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Cultural landscapes and cultivation in the Haugesund/Karmøy region from the Iron Age through to 1800 AD

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Introduction

The Avaldsnes area is rich in archaeology and named as a royal manor of Harald Fairhair (850 – 932 AD) in Snorri Sturluson's Heimskringla written a few hundred years after his death. Avaldsnes has clearly been an area of political importance for thousands of years, not only in the Karmsund, but also in the whole of Norway. The archaeology and the historical sources mean that we already know much about the regions cultural history but we have no information about how this history shaped the landscape. Human practices, such as the need for timber for ships and buildings and supplying food for people and animals, all help shape the landscape by changing forests, agricultural lands, coastal vegetation, lakes and bogs. The landscape and vegetation may also have looked very different to a farmer in the Roman Iron Age than it did to someone working on Harald Fairhairs farm and supplying food to his household. The new royal household may also have had different requirements causing farming practices to change. Some earlier work on the local vegetation has been completed from archaeological sites on Husøy (Lindblom, et al., 1997) but this is the first long-term study of this area and attempts to reconstruct landscape changes over the past 2000 years.

This initial work focusses on a lake site, Bøvatn, located less than 2 km north of Avaldsnes church and was designed to gain an overall image of landscape changes whether due human influence, climate or other natural processes. Such palaeobotanical reconstructions from lakes surrounded by bogs are not usually expected to give detailed information on changes in local cultivation practices as they are 'off-site'. relative to the worked fields. This often needs further work on a site as close as possible to the cultivated fields or grazed/mown areas. Recent work at a site c. 60 km north of Avaldsnes at Fitjar on Stord, Hordaland has applied this model looking at changes since c. 5,300 BC and examining for example, changes in mowing practices (Overland and Hjelle, 2009). This site was also mentioned in Snorri Sturluson's sagas as a Viking Age royal farm during the reign of King Håkon (933 – 960 AD).

Figure 1. Bøvatn in summer (June 2011) and late winter (March 2012).

Background *(Figures 1 and 2)*

Lakes and bogs store information in their sediments about past vegetation, climate, land use etc. Much of this information describes landscapes within a few tens of kilometres around the lake and any changes can be revealed from extracting, dating and analysing the sediments. Bøvatn is a c. 320 x 230 m basin of which c. 140 x 110 m is a lake with a surrounding bog (Fig. 1). It shows a classic sequence of lake infilling. Lakes usually have a deeper zone, often but not always in the centre, and sloping edges to the banks. Sediments from both within the lake generated by organic and inorganic productivity (autochthonous) and from external to the lake by erosion of soils or input of plant material (allochthonous), gradually fill up the lake basin. As the water becomes shallower around the edges, the lake itself becomes smaller, often with a fringe of bog around it. The

Figure 2. Bøvatn showing basin and lake surface morphology, core transecct and core positions. The analysed core, BØ8, is marked by a red circle.

deepest part of the Bøvatn basin lies off centre to the south and the areas to the north have gradually become peat. The core collected will therefore show this transition with a change from lake sediments (also known at gyttja) to bog sediments (peat).

Table 1. Core position GPS coodinates.

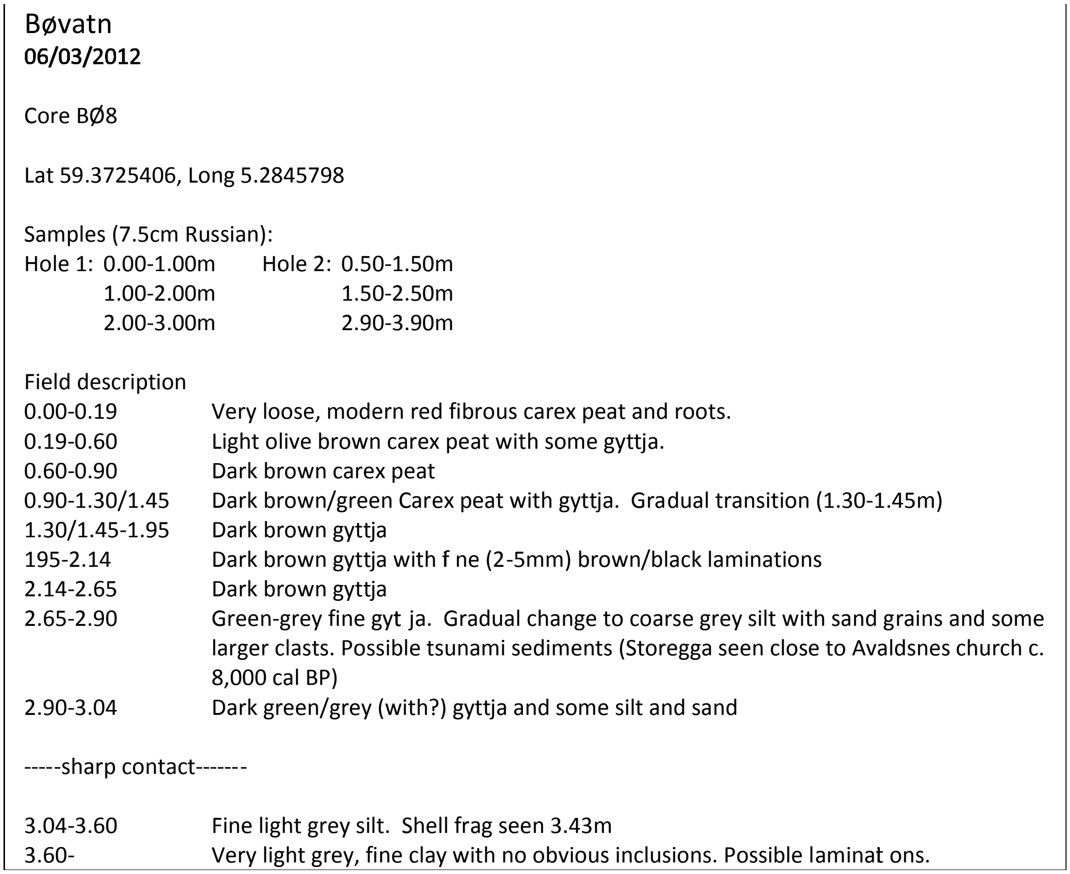
Core	Lat	Lon	Date and time
Bovatn 1	59.3729	5.2843	06-MAR-12 11:13:55
Bovatn 2	59.3731	5.2842	06-MAR-12 11:21:43
Bovatn 3	59.3730	5.2842	06-MAR-12 11:24:29
Bovatn 4	59.3730	5.2843	06-MAR-12 11:29:34
Bovatn 5	59.3728	5.2844	06-MAR-12 11:37:18
Bovatn 6	59.3727	5.2845	06-MAR-12 11:47:29
Bovatn 7	59.3726	5.2846	06-MAR-12 11:54:36
Bovatn 8	59.3725	5.2846	06-MAR-12 11:58:42
Bovatn 9	59.3725	5.2847	06-MAR-12 12:01:34

