *(Cyperaceae)* from the time of the settlement. The seeds found in the plough soil were mostly of common arable weeds. In the pond deposits there is, in addition to pollen and seeds from the local aquatic and wetland vegetation, clear evidence of nearby cultivation in the form of both pollen and seeds of arable weeds and ruderals. We can also see that the bank of the pond became disturbed and polluted (nutrient enriched) as a consequence of the proximity of the settlement. The pond also contains traces of the vegetation likely to have been growing on the rather more stable environment of the field boundary. Outside the cultivated area there seems also to have been a change from heather heathland to rough pasture, with an accompanying rise in the pollen of grasses and sedges. It is however difficult to see the scale of this change – the relative increase in sedge and grass pollen in the later samples may be more due to the removal of the source of some of the dominant heather pollen rather than a dramatic increase in grasses and sedges.

The archaeological investigations showed that the plough soil contained abundant charcoal and pottery fragments, suggesting that the manure used on the fields had contained domestic refuse. The manuring of the soil and the fact that the house floor had been damaged by later ploughing suggested that there had been intensive and repeated cultivation and settlement within a confined area. This interpretation was confirmed by the pedological and soil micromorphological analyses. The overall picture was of small intensively and repeatedly cultivated plots intrinsically bound to the settlement, in a relatively inhospitable mosaic of bogs and heaths – marginal land which was probably used primarily for grazing.

Research at the "Summerhouse Site" established that palaeobotany could make an important contribution to understanding the nature of prehistoric settlement in the blown sand, and inspired by the results, one of the authors (D.L.) spent many evenings of a later field season processing soil samples in order to study the occurrence of seeds in different contexts. Some of the samples were later identified by Hans Arne Jensen (Lyngby) and Jan Peter Pals (Amsterdam), and some new samples were taken by Bas van Geel (Amsterdam).

A sample from the "Summerhouse Site" produced a seed of a medicinal plant that is not native to Denmark, the opium poppy *(Papaver somniferum)*. Whether this represents a weed, or intentional cultivation for food, medicinal or narcotic purposes is impossible to determine, but it is in all events a very interesting discovery. A small sample of carbonized cereal grains, that had been blown free by the wind at the EBA site, Lyngby North, were identified by Grethe Jørgensen as 6-rowed barley *(Hordeum vulgare)* – whether naked or hulled cannot be determined owing to the state of preservation.

During excavation of the Viking site, "Øster Aalum", in 1983 a pit house was excavated, which quite obviously contained very large numbers of cereal grains, which were scattered uniformly throughout its sandy fill. These were examined P. Rowley-Conwy (Rowley-Conwy 1990), and were found to be dominated by grains of rye *(Secale cereale)* with small numbers of barley, oat *(Avena)* and wheat *(Triticum)* grains. A few weed seeds and seeds of plants of damp habitats were also recorded. Rowley-Conwy interpreted the material as a by-product of crop processing, so-called "tailings", i.e. small grains and weed seeds which have been separated from the main crop during processing and cleaning of the grain (Hillman 1981). In the light of other analyses from pit houses however, there is no reason to see the remains as anything other than the charred remains of a locally-grown and harvested crop (Robinson 1993).

A more systematic approach to the question of preserved plant remains was adopted in 1984, when a flotation bucket was used to retrieve plant remains on site at the Bell Beaker "Barrel" site (sb 37) and the Single Grave stratum at Mortens Sande 2. The resulting material was examined by the second author of this paper (D.R.). The analyses from Mortens Sande 2 were published by Robinson and Kempfner (1988) and those from the Barrel Site are to be found in Robinson (1992). The samples from Mortens Sande 2 came from a layer dated by Ground Grave pottery. Only carbonized remains were preserved, and they were dominated by cereal grains, of which the overwhelming majority were of naked barley, although a few grains of hulled barley, emmer *(Triticum dicoccum)* and oats were also recorded. Some naked barley grains still had fragments of the enclosing lemma and palea adhering to their surface. This shows that the grains were not fully ripe when harvested. It also seems likely that the barley had been harvested, stored and brought to the site as hand-plucked ears. This conclusion is based on the fact that fragments of barley rachis (the segments which make up the spine of the ear) were present, while seeds of arable weeds were exceedingly rare. Both these traits are consistent with the ears having been hand-plucked. The few other plant remains which were encountered were ruderals, which grow on disturbed nutrient-rich soils, and plants of moist shady woodland and heath.

The Barrel Site comprised a layer rich in organic material and an overlying more sandy deposit. Both contained the same Bell Beaker pottery. A thicker layer of blown sand separated the Bell-Beaker layers from an overlying Late Neolithic occupation. Several samples were analysed from the lower and upper parts of the Bell Beaker deposit, and one from the Late Neolithic layer – all contained both carbonized and uncarbonized remains.

