Soil Forming Processes in and below a Bronze Age Burial Mound at Lejrskov, Southern Jutland

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Abstract

In the 19th and the beginning of the 20th century archaeological excavations of Bronze Age burial mounds in Jutland occasionally revealed mounds with water saturated cores, in which the conditions of preservation were extraordinary good. The wet areas were totally encapsulated by thin, strongly cemented iron pans, and until 1942 several different theories on the genesis of these pans were proposed. All of the theories referred to some sort of podzolisation in their explanation of the genesis.

In 1995 excavations at a burial mound at Lejrskov, Southern Jutland revealed similar iron pans. This paper describes the results of the chemical and morphological analyses of the burial mound and the buried soil below. It was established that the soil profile development in the top of the barrow was very weak probably as a result of soil erosion, but iron pans had been formed by reduction/oxidation processes (gley-formation) surrounding the core of the mound. The buried soil below the barrow was an acid sandy soil without signs of podzolisation.

Key words

Iron pans, Bronze Age, burial mounds, buried soils, gleying.

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Throughout the South Scandinavian Early Bronze Age from about 1700 to 1100 BC (Vandkilde et. al. 1996) construction of burial mounds was a very significant element in burial customs, and probably the majority of the present day 20,000 preserved and protected barrows within Denmark date from this period (Mathiassen 1957).

The diameter of a typical South Scandinavian burial mound varies between 15 and 30 m and the height normally lies within 3–5 m, though a few barrows are considerably larger with diameters of up to 60 m (Aner & Kersten 1973). An additional accentuation of the mounds was often achieved by erecting them on elevated positions in the landscape.

The coffins or cists were usually placed directly on the ground surface sometimes with elaborate stone constructions surrounding them. Subsequently the mounds were raised by turves placed with their vegetation layers downwards.

In the 19th century and the beginning of the 20th a number of mounds located in Jutland, including the Province of Slesvig, attracted especial attention upon excavation as they contained fully preserved oaken log coffins, and occasionally remnants of skin and hair of the buried persons, together with clothes and other organic grave goods were recovered. The cores of these mounds were almost always unusually wet and surrounded by thin, strongly cemented iron pans (Boye 1896, Thomsen 1929, Broholm & Hald 1939).

Chemical analyses of these iron-rich layers were first performed in 1859 in an attempt to explain how the remarkable conditions of preservation had arisen (Boye 1896). During the following decades several different interpretations of the phenomenon were proposed. Common to all of them was the opinion that the iron pans had been formed by some sort of podzolisation (Thomsen 1929, Broholm & Hald 1939).

The most comprehensive theory was presented by the german geologist K. Gripp in 1942 in connection with an

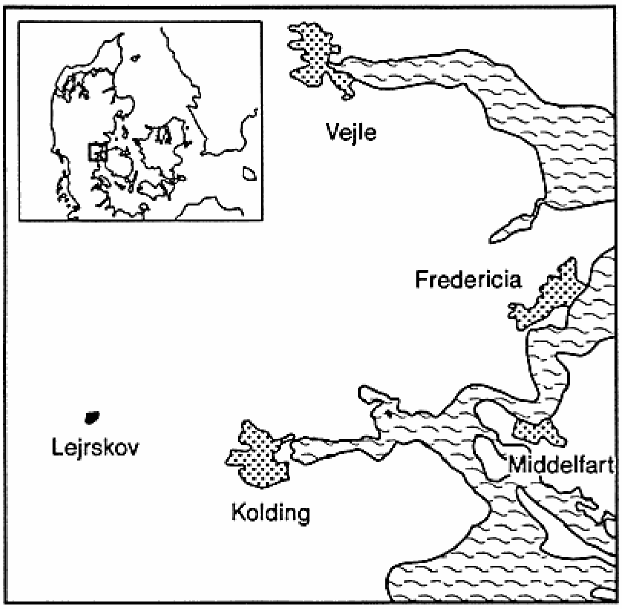

Figure 1: Location of the burial mound at Lejrskov.