Fieldwork and sediment description *(Figures 2 - 6 and Table 1)*

Fieldwork was carried out in March 2012 with the drilling of a borehole transect running between the lake and out to the edge of the bog towards the road (Figs.2, 3 and Table 1). The transect was designed to locate the optimal position on the bog which would retrieve the best possible core for analysis. Coring was

Figure 3. Coring Bøvatn March 2012

Figure 4. Section of retrieved core from BØ8.



Bøvatn

06/03/2012

Core BØ8

Lat 59.3725406, Long 5.2845798

Samples (7.5cm Russian):

Hole 1:	0.00-1.00m	Hole 2:	0.50-1.50m
	1.00-2.00m		1.50-2.50m
	2.00-3.00m		2.90-3.90m

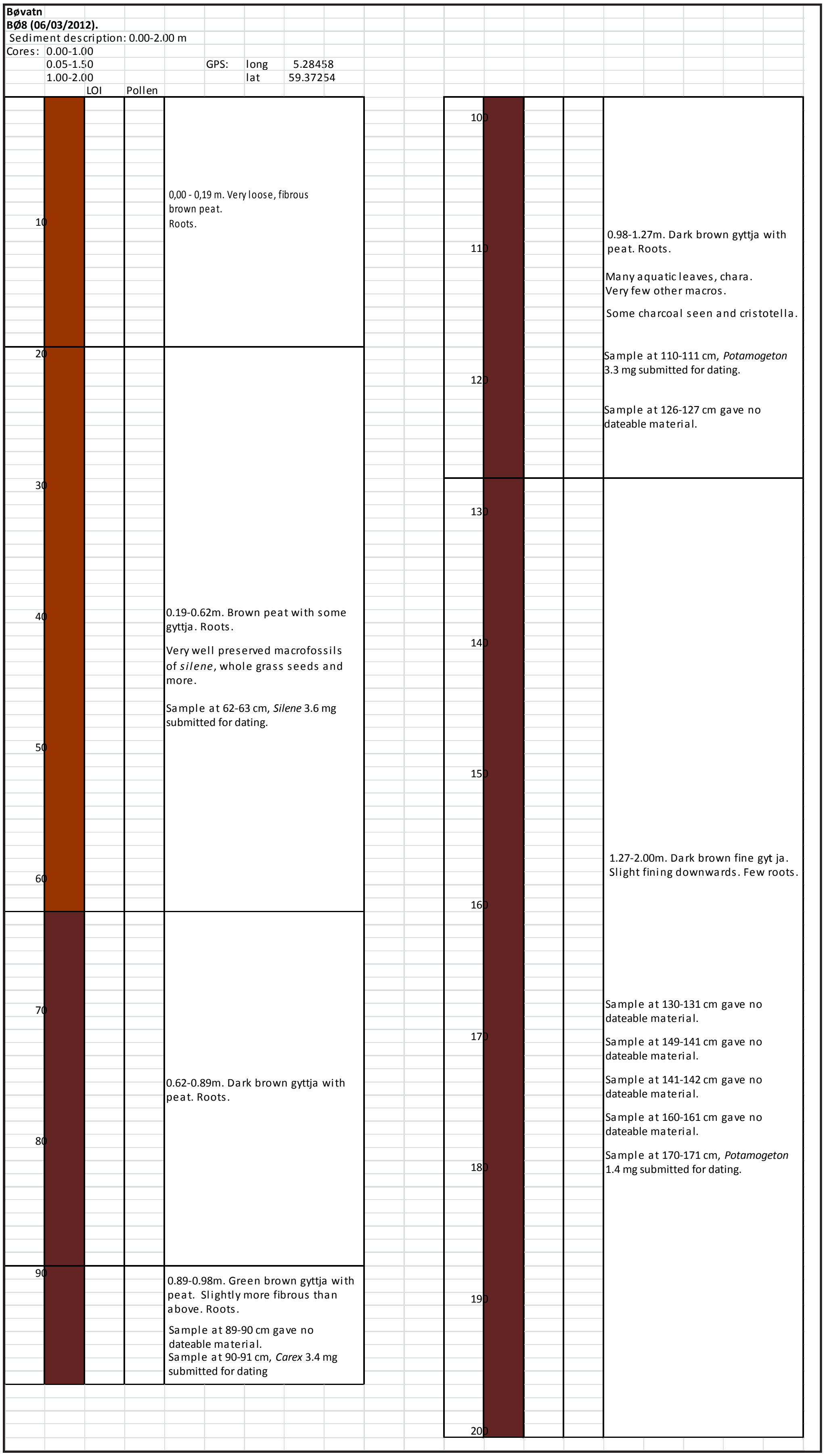
Field description

0.00-0.19	Very loose, modern red fibrous carex peat and roots.
0.19-0.60	Light olive brown carex peat with some gyttja.
0.60-0.90	Dark brown carex peat
0.90-1.30/1.45	Dark brown/green Carex peat with gyttja. Gradual transition (1.30-1.45m)
1.30/1.45-1.95	Dark brown gyttja
195-2.14	Dark brown gyttja with fine (2-5mm) brown/black laminations
2.14-2.65	Dark brown gyttja
2.65-2.90	Green-grey fine gyttja. Gradual change to coarse grey silt with sand grains and some larger clasts. Possible tsunami sediments (Storegga seen close to Avaldsnes church c. 8,000 cal BP)
2.90-3.04	Dark green/grey (with?) gyttja and some silt and sand

-----sharp contact-------

3.04-3.60	Fine light grey silt. Shell frag seen 3.43m
3.60-	Very light grey, fine clay with no obvious inclusions. Possible laminations.

Figure 5 Field description of BØ8 core.



Bøvatn
BØ8 (06/03/2012).
Sediment description: 0.00-2.00 m
Cores: 0.00-1.00
0.05-1.50
1.00-2.00

GPS:	long	5.28458
	lat	59.37254

0,00 - 0,19 m. Very loose, fibrous brown peat.
Roots.

0.19-0.62m. Brown peat with some gyttja. Roots.

Very well preserved macrofossils of *silene*, whole grass seeds and more.

Sample at 62-63 cm, *Silene* 3.6 mg submitted for dating.

0.62-0.89m. Dark brown gyttja with peat. Roots.

0.89-0.98m. Green brown gyttja with peat. Slightly more fibrous than above. Roots.

Sample at 89-90 cm gave no dateable material.
Sample at 90-91 cm, *Carex* 3.4 mg submitted for dating

0.98-1.27m. Dark brown gyttja with peat. Roots.

Many aquatic leaves, chara.
Very few other macros.

Some charcoal seen and cristotella.

Sample at 110-111 cm, *Potamogeton* 3.3 mg submitted for dating.

Sample at 126-127 cm gave no dateable material.

1.27-2.00m. Dark brown fine gytja.
Slight fining downwards. Few roots.

Sample at 130-131 cm gave no dateable material.

Sample at 149-141 cm gave no dateable material.