All the Bell Beaker layers at the Barrel Site contained carbonized cereal grains. Naked barley dominated the spectrum but there were also grains of emmer and a single grain of hulled barley. In keeping with other Neolithic finds, arable weed seeds were rare, with the exception of fat hen (Chenopodium album) which was very common. Fat hen probably grew as a ruderal on the nutrient rich soil around the site, rather than as an arable weed. The seed content of the organically rich basal deposit is much more diverse than that of the other layers. Its composition is consistent with moist scrub woodland and grazed common. The sample from the higher Late-Neolithic layer contained no remains of crop plants but there were remains of plants which typically grow in scrub woodland, on grazed common and in wetland areas.

At various times, massive peat and gyttja deposits have been exposed by coastal erosion at Gjævhul, and in 1982 a sample column was collected by Bas van Geel. In 1987, preliminary pollen analysis of the deposit was begun by DR and two samples were radiocarbon dated, one from the top and one from the bottom. The resulting "skeleton" pollen diagram and a description of the stratigraphy of the deposits is presented in fig. 5. Although still at a preliminary stage, the pollen diagram is presented here because it contains valuable information and it is unlikely that resources will be available in the foreseeable future to enable its completion.

The lower 40 cm of the deposit consists of very humified and degraded wood peat, which formed over boulder clay under terrestrial conditions some time just prior to the beginning of the 4th Millennium BC, radiocarbon dated to 5050 ± 90 bp, calibrated 3960 – 3790 BC (K-4849) (Stuiver & Pearson 1993). Some quite large pieces of charcoal were apparent in the upper part of the wood peat. At 41 cm there is then a very sharp transition to gyttja (i.e. a deposit formed under water), which then made up the remaining 2.1 metres of the deposits. The transition from peat to gyttja has not yet been radiocarbon dated and this is something which obviously should be done (see later). The sand content of the gyttja varies considerably up the profile and a number of thin sand layers and lenses are obvious in the deposits, notably at the transition from peat to gyttja. The top of the gyttja is radiocarbon dated to 2720 ± 70 bp, calibrated ± 1 standard deviation: 920 – 820 BC (K-4850) (Stuiver & Pearson 1993). As the top of the deposit appeared to have been eroded, this may be earlier than the actual cessation of sedimentation in the lake.

Analysis of the basal wood peat revealed that pollen was either absent or very scarce and degraded, which suggests that the deposit had been subjected to periodic drying out and considerable bioturbation by the soil fauna. Only two pollen samples from the wood peat could be counted satisfactorily, luckily one of them comes from the level of the radiocarbon date. This analysis confirms that the deposits are terrestrial in origin and that in the early Neolithic there was woodland at the site, probably alder carr, with hazel *(Corylus)* and possibly pine *(Pinus)* in the vicinity. The smaller amounts of pollen of other tree species may have originated from long distance transport. Grass and sedge pollen is present only in modest amounts, heather pollen is absent, and very few herb species are recorded. Spores of ferns *(Filicales)* and adder's tongue *(Ophioglossum)* are well represented, which is consistent with there having been woodland at the site.

A sample from the uppermost 5mm of the wood peat shows the continued dominance of alder woodland with ferns, but the influence of the overlying aquatic deposits is clearly seen. At the transition to gyttja the pollen spectrum changes dramatically before remaining more or less constant for the remaining 2.1 metres of the deposits. The pollen is generally much better preserved and the spectra are characterized by very low tree pollen values, with the exception of hazel-type (which also includes bog myrtle *(Myrica gale)* pollen), and high values for grass, sedges and heather. Cereal-type pollen is present in the majority of samples and anthropogenic indicators such as ribwort plantain *(Planta-*