excavation of a burial mound at Harrislee. He suggested that the mound had been erected in a continuous building sequence and afterwards surplus precipitation had accumulated in the mound core. In this wet body humic acids were extracted from the plant remnants of the turves. It was assumed that these acids had partly preserved the organic material and partly dissolved the iron of the soil. When further surplus precipitation transported iron from the mound mantle to the core iron would precipitate on the border between mantle and core. At the same time an iron pan was formed below the mound on the border between the wet core and the dry, aerobic subsoil. The lower iron pan below the core was considered stable by Gripp, whereas the upper pan was thought to have been repeatedly dissolved and reformed at a deeper location during the following millennia. This process produced a distinct difference between the mantle, where the organic material had decomposed, and a slowly but steadily shrinking core where only limited decomposition had taken place (Gripp 1942).

Gripp's theory of the genesis of the iron pans combines elements from both reduction/oxidation-processes and podzolisation. This explanation was widely accepted within German and Danish archaeology and no new analyses or interpretations were proposed during the following decades.

In recent years archaeological excavations in Jutland have revealed several burial mounds with iron pans, which has led to a reappraisal of the old theories (Breuning-Madsen 1997). The iron pans encountered were generally less well-developed than the pans known from the classic log coffin mounds and the conditions of preservation were correspondingly less remarkable. However, one burial mound excavated at Lejrskov, Southern Jutland (fig. 1) by the museum at Koldinghus in 1995 closely resembled the classic log coffin mounds (Prangsgaard 1996).

The burial mound at Lejrskov

The burial mound was excavated in 1995 prior to highway construction. The barrow had been erected on sandy well-drained soil in a flat outwash plain of the Weichsel glaciation. The diameter of the mound reached 35 m, and the preserved height was about 1.7 m. The original height could no longer be determined. In section the mound appeared bipartite with a very wet, bluish grey mound core with extraordinary conditions of preservation overlain by a brownish, dry mantle in which organic material had been subject to normal decomposition processes (fig. 2).

The core had a diameter of 26 m and a height of about 1 m. It had been built of turves as was evident from thin layers of very well-preserved plant remnants mainly mosses. The moss layers were most distinct in the lower parts of the core, which were also the wettest area. Although the brownish mound mantle had been built of turves too, the plant remnants in it had decomposed and could only be seen as thin black layers, which were very difficult to recognize in the topmost part of mound. The transition from the core to the mantle in terms of colour and conditions of preservation was somewhat diffuse with a gradual change over a distance of 30–40 cm. However, when the placing of the turves was studied a more distinct border between core and mantle could be drawn locally, as the core was characterized by turves placed predominantly in horizontal layers, whereas the turves of the mantle tended to slope inwards. This difference must reflect two construction stages. There was no vegetation layer on top of the lower construction stage, and the border between the two mound stages was not distinct everywhere, but where observable it was located below the colour transition zone. Thus the border between the construction stages did not correspond exactly to the change of colour and conditions of preservation.

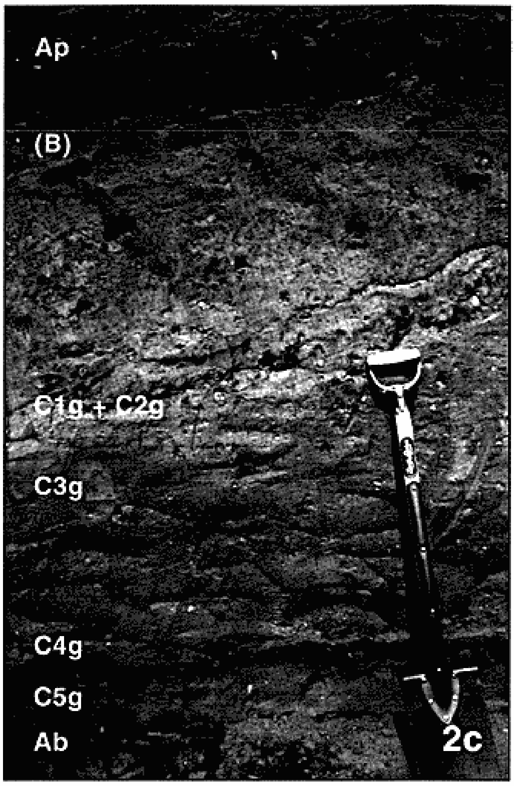

Figure 2: *Photos from the mound at Lejrskov*
a) Horisontal section of the mound just over basis. The wet core appears bluish grey surrounded by the brownish mantle. Photo: K. Prangsgaard.
b) Vertical section through part of the mound.
c) Soil profile of the mound including the Ab-horizon from the buried soil.
d) The edge of the iron pan where the lower and upper iron pans are conjuncted.