Sample at 141-142 cm gave no dateable material.

Sample at 160-161 cm gave no dateable material.

Sample at 170-171 cm, *Potamogeton* 1.4 mg submitted for dating.

Figure 6. Lab description of BØ8 core showing horizons of samples for radiocarbon dating

achieved by using a Russian sediment corer with a 7.5 cm chamber. Sediment type and sedimentation rate changes affecting pollen deposition were avoided by selecting a core position which contained as much of the last 2000 years in the lake sediments. The core selected (BØ8) was located c. 15 m from the lake edge and showed no visible signs of disturbance (Fig.4). The shift between lake and peat sediments was positioned at 62 cm depth. Some sedimentary disturbance was seen in the cores positioned close to road. The core sediments were described relative to depth in the field (Fig. 5) and later in the laboratory (Fig.6).

The analysis was designed to cover the most recent 2000 years and the core was described and sampled with this aim. This is difficult prior to the completion of radiocarbon dating but in this case succeeded and the analysis covers from present day through to 200 AD. The sediment descriptions, magnetic susceptibility, loss-on-ignition begins at 200 AD and the pollen analysis begins at 313 AD. The upper c. 40 cm of the core consisted of very loose, wet peat and could not be sampled in a way which would ensure the stratigraphic integrity of the sediment and would require retrieval with a freeze core. The sediment core was therefore analysed between 42 and 170 cm depth.

Radiocarbon dating *(Figures 6 - 7 and Table 2)*

The age chronology for the Bøvatn core has been constructed using AMS radiocarbon dating of plant macrofossils (Table 2. Fig. 6). Samples for dating were selected to give a reliable age-depth model and taking account of sedimentary changes. To extract the samples, 1 cm of sediment was sieved through a 250 µm mesh and plant remains were then selected using a binocular microscope. Standard procedures dictate that only terrestrial plant macrofossils are dated wherever possible, avoiding problems involving the presence of old carbon in the lake system and therefore in the aquatic plants. This is a major limitation in regions of highly calcareous material. In this case, and despite examining many samples (see Fig. 6), it was not possible to find terrestrial material below 100 cm in the core and it was necessary to submit samples of *Potamogeton* (pondweed/tjørnaks). In the case of Bøvatn, this is unproblematic due to the limited availability of calcium carbonate in the bedrock of the region.