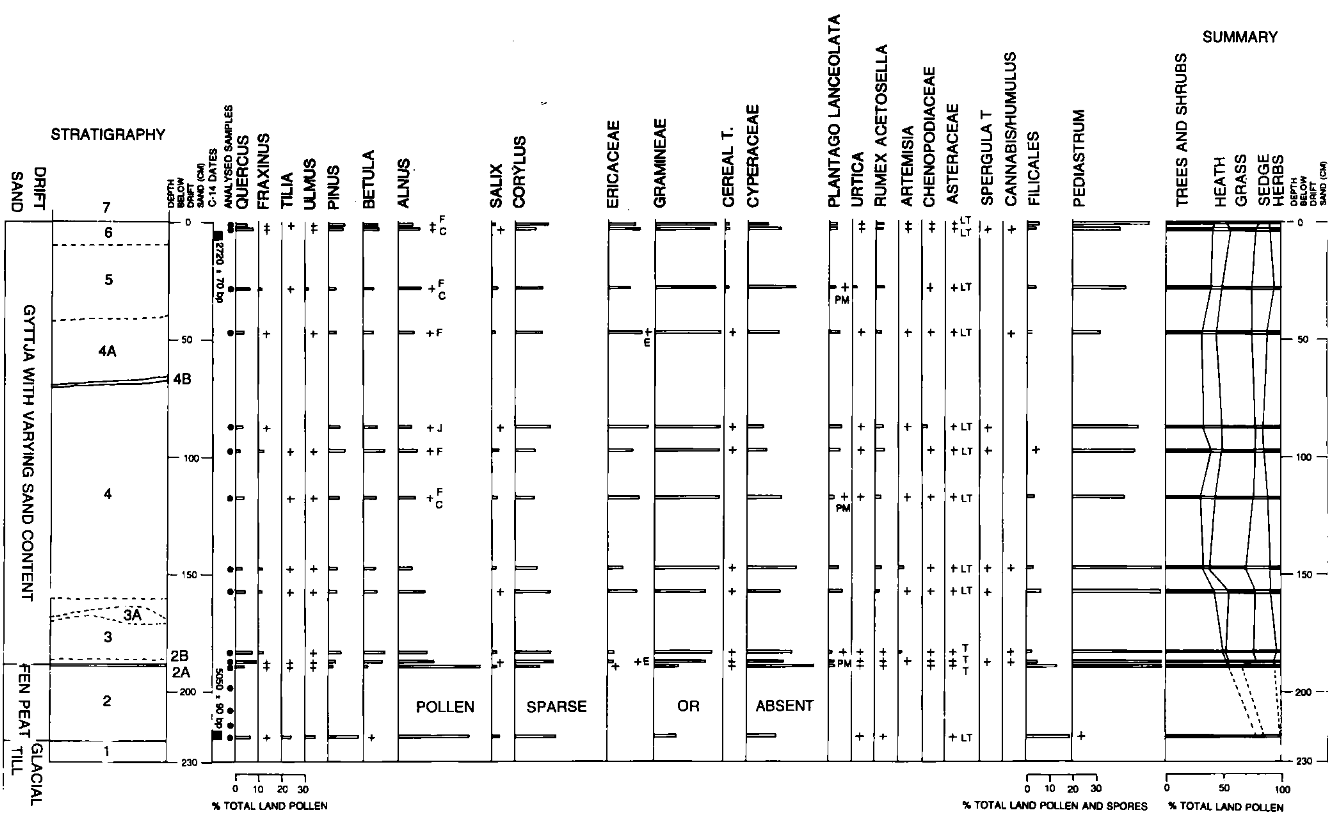

Fig. 5. Preliminary pollen diagram from "Gjævhul Sø" – peat and lake deposits from the Neolithic and Bronze Age, buried under drift sand. Only the most abundant or most important taxa are shown; other pollen and spore taxa were recorded at lower frequencies, but have been omitted for reasons of space.

Key: + = values of less than 1% of total land pollen; F = Fagus; C = Carpinus; J = Juglans; E = Empetrum; PM = Plantago media/major; L = Liguliflorae; T = Tubuliflorae.

Pollen sum (total land pollen): between 213 and 628 (average 457).

Stratigraphy: 1 = glacial till; 2 = degraded fen peat; 2A = fine sand; 2B = mixture of fen peat and gyttja; 3 = gyttja with a moderate to high sand content; 3A = gyttja with very high sand content; 4 = gyttja with low sand content but with occasional stripes and lenses of fine sand; 4A = gyttja with low sand content; 4B = fine sand; 5 = gyttja with moderate to high sand content; 6 = weathered/degraded gyttja; 7 = drift sand.

Radiocarbon dates: TOP: K-4850 = 2720 ± 70 bp (920 – 820 BC corrected ± 1 standard deviation (Stuiver & Pearson 1993)).