Below the mound a 15–20 cm thick buried A-horizon was identified. It was delimited from the mound fill by a thin, continuous layer of plant remnants similar to the layers defining the turves of the core. In this A-horizon sometimes on the border to the mound core an up to 8 cm thick, continuous and strongly cemented iron pan was found. It had an undulating surface and formed the lower border of the bluish grey soil. Directly above the pan, small areas with very wet, olive-green soil could be found, and in a few places vivianite was also observed. About 1 meter outside the border of the lower construction stage the iron pan made a rounded bend upwards and started to incline inwards following the upper border of the colour transition zone between the grey-bluish mound core and the brownish mantle. After a short distance of 1–2 m the iron pan was split up into several parallel horizontal discontinuous pans spread out through the 30–40 cm thick colour transition zone above the lower construction stage (fig. 2).

The mound at Lejrskov in this way corresponds closely to the classic oaken log coffin mounds: A wet bluish core with remarkable conditions of preservation totally surrounded by iron pans and overlain by a dry brownish mantle.

Soil sampling and analysis

Soil samples were taken at different depths from the exposed mound section (fig. 2). One sample was taken from the modern ploughlayer, one from the upper part of the mantle, and one from the soil between the different discontinuous upper iron pans in the so-called colour transition zone. As regards the mound construction sequence, the latter sample also belongs to the upper construction stage. One sample was taken from the discontinuous upper iron pans, one sample was taken from the upper and one from the lower part of the bluish core, i.e. the lower construction stage. The lower iron pan was represented by one sample as was the buried A-horizon underneath the core. Also a sample of the olive-green soil directly above the iron pan was collected. Finally seven samples were taken at different levels from the subsoil down to a depth of 205 cm below the surface of the buried A-horizon. With 160 cm of mound fill the profile section measured altogether 365 cm in height. Soil samples for bulk density determinations were collected in tubes of 100 cm^3 volume.

In the soil laboratory particle size analyses were carried out using sieving for determining the sand fractions and the Andreasen pipette method for determining the silt and clay fraction. The organic matter content was determined by a LECO-carbon analyzer (Tabatabei & Bremner 1970). By this method the samples are burned at 1600°C, the organic matter will decompose and the amount of carbon dioxide produced is determined by the use of infrared light. The organic matter content is calculated under the assumption that carbon makes up 58% of the organic matter content. pH is determined potentiometrically in a suspension of 10 g of soil and 25 ml 0.01M $CaCl_2$.

The total amounts of non-silicate bound iron, manganese and aluminium were determined by extraction with dithionite-citrate. The principle of this method is to reduce the iron and manganese by dithionite, and hereafter citrate is used to form complexes with iron, manganese and aluminium. 5 g of soil is shaken over night in a 100 ml dithionite-citrate solution. After centrifuging the content of iron, manganese and aluminium was determined in the supernatant liquid by AAS. The dithionite-citrate solution consisted of 20 g sodium dithionite and 100 g sodium citrate in one litre of water. The amount of organic bound iron, manganese and aluminium was determined by extraction with sodium pyrophosphate by shaking 5 g of soil over night with 200 ml 0.1 M sodium pyrophosphate. After centrifuging the content of iron, manganese and aluminium was determined on the supernatant liquid by AAS.

Exchangeable bases Ca, Mg, K and Na were determined by extraction with 1M NH_4-acetate. The samples were shaken for two hours in 1M NH_4-acetate and filtered into a beaker. The samples are then washed 12 times with small amounts of 1M NH_4-acetate, every time filtered down into the bowl. The bowl is filled with 1M NH_4-acetate to a specific volume and Ca and Mg of the solution are determined by ASS and K and Na by FES.