All raw radiocarbon dates need to be calibrated to calendar years using a standard radiocarbon calibration curve (INTCAL09) which corrects for variable production of ^{14}C in the atmosphere (Table 2). All dates shown in the figures and discussed in the text are calibrated calendar years (cal AD). Simple age-depth models have been applied between the radiocarbon dates as no suggestion of sedimentation rate shifts can be seen in the core, other than the shift to peat from lake sediments (Fig. 7). This age-depth model does not include errors and

Table 2. Radiocarbon dates from Bøvatn

Lab.code	Depth (cm)	Dated material	Weight (mg)	^{14}C age (BP)	Calibrated age 2δ (AD)	δ ^{13}C
Beta 322398	62-63	Silene seeds	3.6	130 +/- 30 BP	1810 +/- 140	NA
Beta 339314	90-91	Carex seeds	3.4	830 +/- 30 BP	1210 +/- 50	-25.5 o/oo
Beta 322399	110-111	Potamogeton seeds	3.3	1170 +/- 30 BP	875 +/- 95	-26.3 o/oo
Beta 339315	170-171	Potamogeton seeds	1.4	1769 +/- 40 BP	255 +/- 125	NA

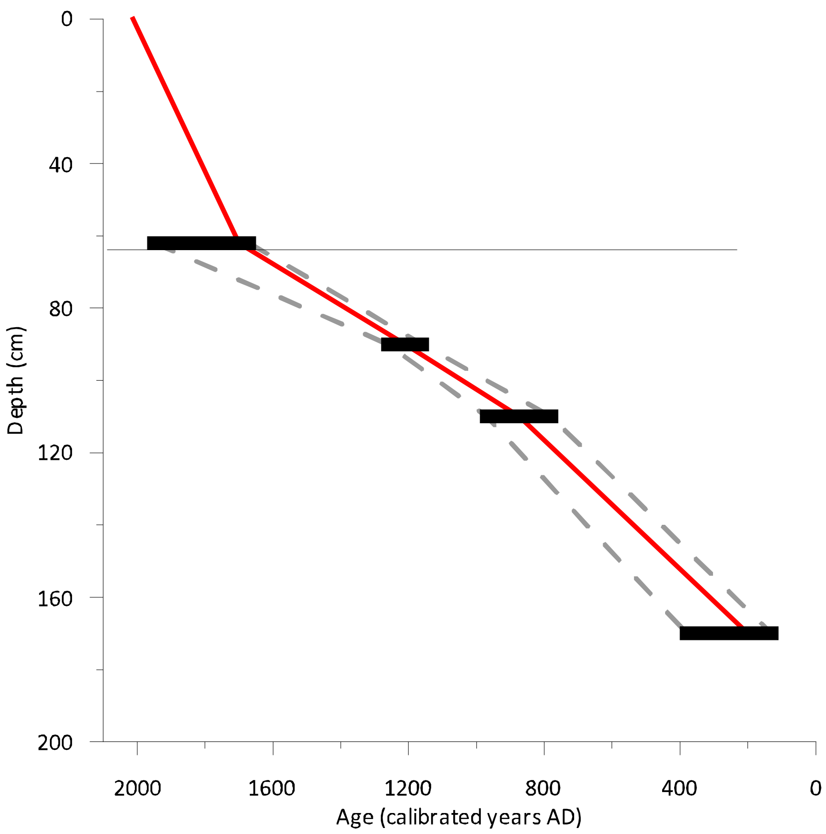


Figure 7. AMS radiocarbon ages with errors shown by black bars with grey dashed lines errors. Horizontal black line indicates change from lake sediments to peat. Red line shows age-depth model constructed in 4 linear equations: 1. Y = -0.1987 * X + 399.8205, 2. Y = -0.0571429 * X + 159.1429, 3. Y = -0.0597 * X + 162.2388, 4. Y = -0.0889 * X + 187.7778.

given ages in the text include an error relative to the calibrated error (see Table 2) and must be considered as a 'guide age'.

As can be seen on Fig. 7, an almost three-fold increase in sedimentation rate occurs at the junction between lake sediments and peat sediments. This increase is mostly due to the high water content and 'young' sediments which are not yet compacted. The lake sediments show a sedimentation rate decreasing from 0.9 mm per year (200-865 cal AD) to 0.6 mm per year (865-1700 cal AD).

Erosional indicators *(Figure 8)*

Erosion around a catchment is often tightly linked to changes in vegetation which anchor the soils. Both natural processes and human practices, for example overgrazing, can increase erosion into the lake.

A rapid assessment of erosion into a lake or bog can be gained by volume specific magnetic susceptibility (MS). This measures how much the particles in a sample can be magnetized and gives information on the minerals present in the sediment but also, and importantly in this context, information on the size of the particles in the