BOTTOM: K-4849 = 5050 ± 90 bp (3960 – 3790 BC corrected ± 1 standard deviation (Stuiver & Pearson 1993)) *go lanceolata)*, nettle *(Urtica dioica)*, sheep's sorrel *(Rumex acetosella)* and mugwort *(Artemisia)* are also well represented. Fern values decrease and the very large numbers of colonies of the green alga *Pediastrum* confirm that the sediments formed under aquatic conditions. We do not know as yet when or why the area became inundated, neither do we know the length of time which the gyttja deposits represent. A radiocarbon date from the peat/gyttja boundary would be helpful in this respect. It is however unlikely that two metres of gyttja could have accumulated in under 1000 years. The pollen diagram from the gyttja covers therefore a very long period of time, perhaps the whole of the later Neolithic and Bronze Age, during which there was an apparently open and agriculturally-dominated landscape. The openness of the landscape corresponds very well with the picture we get from the Hassing Huse Mose pollen diagram (Andersen et al. 1991; Andersen 1992; 1995 (this volume)), although the high values of pine pollen seen in the Hassing Huse diagram at this time are not apparent in the deposits at Gjævhul Sø. We can also see from the Gjævhul diagram that heath formation had not begun locally in the early Neolithic, but occurred later. The first heather pollen appears at the base of the gyttja, after which values increase steeply to a level which is maintained throughout the rest of the diagram. A date from the peat/gyttja transition would again be useful as it would fix the start of the development of heathland in the southern part of the study area.

Collection and analysis of further material from the sand-dune area for botanical analysis in the future will depend very much on available manpower and economic resources. The scientific potential of the area is enormous, particularly now that we are so fortunate in having the regional pollen diagrams from Hassing Huse Mose and Ovesø (Andersen et al 1991, Andersen 1992, Andersen & Rasmussen 1992) to provide a reference framework both for the sites turning up on the coast and those being investigated inland under the auspices of the Thy-Project.

A SPECIAL QUESTION – OLD CULTIVATION SOILS

One of the unexpected discoveries was that old cultivation layers could be found in the blown sand. Plough layers with ard marks have been identified at five points along the 14 km stretch of coastal cliff, and further deposits have the appearance of old cultivated soils although no ard marks have been found in them. All dated occurrences have been from the LBA or the Pre-Roman Iron Age (apart from the Viking Age plough layer at Øster Aalum, which is not strictly a sandhills site). No signs have yet been found of Neolithic or EBA cultivation. It seemed we had nothing less than a whole buried landscape with the unique opportunities for studying land use and agricultural methods in prehistoric Denmark! Blown sand seems nevertheless a surprising substrate for crop cultivation, but with a little thought it became plain that the inhabitants had not simply gone out and cultivated blown sand, but had chosen places with well developed humic or peaty surface deposits with a solid plant cover, and had almost certainly added organic matter in the form of manure and/or peat. The cultivated areas have the appearance of sandy soils now because the organic fraction has largely broken down as a result of cultivation and the passage of time; the plough soils have reverted to grey powdery sand.

Logically the first question to ask was how big were the cultivated areas and how were they delimited. It turned out however that the boundaries of the cultivated areas could not always be found. In fact it was only at the two youngest sites, Øster Aalum and the Summerhouse Site, that the edge could be determined precisely. At Øster Aalum the ploughsoil ended northwards at a very distinct artificially constructed field bank of sand (southwards it sank to below beach level and was lost to sight). A section through the bank is seen in fig. 6. Unfortunately despite repeated efforts it has not been possible to find this bank again. The plough layer was intersected by or passed over 2-3 narrow ditches, which must have had some purpose in their time, perhaps that of drainage. They appeared to contain a good deal of organic material, the analysis of which is in progress. The furrow marks in the base of the field layer differed from those at other sites along the cliff in including broad, one-directional furrows that are likely to have been made by a mouldboard plough, but criss-cross ard marks were also present (fig. 6). It has not been possible to decide whether the two kinds of marks were of from the same or different ages, for there was limited evidence of Late Neolithic and possibly also of Pre-Roman Iron Age activity at the site.

The situation at the Iron Age Summerhouse Site was somewhat different (Liversage et al. 1987). From its

Fig. 6. Marks of two different ploughing implements at Øster Aalum. In background section through the field bank bounding the cultivated area.