Results and discussion

Parent material for the soil forming processes

The particle size analysis and organic matter content of the different samples are shown in table 1. The mound consists of a sediment with a clay content varying between 2,9 and 7,1%. The silt content lies between 14,1 and 18,2% and the sand ranges from 74,7 to 82,9%. All samples can be classified as loamy sand. The texture of the iron pans must be

Table 1: *Texture and organic matter content. Figures in percentage.*

	Sample depth/cm	***< 2 µm***	***2-20 µm***	***20-63 µm***	***63-125 µm***	***125-250 µm***	***250-500 µm***	***500-2000 µm***	***Organic matter***
Ap Plough layer	0-21	4.1	5.0	10.7	6.0	24.0	32.6	17.6	1.31
(B) Upper mantle	21-56	2.9	4.2	14.8	8.4	23.3	30.5	15.9	0.72
C1g Lower mantle	56-88	3.0	3.9	10.2	4.5	22.5	33.6	22.3	0.36
C2g Upper iron pan	56-88	3.1	3.7	10.1	5.5	20.8	32.3	24.5	0.57
C3g Upper core	88-115	3.1	4.7	11.8	6.6	23.7	31.3	18.8	1.55
C4g Lower core	115-154	7.1	6.9	11.3	5.7	19.9	28.7	20.4	2.03
C5g Lower iron pan	154-160	0.0	4.9	14.0	6.7	22.9	33.1	18.4	2.37
Buried Ab	160-175	3.0	4.3	9.7	4.5	20.3	35.2	23.0	0.58
Buried C1b	175-186	0.1	0.0	2.6	0.9	17.5	50.9	28.0	0.26
Buried C2b	186-214	1.7	1.1	1.3	1.3	20.5	43.8	30.3	0.21
Buried C3b	214-230	3.8	3.1	17.7	37.7	35.0	2.7	0.0	0.21
Buried C4b	230-277	0.3	0.2	0.7	10.0	68.3	20.5	0.0	0.26
Buried C5b	277-310	1.9	0.5	1.7	2.2	30.2	41.4	22.1	0.14

considered with some reservations as the strong cementation hindered a total dispersion of the samples. This accounts for the total lack of clay in the lower iron pan. The texture class of the buried soil varies between loamy sand and sand.

There is very little variation in the texture composition of the different samples of the mound. Furthermore, the texture of the mound fill closely resembles the texture of the buried A-horizon below the mound. Consequently both the core and the mantle of the mound may be considered to have been constructed of turves cut in the immediate vicinity of the mound. This result is in accordance with soil and pollen analysis from other early Bronze Age burial mounds (Breuning-Madsen & Holst 1995).

The organic matter content reflects the conditions of preservation. High values are found in the core encapsulated by the iron pan, especially in the lower part.

Soil forming processes in the burial mound

The mantle: The soil profile development in the mantle is rather weak. A distinct brown (10YR4/3 moist) plough layer overlies a slightly lighter coloured very weak structural (B) horizon. Remnants of the vegetation layers of the turves comprising the mantle were present locally showing that bioturbation has not strongly influenced the profile development. This is probably the result of soil erosion which has truncated or completely removed the original soil profile. The erosion was initiated when the burial mound was incorporated in the normal agricultural rotation system which probably happened a few hundred years ago. Soil erosion is an ongoing process in ploughed-over burial mounds, in some cases removing several metres of soil and causing severe damage. In this way many mounds have almost disappeared (Kristiansen 1985). The mound being studied was known originally to have been more than 4 m high (Prangsgaard 1996).

The lower part of the mantle below the (B)-horizon is interpreted as a Cg-horizon. It is a yellowish brown horizon with many discontinuous reddish brown (5YR 4/5 moist) iron bands. They have been formed by gley processes, see below. The soil is classified as an Anthrosol according to FAO-Unesco (1990) as it is developed in a man-made sediment. Anthrosols are subdivided into four groups: Aric Anthrosols showing remnants of diagnostic horizons due to deep ploughing, Fimic Anthrosols with more than 50 cm deep A-horizons, Cumulic Anthrosols showing accumulation of fine sediments, and Urbic Anthrosols developed in waste from mines or urban fills. The soil does not fit into any of the four subgroups. Except for Histosols and Anthrosols, all soil types defined in FAO-

Unesco (1990) have a name (Haplic or Eutric) for soils not fitting into one of the specific defined subgroupings. In that way it will always be possible to classify the soils to subgroup level. A fifth subgroup for Anthrosols is therefore proposed, Haplic Anthrosols.