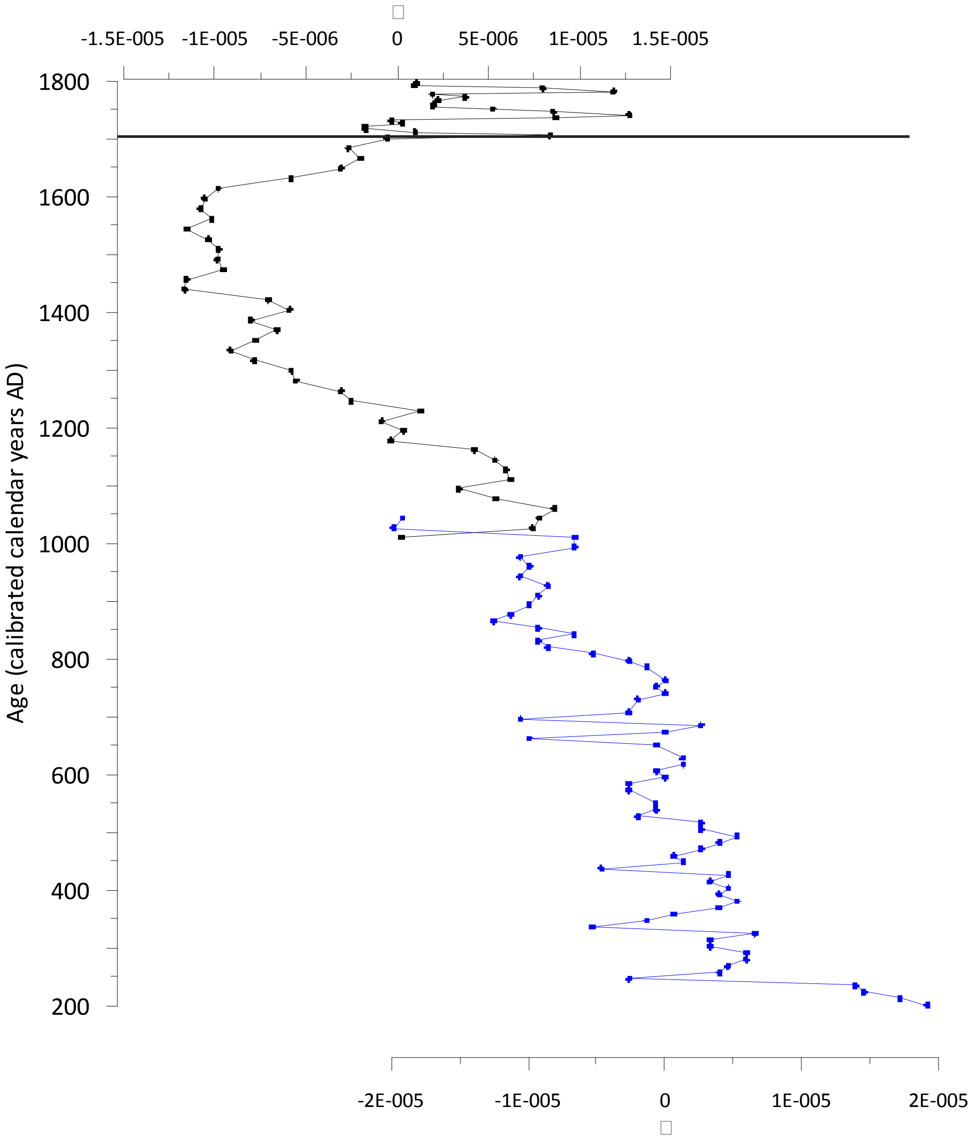


Figure 8. Magnetic susceptibility results shown in dimensionless value κ . The two different measurement runs therefore give different x-axes. The horizontal black line indicates the position of the shift from lake sediments to peat.

sediment. This method is therefore often used to supply a rapid representation of the particle size changes in a sediment core (Thompson and Morton, 1979). Finer sediment sizes, for example silt, are more susceptible to magnetization and therefore give higher values. Volume specific MS results are in dimensionless values and in this study the down core measurements of the Bøvatn core were conducted in two different runs each of which was replicated. The results are therefore shown on different scales and have been collated giving the general pattern of variation in MS down through the core to 170 cm (Fig. 8).

It is the changes in MS variability which are the most informative when interpreting MS results. The clear increase in variability after c. 1700 AD (62 cm) is mainly due to the shift from lake to bog conditions with the associated change in water content and the presence of *Equisetum* roots in the peat layers. In the lake sediments below c. 1700 AD, the combined MS curve shows particle sizes from c. 200 AD increasing through to

1700 AD. This would be expected as the lake edge creeps closer to the core position during lake infilling and coarser particle sizes become more available. Therefore the material laid down in the lower sections of the core occurred while the water depth was deeper at the core site and the water gradually became shallower. The single point measurements with low values could indicate short lived events of increased erosion but these were not seen in the duplicated results (not shown) and are more likely to represent anomalies.

The general trend does however, show some interesting deviations. For example between c. 1400 and 1600 AD (69-79 cm), a period of decreased MS could indicate an increase in average particle size possibly caused by lake infilling. But this decrease in MS/increase in particle size occurs c. 100 years prior to the shift to bog conditions and may also reflect some increased erosion and/or disturbance in the catchment.

Lake chemistry indicators *(Figure 9)*

Loss-on-ignition is a method which assesses the organic and calcium carbonate content of sediments (Boyle, 2001)(Fig. 9). The core was sampled at 1 cm intervals and each sample was weighed and oven dried at 105°C overnight, fired at 550°C for 4 hours and at 1000°C for 2 hours. The samples were weighed between each firing and the percentage of material lost calculated giving an estimate of percentage of organic and calcium carbonate content. Residue can be considered as the material not removed by firing at 1000 °C.

The organic content (OC) curve shows very stable values from 200 AD until a shift to higher OC percentages at c. 650 AD after which values are stable again until c. 1300 AD where a distinct increase is seen. These shifts do not coincide with changes in any of the other indicators and is probably reflecting geochemical changes within the lake itself. The large shift at c. 1300 AD from values around 40% to around 60% is of relevance and coincides with the major increase in wet soil herbs (vådbundsplanter) as the lake infills and the edge moves closer to the core position.

Calcium carbonate content is low throughout as would be expected due to the composition of the local bedrocks.

The shift at c. 1700 AD in organic, calcium carbonate and residue marks the onset of peat sedimentation.