uninviting situation out in the sandhills it was first assumed that it must represent short-term "outfield" cultivation. This is the system in which areas of marginal land are opened up and cropped for a year or two and then allowed to revert to the wild. However from her study of the soil micromorphology M.-A. Courty was able to conclude that cultivation had continued over a substantial period of time. This was supported by various other indications as already described – the ploughed-over house remains, the low banks formed through the gradual deposition of blown soil, the secondary internal bank, the substantial amounts of pottery and flint chips. These all showed that the place had been settled for too long a time to be an "outfield". There was further support from palaeobotanical evidence indicating vegetational changes that were too marked to result from short-term utilization. Finally the strong leaching of the underlying sand was consistent with a long period of cultivation. Thus the archaeological, palaeobotanical and pedological evidence all pointed towards a period of cultivation lasting at least for decades. The limits of the fields at Øster Aalum and the Summerhouse Site were easily found, but this was not the case at the other sites where ard marks were encountered. Homogenized soil with clear ard marks at its base might be discovered, but when followed sideways it would gradually change to an unhomogeneous material with horizontal streaks of dark and light sand, and there would no longer be ard marks, i.e. it lost the character of a cultivated soil, but no clear boundary could be found between the cultivated and the uncultivated. The explanation is certainly bioturbation. At Øster Aalum and the Summerhouse site the ploughsoils had been sealed by new blown sand soon after the sites were abandoned. This is clear because the new natural vegetation hardly managed to re-establish itself on them before they were covered by more blown sand. Being quickly buried had greatly reduced the amount of bioturbation that took place after they were abandoned. Some other plough soils remained uncovered for centuries after cultivation ceased. During this time natural plant growth and burrowing animals eradicated most of the signs that could have identified them as old cultivated soils. Even at Stensbjerg North, where there was evidence of prolonged Late Bronze Age settlement, it was impossible to delimit the cultivated area. The homogenized ploughsoil became gradually streaky in one direction, and had been destroyed in the other by a recent blowout.

In the cultivated soil at Stenbjerg North there were the remains of a post-built house with its floor lying about 30 cm below the surface of the field. The excavation plan is given as fig. 7. The fill in the depression where the building stood was indistinguishable from the surrounding ploughsoil, except that on the very bottom there was a thin, dark, greasy deposit representing dirt on the floor. This floor deposit was cut by a network of ard marks, showing that the ploughman had cultivated down through the depression left when the walls and posts of the house had been cleared away. Fainter traces of ard marks at various levels higher in the fill, made it clear that cultivation continued throughout the filling up process. The section (fig. 8) shows that cultivation continued until the hollow had been completely filled up and the surface passed horizontally across it without the slightest sign of the depression underneath. This can only mean that the site was cultivated for a considerable number of years. As at the Summerhouse site, the story told is of continued cultivation for a period not of a few years, but that has to be counted in decades or generations. Again the "outfield" theory must be ruled out.

When the site was finally abandoned a peaty horizon with woody vegetation formed on the surface of the abandoned field and represents the centuries before the next blown sand arrived. Innumerable water voles dug their burrows with characteristic storage chambers and virtually obliterated the ard marks except down in the deeper hollow where the house had been. Outside the house only a few short lengths of furrow could be distinguished in the confusion of burrows.

The plough layers without ard marks that have been mentioned resembled this plough layer as it survived outside the house enough to suggest that they indeed were ancient cultivated soils that had become virtually unrecognizable through bioturbation.

LANDSCAPE DEVELOPMENT AND HUMAN SETTLEMENT

In the earliest times there was normal forest development on boulder clay, just as anywhere else in the country. By Atlantic times the rising sea had flooded the low-lying areas that are now the North Sea, and an arm reached into Ovesø. The coastline was very different from the present one, and the boulder clay prominences in the southern part of the present cliff continued as a land mass far to the southwest, partly closing the western Limfjord. The sea was certainly closer north than west of most of our sites. Though the Limfjord was closed to big waves, salt water began to enter it in early Atlantic times. On the boulder clay prominences we find occasional traces of Funnel Beaker settlements. Sv.Th. Andersen's pollen analyses from Hassing Huse Mose and Ovesø Lake show that the effect of the TRB culture on the forest in southern Thy was relatively light

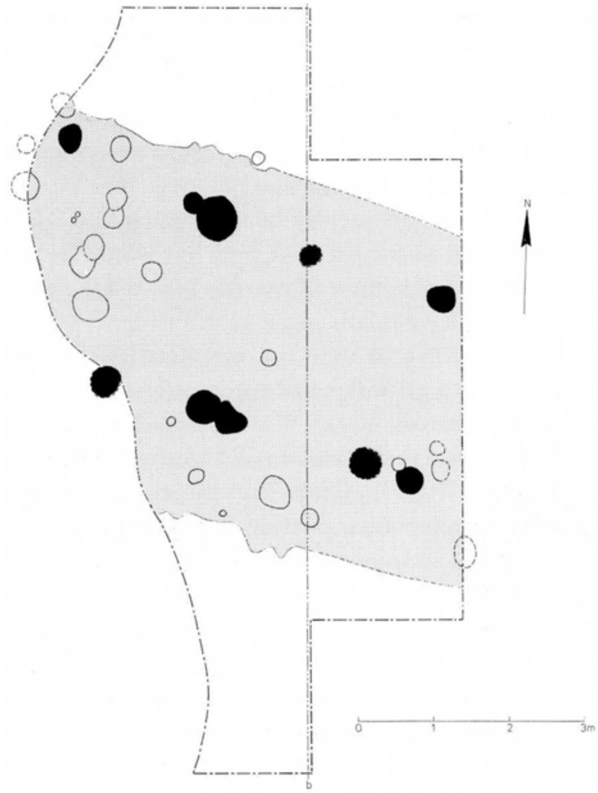

Fig. 7. Plan of a Late Bronze Age sunken dwelling at Stenbjerg North.