The core: The most distinct pedological process in the core is the formation of thin iron pans encapsulating the wet anaerobic core. The transportation and precipitation of iron in thin pans can have occurred as a result of podzolisation or reduction/oxidation process (gley-formation).

Podzolisation is characterized by a translocation of iron, aluminium and organic acid complexes from the topsoil to the subsoil where they are precipitated, forming a spodic horizon. A typical podzolised soil is thus characterized by a horizon sequence with mor layer on the surface, a greyish eluvial albic E-horizon in the uppermost part of the mineral soil followed by an illuvial spodic B-horizon enriched in Al, Fe and humus.

If podzolisation is responsible for the formation of the iron pans there will be a marked increase of organic matter and organic bound iron and aluminium in the iron pan. Manganese is not translocated by podzolisation, and should consequently not show marked changes. According to Soil Survey Staff (1975) and FAO-Unesco (1990) the pyrophosphate-extractable iron and aluminium (Fe_p and Al_p) should account for more than half of the dithionite-citrate extractable iron and aluminium (Fe_d and Al_d):

$$Fe_d + Al_d < 2(Fe_p + Al_p)$$

This is based on the general assumption that the dithionite-citrate extraction of iron and aluminium gives the total amount of non-silicate iron and aluminium in the soil, while the extraction with pyrophosphate gives a figure for the organic bound iron and aluminium.

Reduction/oxidation processes (gley-formation) occur under anaerobic conditions, where iron is reduced from ferric-iron (Fe^{3+}) to ferrous-iron (Fe^{2+}) and manganese from Mn^{4+} to Mn^{2+}. Fe^{2+} and Mn^{2+} are more soluble than Fe^{3+} and Mn^{4+} and will move by diffusion and follow the water flow in the soil. On reaching aerobic areas the iron and manganese will be oxidized and precipitated as iron(III) and manganese(IV)oxides. The anaerobic parts of the soil will often appear greyish, sometimes with bluish and greenish shades if the iron content is high.

If the iron pans of the Lejrskov mound are the result of gley-formation there should be a marked maximum of dithionite-extractable iron and manganese in the pan, and the dithionite-citrate values should be considerably larger than the pyrophosphate. Aluminium and humus are not translocated by oxidation/reduction-processes, and they should consequently not have a maximum in the pan.

Table 2 shows the results of the chemical analyses of the different samples from the mound, the iron pans and the subsoil below. There is a marked increase in the amount of dithionite-extractable iron and manganese in both the upper and the lower iron pans. The maximum is most distinct in the lower pan in agreement with the fact that this pan was far stronger and more cemented than the discontinuous upper pan. The values for dithionite-citrate extractable aluminium do not increase in the pans. Values for the pyrophosphate extraction vary slightly down through the profile and for aluminium and manganese no distinct maxima can be distinguished. Iron shows minor maxima in both the upper and the lower iron pan, but the pyrophosphate values are far less than half the dithionite-citrate values. Except for the general increase of organic matter content towards the base of the mound core where conditions of preservation are better, no accumulation of organic matter can be seen in the profile. Hence the chemical analyses unambiguously demonstrate that the iron pans of the Lejrskov barrow exclusively are the result of a gleying process. This is also in accordance with the visual and physical appearance of the mound section, which has none of the characteristics of the podzol profile. On the contrary both the wetness and the bluish grey and olive- green colours of the core indicate anaerobic conditions, as does the presence of vivianite. Furthermore the olive-green soil directly above the lower iron pan was tested with α,α-dipyridyl, which reacts with ferrous-iron by development of a pronounced pink colour. The result was positive.