Vegetation and landscape indicators *(Figures 10-14)*

Pollen analysis method and identification

The core was sampled at 1 cm resolution and samples were selected for pollen analysis at regular intervals. Each sample was prepared using standard techniques in silicone oil with the addition of Lycopodium spores to allow for the calculation of absolute pollen concentrations (Stockmarr, 1971). The samples were mounted onto glass slides and analysed at 400x, 650x and 1000x magnification using phase contrast at 1000x to aid

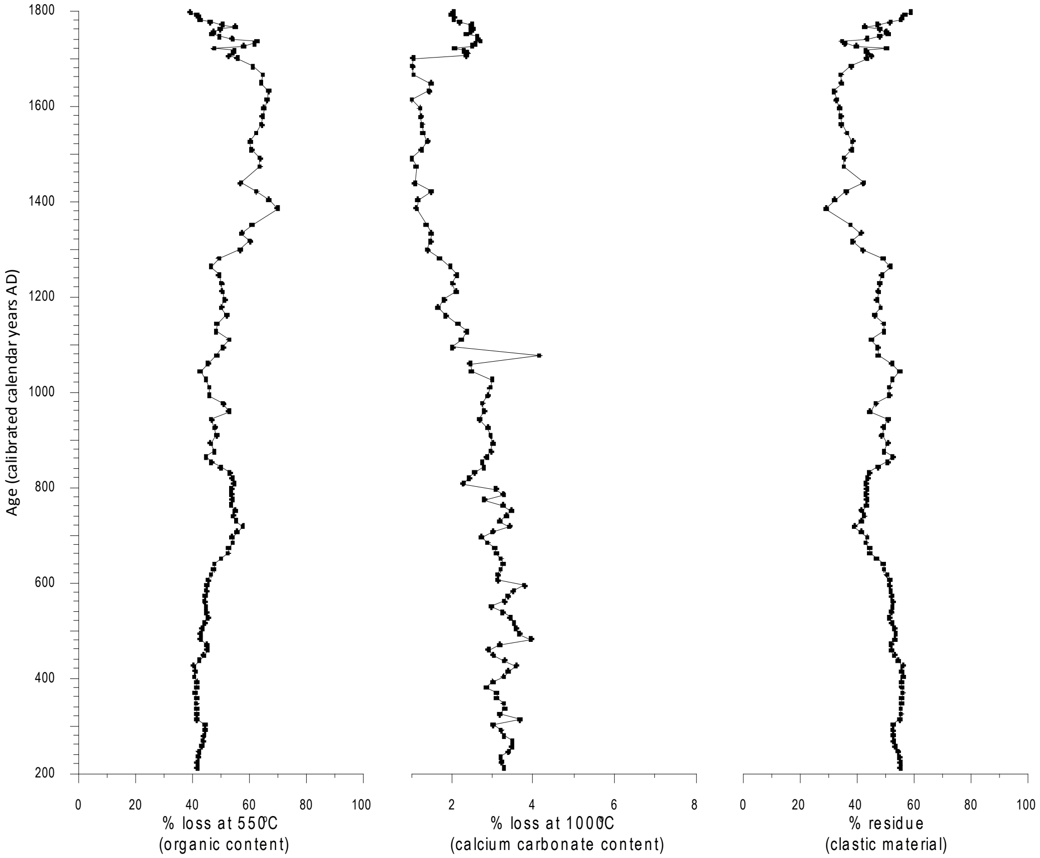


Figure 9. Loss-on-ignition data from Bøvatn. Note different 'x' axes scales.

the identification of cereal pollen grains. The identification follows Fægri & Iversen (Fægri and Iversen, 1975), Beug and Andersen for further identification of cereal pollen (Beug, 2004, Andersen, 1978) and the reference collection of the National Museum of Denmark.

Pollen grains can mostly only be identified to genus or even family level. Most are therefore shown thus but some are shown to species level where this can be confidently asserted. The many different grass taxa tend to produce pollen which are morphologically very similar and are often classified as one group (Fig. 10). Cereals are domesticated grasses but their importance in archaeological investigations has meant that their identification has been, and is still, of great interest and has been studied for many years. Rye (rug) and barley (bygg) can be relatively confidently identified but there are often difficulties in separating wheat (kveite) and oats (havre) dependent upon how well the pollen has been preserved. In this study, rye (rug) and barley (bygg) have been separated but it has not been possible to reliably separate wheat (kveite) and oats (havre).

Each sample was counted until a total of 500 terrestrial pollen grains as standard was achieved. Very low concentrations in 3 samples meant that this was not possible but over 300 terrestrial pollen grains were counted in all samples.

The full analysis results are shown as percentages of the terrestrial pollen sum (Fig.11) and as absolute

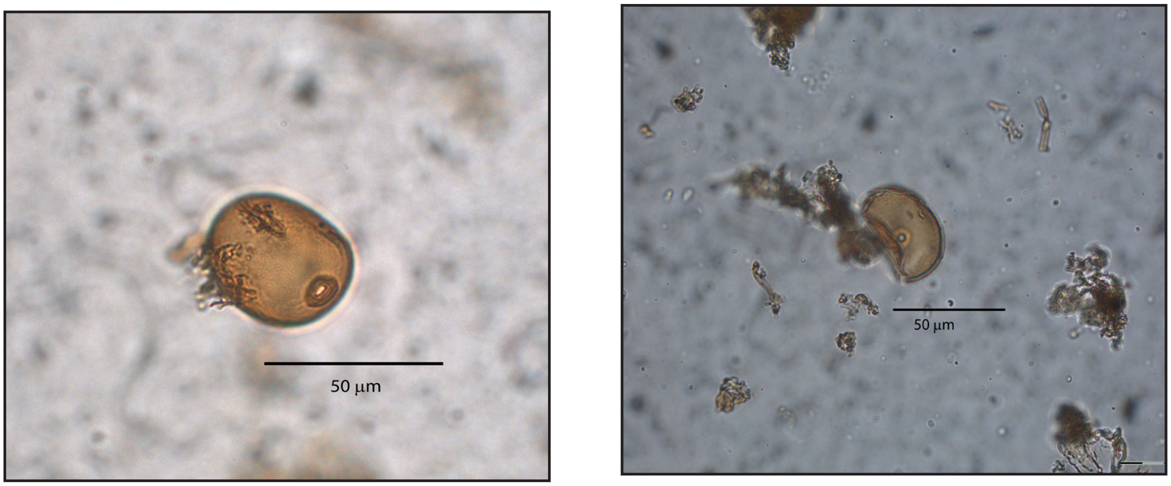


Figure 10. Cereal pollen from Bøvatn. Left: Barley (bygg) type from 140 cm depth (c. 500 AD). Right: Wheat (kveite)/ Oat (havre) type from 100 cm depth (c. 1050 AD)