(Andersen et al. 1991, Andersen 1992, this volume, Andersen & Rasmussen 1992).

By the time of the Single Grave Culture, blown sand was being deposited over the beach sand that had long been filling up the bay leading to Ovesø. Sv.Th. Andersen's pollen diagrams as well as ours from Gjævhul Sø show that a very marked and sudden deforestation took place at this stage, with the formation of extensive

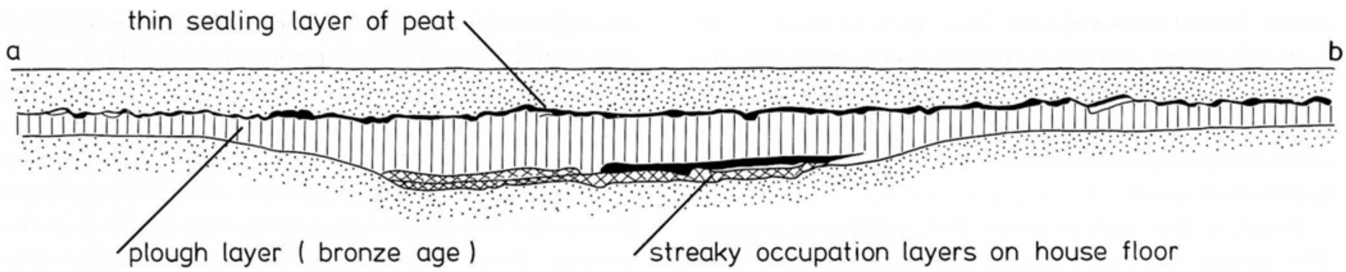

Fig. 8. Section through the sunken dwelling shown in fig. 7.

grazing areas, and an increased human presence is also indicated by the much larger number of occupation sites in the dune area.

The Single Grave/Late Neolithic sites were mainly restricted to the southernmost part of what by then was a largely filled-up bay leading to Ovesø. The beach sand in the bay would readily be caught by the wind and swept inland to form dunes, and this would be particularly marked at a time of marine regression, such as is thought to have taken place at this time.

In the course of time the northern part of the bay aggraded to a great flat and apparently unsettled expanse of marshes and meres, that extended to the northern end of the 14 km section of coast where old deposits are accessible. These marshes and meres are represented now by a metre-thick peat and gyttja layer in the cliff, which stands in something the same stratigraphical relation to the earliest blown sand as the Beaker sites do. It reveals an uninhabitable zone northwards of the area with Single Grave/Late Neolithic settlements, which from the small size and limited amount of finds at the sites appear to be temporary camps, no doubt of herdsmen who minded their livestock in the blown sand area. Their cultivated fields and main homes were no doubt substantial long houses on till soils, like those excavated by the Thy project. The limited pollen analytical evidence from the sandhill area suggests both dune vegetation of willow and heather, and local growth of various trees, including oak. The extensive heaths had not yet developed.

Subsequently sandhills marched across the marshes, leaving sheets of blown sand behind. Climate was not necessarily the cause of this change of regime, for it could have resulted from either the approach of the sea from the west as the shore was eroded back, or of a withdrawal seawards of the coastline through the deposition of expanses of beach sand, which could to be caught by the wind and swept inland. On the other hand climatic causes cannot be ruled out.

In the course of some centuries a new plain was created at a higher and drier level in the northern two thirds of the area of study. This provided an environment suitable for Late Bronze Age farming and year-round settlement.

South of this high plain we find a different regime. The terrain was lower and more irregular, with small dunes on some of which Late Bronze Age settlements were established and existed for some decades during this long period. These were much more substantial settlements than earlier. Some of them had solid buildings whose posts had been renewed at least once before abandonment, and there were deep midden layers containing much pottery.

There is a so far an unexplained discrepancy between the settlement history of the blown sand area and the interior, as shown by Sv.Th. Andersen's pollen diagrams. These suggest a high population density in the Early Bronze Age (increased forest clearance), and a lower one in the Late Bronze Age (limited return of the forest). However along the coast settlement from the Early Bronze Age is scantily represented, but a marked expansion can be detected in the Late Bronze Age.