On the basis of the chemical analyses it is possible to outline the course of events which led to the formation of the iron pans in the Lejrskov mound. The process must have begun with the rise of wet conditions in the mound, which hindered the access of oxygen to the soil. Subsequently, decomposition of the turves caused oxygen depletion and a fall in the redox potential. This led both to a reduction of iron and manganese in the core and to a halt in the decomposition of organic matter.

As clearly demonstrated by the remarkable conditions of preservation, this must have happened only shortly after the construction of the mound. Otherwise the organic ma-

Table 2: pH, Sodium-pyrophosphate-soluble and dithionite-citrate-soluble Fe, Al and Mn.

	pH($CaCl_2$)	***Pyrophosphate extractable***			***Dithionite-citrate extractable***			***Organic mattter***
		% Fe	***% Al***	***% Mn***	***% Fe***	***% Al***	***% Mn***	***%***
Ap Plough layer	6.35	0.12	0.09	0.00	0.37	0.09	0.03	1.31
(B) Upper mantle	4.50	0.12	0.08	0.00	0.43	0.09	0.03	0.72
C1g Lower mantle	4.05	0.08	0.07	0.00	0.11	0.05	0.00	0.36
C2g Upper iron pan	4.15	0.23	0.10	0.01	2.06	0.18	0.20	0.57
C3g Upper core	4.25	0.13	0.08	0.01	0.21	0.12	0.01	1.55
C4g Lower core	4.50	0.17	0.06	0.04	0.32	0.06	0.05	2.03
C5g Lower iron pan	4.80	0.93	0.05	0.01	4.85	0.12	0.31	2.37
Buried Ab	4.50	0.13	0.07	0.01	0.47	0.08	0.05	0.58
Buried C1b	4.60	0.07	0.09	0.01	0.26	0.11	0.02	0.26
Buried C2b	4.20	0.07	0.09	0.00	0.24	0.08	0.02	0.21
Buried C3b	4.10	0.06	0.06	0.00	0.26	0.06	0.02	0.21
Buried C4b	4.70	0.04	0.04	0.00	0.18	0.04	0.01	0.26
Buried C5b	4.20	0.07	0.06	0.00	0.19	0.05	0.02	0.14

terial would have decomposed to a much larger degree. It must be assumed that it is primarily the anaerobic conditions which have ensured the preservation of the organic material, though it cannot be excluded that special chemical conditions in the mound also have been of some importance. In any case, the pH-values (table 2) do not suggest that organic acids in the core have influenced the preservation decisively as Gripp (1942) supposed.

The iron pans precipitated on the boundary between anaerobic and aerobic soil. The very clear delimitation of the lower iron pan shows that there must have been a very distinct border between aerobic and anaerobic conditions below the mound, whereas the discontinuity and scattering of the upper pan indicate a blurred transition between aerobic mantle and anaerobic core.

How the wet conditions in the core arose is still somewhat unclear. We can suggest two main hypotheses:

1: In the first hypothesis it is assumed as point of departure, that the wet conditions came into existence after the construction of the mound was completed. This would most likely have happened as a result of a period with a large surplus of precipitation. Somehow the core was constructed in a way so that it impeded the flow of infiltration water through the mound leading to relatively wet and consequently anaerobic conditions in the central parts of the mound. Perhaps the laying of the turves in horizontal layers was sufficient. A careful compaction of the turves in the core would also have increased the probability of anaerobic conditions arising in the central parts of the mound, though such a compaction was not reflected in the bulk density determinations (table 3).

2: The second hypothesis is based upon the assumption that the wet conditions partly arose during the construction of the core or at least before the mantle was erected. This could have happened as a result of intense precipitation but possibly also through human intervention, as water may have been used to create a very stable mound core, around and upon which the mantle subsequently was erected. Irrigation of the mound might also have served ritual purposes. The construction of the mantle of dry material must have followed shortly after the core was completed as indicated by the conditions of preservation and the lack of a well developed soil profile and vegetation cover on top of the core.

In Lejrskov there are no direct indications of the mound core having been wetted prior to the construction of the mantle. However, at a number of other Bronze Age burial mounds water deposited sediments on the sides of mound cores and on the old surface outside the cores have been observed (Jørgensen 1984, Aner & Kersten 1973).