concentrations (Fig. 12). Wet soil herbs (vådbundsplanter) and aquatic plants (vannplanter) are also calculated as a percentage of the terrestrial pollen sum. 'Unid' shows grains, which due to corrosion or folding etc., could not be identified. In order to highlight parts of the discussion, diagrams of important or indicator taxa have also been produced (Figs. 13 and 14). Pollen percentage diagrams show the relative composition of the vegetation, for example, how much is woodland relative to open grassland or the increase in human indicators. Pollen concentration diagrams show the absolute input of pollen of particular taxa and can indicate changes in their pollen production which is partially dictated by climatic factors.

The names of plant taxa are shown as Scientific/English/Norwegian in the figures. English common names are used in the text with Norwegian common names in brackets.

Pollen source area

As a general rule, larger lake basins collect pollen from larger areas (Hjelle and Sugita, 2012, Sugita, 1994). The size of the lake can therefore be used to give a very general estimate of the source area of the pollen preserved in its sediments i.e. the landscape the pollen represents. The present lake at Bøvatn is c. 140 x 110 m which can be estimated to have relevant source area of pollen (RSAP) of c. 1 – 2 km (Overland and Hjelle, 2009 and references therein). Although it is not possible to reconstruct the changing size of the lake through time from this study, we know that it was larger in the past and can expect that the RSAP covered a slightly larger area. Lake and bog sediments collect pollen differently. When pollen lands on a bog, it is fixed and generally not transported further. Pollen falling on a lake will however be subject to both movement within the water column and any sediment transport. In effect, pollen is commonly focussed and concentrated when deposited in a lake and the pollen grains are often better preserved than in other sediment types.

Transition from lake to bog conditions

The shift from lake (gyttja) to bog (peat) sediments is clearly shown in Figs. 11 and 13 as occurring at c. 1700