The pollen diagram from Gjævhul Sø suggests that there was substantial areas of heathland throughout the Bronze Age, and there is heather charcoal at the Late Bronze Age sites. Investigations at the early Pre-Roman Iron Age "Summerhouse Site" indicated that the natural environment into which settlement intruded was a nearly treeless heather moor. It would be interesting to study these natural surfaces so see whether there was evidence of the periodical burning of the heath, which could be expected if it was wished to maintain its quality as grazing land.

A big question is what happened to the dunes after their settlement came to an end in the last centuries B.C. It is very surprising that there are no sites from the period c.100 B.C.- 200 A.D., for this period is signalled in Thy by an unequalled richness and abundance of settlement finds. The inhabitants must have had large numbers of cattle and would surely not have neglected the especial resource area along the coast. A possible explanation is that society at this stage was so well run that the inhabitants could simply mark their cattle and let them loose in the dunes without sending herdsmen to protect them from human or animal predators. If true, evidence of the continued human presence might be indicated by heath management. It is well known that heather heaths will degenerate to much less pastorally useful habitats unless maintained by grazing and regular burning.

Though the earliest Iron Age apparently presented a bare heath, the younger layers in the cliff reveal at a glance that vegetation types other than heath were also present. Even very cursory examination shows that some areas were very wet, as indicated by remains of bog moss, other mosses, gyttja and peat. At other places twigs, or even larger branches appear to represent deciduous thickets such as we rarely find today, because all the inner part of the sands has been planted with conifers. In the absence of archaeological finds there is no way of dating these upper layers except by radiometry. When applied, this has indicated earlier datings that expected. For instance a very pronounced peaty later at a high level in the cliff section, which was expected to represent the last stabilization before the Little Ice Age turned out to be from the Viking period.

So far we have not succeeded in identifying any buried plant layers from the Middle Ages. A possible explanation could be that the dunes were a sandy desert without plant cover at this time, but the question needs further investigation.

It should be mentioned finally that the interpretation of the events we can see is not always so simple as might at first be thought. A simple climatic explanation cannot be assumed when there is evidence of deteriorating conditions, for the approach of the sea resulting from the steady erosion of the coast must everywhere have brought about an inexorable climatic "deterioration", as increasingly coastal regimes moved in over the localities. It is also a question what an increase in the deposition of blown sand really indicates. If a climatic explanation is presumed, would cold, wet and windy conditions as in the "Little Ice Age" most increase dune formation, or would it be warm dry conditions, which weakened the plant cover through drought and allowed the sand to blow about more easily? We should also be careful before assuming a simple causal connection in cases where a period of settlement was immediately followed by renewed sand deposition. The abandonment of some sites was indeed followed rapidly by the deposition of more sand, and it would be easy to argue that the inhabitants had destroyed the anchoring vegetation and precipitated a natural catastrophe. At other sites on the other hand, abandonment was not immediately followed by renewed sand deposition at all but there is no obvious reason for the difference. There is certainly no statistical rule connecting settlement with an immediate subsequent increase of sand deposition. There are indications that the sand came as dunes, that originated at the coast and wandered across the country, as described by Hansen (1957). Their arrival soon after a settlement was abandoned could therefore be purely coincidental. Indeed the ultimate cause of some changes of regime for which a climatic or anthropic cause might be sought, could have been earlier changes of coastal configuration affecting the size of the beach, and thereby the amount of sand available to be blown inland. In all events the causative connections between sand deposition and climatic or human factors are so complex that simple or premature explanations are untenable.

One thing is clear, with its rich archaeology and wonderful preservation of environmental evidence the coastal sandhill area offers a unique possibility for studying in depth the evolution of a landscape and how the human presence played a part in this evolution.

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Acknowledgements
Our best thanks are due to Harald Holm and Peter Hirsch with family, without whose unfailing interest over many years only a few of the sites would have been discovered. We wish also to thank Eigil Andersen, the forester in charge of Lodbjerg plantation, for a enormous amount of interest and practical help over many years, and Henrik Sjøtt Christensen, the forester in charge of Nørhå plantation, for the same over a shorter period. Many others from home and abroad have helped in the field or in the study of material that had been brought back.

NOTE

1. At all stages the work has depended on the participation of two amateur archaeologists, Harald Holm and Professor Peter Hirsch (with family), who between them found and reported to the National Museum most of the archaeological sites. One of the authors (D.L.) then carried out trial excavations recording the stratigraphy and other details.

REFERENCES

Andersen, S.T. 1992: Miljøhistorie og Kulturhistorie i det vestlige Limfjordsområde. *Limfjordsprojektet Rapport* 5 (1992), pp. 87-91.

– 1995: History of Vegetation and Agriculture at Hassing Huse Mose, Thy, Northwest Denmark, since the Ice Age. *Journal of Danish Archaeology* vol. 11, 1992-93 (1995).