After the wet conditions had arisen in the core, the subsequent course of events seems to follow the same scheme independently of which of the two above mentioned hypotheses are correct.

In the wet core iron and manganese would be reduced and start following the flow of the water. As the subsoil poor in organic material remains aerobic, a lower iron pan would start to develop around the border between the mound and the subsoil. As the pan hindered the drainage of water under the central parts of the mound the continued supply of infiltration water would start flowing outwards, extending the lower iron pan.

At a certain distance from the edge of the mound the influx of oxygen kept the mound fill aerobic, and instead of expanding horizontally the iron pan would here develop along an inwards inclining boundary line forming a conic bowl (fig. 2). Though displaced slightly into the upper construction stage the pan in Lejrskov seems to follow the boundary between the lower construction stage with horizontally placed turves and the upper stage with sloping turves, indicating that a difference in the construction of the core and the mantle might be of decisive importance for the genesis of the upper iron pan.

As the iron pans were impermeable, water accumulated in the core of the mound and formed a relatively stable wet environment. In dry periods water from the core was transported by suction up into the dry, aerobic mantle and iron precipitated as ironoxides. However, since the transition from aerobic to anaerobic conditions was diffuse and fluctuated in level a fully cemented pan was not precipitated but several weak discontinuous and partially cemented pans were developed.

Table 3: Bulk density for selected horizons (g/cm^3).

Ap Plough layer	1.30
(B) Upper mantle	1.38
C1g Lower mantle	1.39
C3g Upper core	1.31
C4g Lower core	1.27
Buried Ab	1.31

Contrary to what Gripp (1942) suggested, it is clear that when once formed the iron pans, both the upper and the lower, remain stable.

The buried soil

The buried soil is developed in medium sand, slightly more uniform in grain size than the material making up the burial mound. The soil profile records soil development from the Weichsel Glaciation until the Bronze Age and the chemical composition of soils in the Bronze age as the formation of the lower iron pan shortly after the erection of the mound has prevented further leaching of the buried soil. Furthermore groundwater does not seem to have influenced the soil formation because no mottling or other hydromorphic features indicating gleying were observed.

The uppermost 15 cm of the soil profile is a dark yellowish brown (10YR 4/6 moist) ochric A horizon containing slightly more than 0.5 percent of organic matter. In the Bronze Age this was probably somewhat higher, but it has since decreased through decomposition. The A horizon can be described as a plough layer even though only an ard has been used for mechanical tillage of the soil. Below a yellowish brown (10YR 5/6 moist) (B)-horizon is found. The colour is lighter than in the A-horizon partly as a result of a lower organic matter content. Below the (B)-horizon various C-horizons are present, distinguished from each other mainly on differences in texture. All C-horizons have very low organic matter contents and the colours vary between yellowish brown, light yellowish brown and brownish yellow.

The soil profile is acid, pH is below 5 in all horizons. This shows that already in the Bronze Age leaching of the soil was pronounced, at least in freely drained sandy soils. Table 4 shows the exchangeable bases from selected horizons in the buried soils and in the mantle. In the buried soil calcium is the dominant exchangeable base accounting for about two third of the bases. Mg accounts for about one fifth of the exchangeable bases, Na slightly more than 10% while K accounts for about 5%. Similar relative values are found for samples in the mound except for the modern plough layer. Here liming has changed the composition of exchangeable bases, and Ca accounts for more than 80% of these, none of the other base cations amounts to more than 8%. The relative composition of exchangeable bases in the buried soil does not fit well with modern limed plough layers but fits rather well with the present chemical composition of non-arable sandy soils (Madsen 1983).

Table 4: Exchangeable bases in the mantle and in the buried soil from the Bronze Age.