S.T. Andersen, Odgaard, B.V. & P. Rasmussen 1991: *Pollenanalytiske Undersøgelser* 1988-89-90. Miljøministeriet, Danmarks Geologiske Undersøgelse, Skov og Naturstyrelsen.

ANDERSEN, S.T. & RASMUSSEN, P. 1992: *Geobotaniske undersøgelser af kulturlandskabets historie,* DGU Kunderapport no. 10. 1991.

BRÜEL, J. 1918: *Klitterne i Vestjylland og paa Bornholm.* Copenhagen.

FUGLSAND, A. 1949: Bidrag til Sandflugtens historie. *Jyske Samlinger,* series 5 vol.8, pp. 162-94.

HANSEN, V. 1957: Sandflugten i Thy og dens indflydelse på kulturlandskabet. *Geografisk Tidskrift* 56 (1957), pp. 69-92.

HILLMAN, G. 1981: Crop Husbandry from Charred Remains. In R. MERCER (ed.): *Farming Practice in British Prehistory.* Edinburgh: University Press, pp. 123-162.

HIRSCH, K. & LIVERSAGE, D. 1987: Ravforarbejdning i yngre stenalder. *Nationalmuseets Arbejdsmark* 1987, 193-200. Copenhagen.

JESSEN, A. 1920: *Stenalderhavets Udbredelse i den nordlige Jylland.* Danmarks Geologiske Undersøgelse 2nd series, no.35. Copenhagen.

KUHLMAN, H. 1975: Kystklitterne. In T.W. BÖCHER *et al.* (eds.) *Danmarks Natur,* vol. 4, 160-86.

LIVERSAGE, D. 1988: Mortens Sande 2 – a Single Grave Camp Site in Northwest Jutland. *Journal of Danish Archaeology* 6, 1987 (1988), pp.101-24.

– 1989: Radiometrisk datering og beaker bosættelse i en nordvestjysk biotop. In L. LARSSON (ed.): *Stridsyxekultur i Sydskandinavien. Rapport från det andre nordiske symposiet om Stridsyxetid i Sydskandinavien.* University of Lund Institute of Archaeology, Report Series No. 36. Lund. pp. 219-226.

LIVERSAGE, D. & SINGH, P.K. 1985: A Comparison of two Neolithic Flint Industries. *Journal of Danish Archaeology* 4 (1985), pp. 70-78.

LIVERSAGE, D. & ROBINSON, D.E. 1988: Mens havet æder ind i det nordjyske hedelandskab. *Naturens Verden* 1988(7), pp. 262-71.

LIVERSAGE, D., MUNRO, M.A.R., COURTY, M.-A., & NØRNBERG, P. 1987: Studies of a Buried iron Age Field. *Acta Archaeologica,* 56, 1985, 55-84. Copenhagen.

MOORE, P.D., WEBB, J.A. & COLLINSON, M.E. 1991: *Pollen Analysis* (2nd ed.). Oxford: Blackwell.

PETERSEN, K. S. 1983: Late Weichselian and Holocene Marine Transgressions in Northern Jutland, Denmark. *Eiszeitalter u. Gegenwart* 35, pp. 71-78. Hannover.

– 1994: *Limfjordstangerne.* Danmarks Geologiske Undersøgelse Kunderapport no. 85 (1994).

PONTOPPIDANS *Danske Atlas.* 1761.

ROBINSON, D.E. 1992: Analyse af planterester fra Lodbjerg Sb37 (Olietøndepladsen) – en "sæter" boplads fra klokkebægerkulturen i Vestthy. *NNU Rapport* nr. 28. Copenhagen: National Museum.

– 1993: Plant Remains from the Late Iron Age/Early Viking Settlement at Gammel Lejre. *Journal of Danish Archaeology* 10, 1991 (1993), pp. 191-198.

ROBINSON, D. & KEMPFNER, D. 1988: Carbonized Grain from Mortens Sande 2 – a Single Grave Site in Northwest Jutland. *Journal of Danish Archaeology* 6, 1987, pp. 125-29.

ROWLEY-CONWY, P. 1990: Rye in Viking Age Denmark: New Information from Øster Aalum, North Jutland. *Journal of Danish Archaeology* 7, 1988 (1990), pp. 182-90.

STUIVER, M. & PEARSON, G.W. 1993: High-Precision Bidecadal Calibration of the Radiocarbon Time Scale, AD 1950-500 BC and 2500-6000 BC. *Radiocarbon* 35(1)(1993), pp. 1-25.

ØSTERBOL, A. 1878: Fra Agger Sogn. *Geografisk Tidsskrift.* 2, pp. 129-38.