Horizons	*Ca cmol +/kg*	*Mg cmol + /kg*	*Na cmol +*	*K cmol + /kg*
Ap Plough layer	3.95	0.40	0.13	0.30
Clg Lower mantle	0.56	0.17	0.10	0.11
Buried Ab	0.75	0.19	0.13	0.07
Buried (B)	0.38	0.14	0.09	0.05

The buried soil does not show any sign of podzolisation, neither morphologically nor analytically, even though the texture, the acidity and the low content of dithionite-citrate soluble iron and aluminium favour this profile development. There is no bleached E-horizon or spodic horizon visible in the profile and the dithionite-citrate soluble iron and aluminium and the organic matter content show no clear local maximum in any of the subsurface horizons. Furthermore the content of pyrophosphate soluble iron and aluminium is much lower than the dithionite-citrate soluble iron and aluminium which should not be the case if a podzolisation process has occurred (Table 2). The reason for the absence of podzolisation might be the vegetation cover. Beech forest and heather vegetation which favour the podzolisation process were not so common in the Bronze Age as in more recent periods like the Iron Age and the Viking age. Thus podzolisation were not as extensive in the Bronze Age as in the later periods. On the other hand Christensen's investigation (Broholm & Hald 1939) of the Skrydstrup mound reveals that podzolisation can occur in the Bronze age. Using the FAO-Unesco key (1990) the buried soil profile at Lejrskov would be classified as an Albic Arenosol because of the sandy texture, an ochric A-horizon and albic colours in some of the C-horizons within 125 cm of the surface.

Conclusion

This investigation shows that the soil development in the uppermost part of the burial mound, the mantle, is very weak probably as a result of soil erosion after the burial mound was incorporated in the normal agricultural rotation system. The iron pans surrounding the core of the mound were formed by reduction/oxidation processes. The development of the iron pans must have occurred immediately after the construction of the mound as almost fully preserved plant remnants were found in the lower part of the wet core. The reason for the formation of the wet core surrounded by iron pans is not yet understood but probably it could be related to the way the barrow was constructed. The formation of the lower iron pan has preserved an almost intact Albic Arenosol from the Bronze Age below the mound. This profile was sandy and acid, showing strong leaching. There were no morphological features or analytical data indicating podzolisation.

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Table 4: Exchangeable bases in the mantle and in the buried soil from the Bronze Age.

Horizons	*Ca* cmol +/kg	*Mg* cmol + /kg	*Na* cmol +	*K* cmol + /kg
Ap Plough layer	3.95	0.40	0.13	0.30
Clg Lower mantle	0.56	0.17	0.10	0.11
Buried Ab	0.75	0.19	0.13	0.07
Buried (B)	0.38	0.14	0.09	0.05

The buried soil does not show any sign of podzolisation, neither morphologically nor analytically, even though the texture, the acidity and the low content of dithionite-citrate soluble iron and aluminium favour this profile development. There is no bleached E-horizon or spodic horizon visible in the profile and the dithionite-citrate soluble iron and aluminium and the organic matter content show no clear local maximum in any of the subsurface horizons. Furthermore the content of pyrophosphate soluble iron and aluminium is much lower than the dithionite-citrate soluble iron and aluminium which should not be the case if a podzolisation process has occurred (Table 2). The reason for the absence of podzolisation might be the vegetation cover. Beech forest and heather vegetation which favour the podzolisation process were not so common in the Bronze Age as in more recent periods like the Iron Age and the Viking age. Thus podzolisation were not as extensive in the Bronze Age as in the later periods. On the other hand Christensen's investigation (Broholm & Hald 1939) of the Skrydstrup mound reveals that podzolisation can occur in the Bronze age. Using the FAO-Unesco key (1990) the buried soil profile at Lejrskov would be classified as an Albic Arenosol because of the sandy texture, an ochric A-horizon and albic colours in some of the C-horizons within 125 cm of the surface.

Conclusion

This investigation shows that the soil development in the uppermost part of the burial mound, the mantle, is very weak probably as a result of soil erosion after the burial mound was incorporated in the normal agricultural rotation system. The iron pans surrounding the core of the mound were formed by reduction/oxidation processes. The development of the iron pans must have occurred immediately after the construction of the mound as almost fully preserved plant remnants were found in the lower part of the wet core. The reason for the formation of the wet core surrounded by iron pans is not yet understood but probably it could be related to the way the barrow was constructed. The formation of the lower iron pan has preserved an almost intact Albic Arenosol from the Bronze Age below the mound. This profile was sandy and acid, showing strong leaching. There were no morphological features or analytical data indicating podzolisation.

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