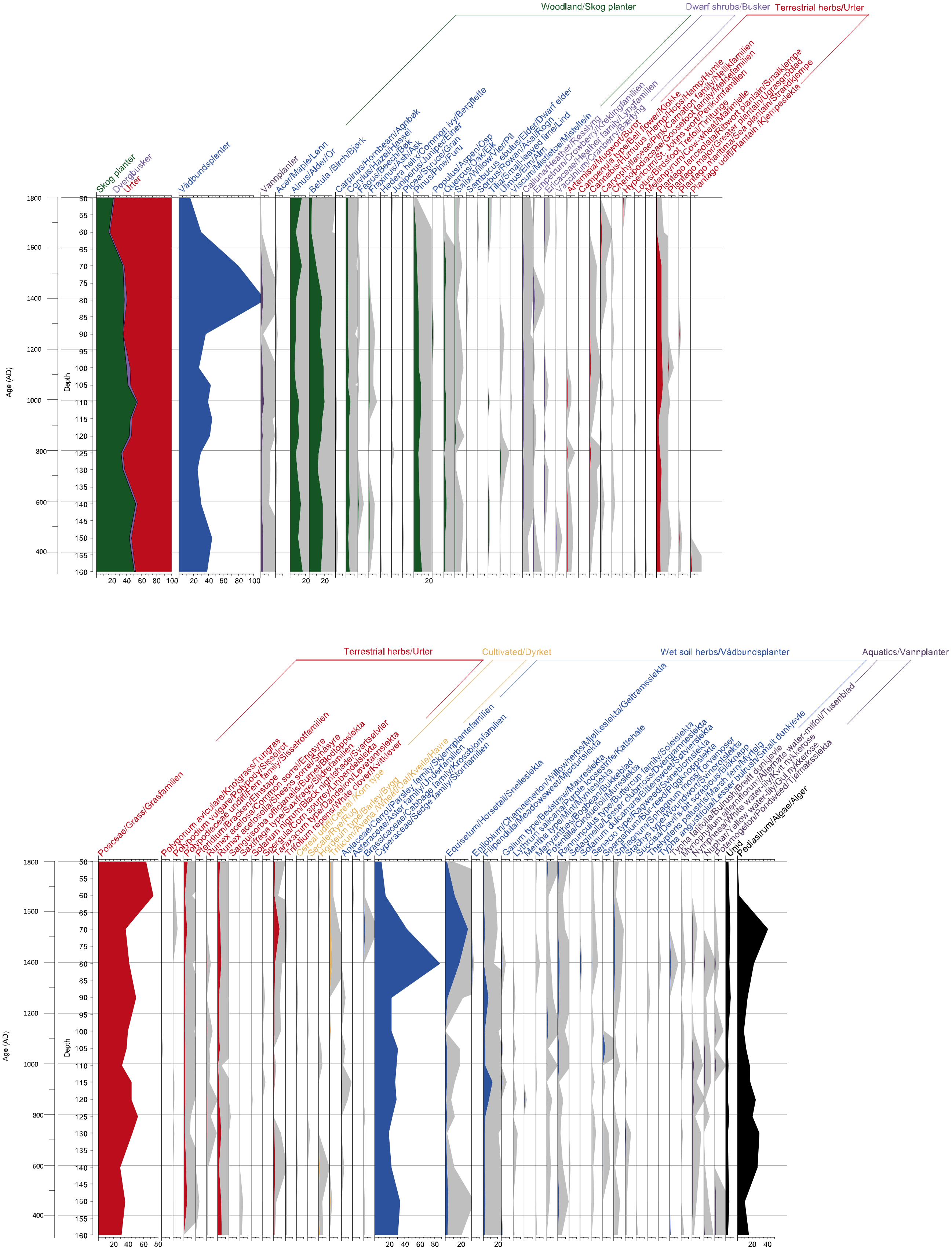


Figure 11. Bøvatn pollen percentages.

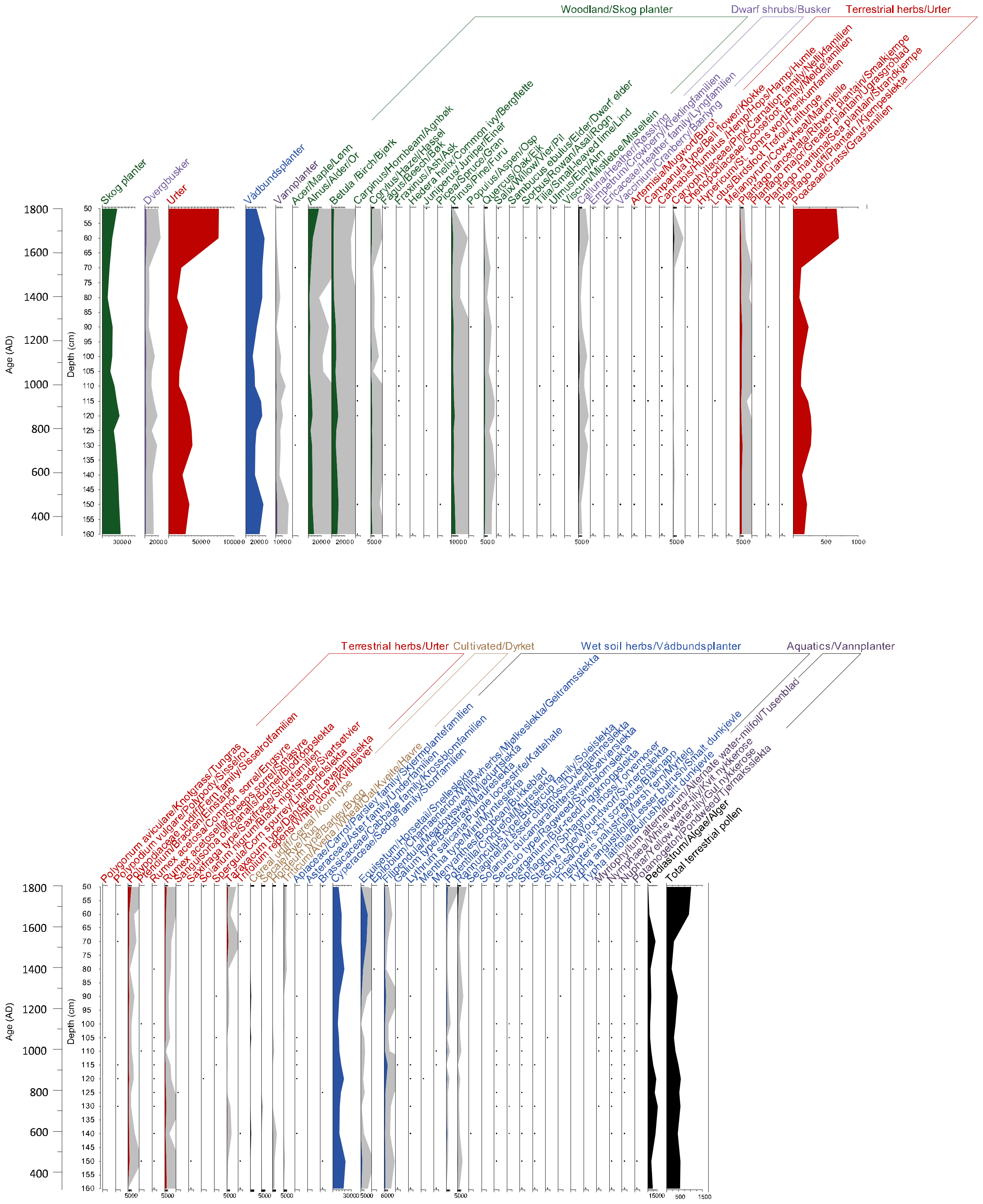


Figure 12. Bøvatn pollen concentrations.

AD at this core position. Figure 13 highlights pollen taxa which illustrate this transfer and the encroachment of the lake edge towards the core position. Wet soil herbs (vådbundsplanter) which includes sedges (storr) and horsetail (snelle) grow on peat bogs and often on those around lakes. Both these taxa can be seen to increase significantly from c. 1300 AD illustrating that, although peat is not recorded until c. 1700 AD, these 'peat' taxa become more dominant in the pollen profile c. 400 years previously. At the same time, the algae Pediastrum which indicates lake water is still present in high percentages. This may indicate that lake pools were present at the edge of the lake, very much like the present day where very wet conditions prevail some meters away from the lake edge. Samples later than 1800 AD were not analysed due to disturbance in the sediment cores.

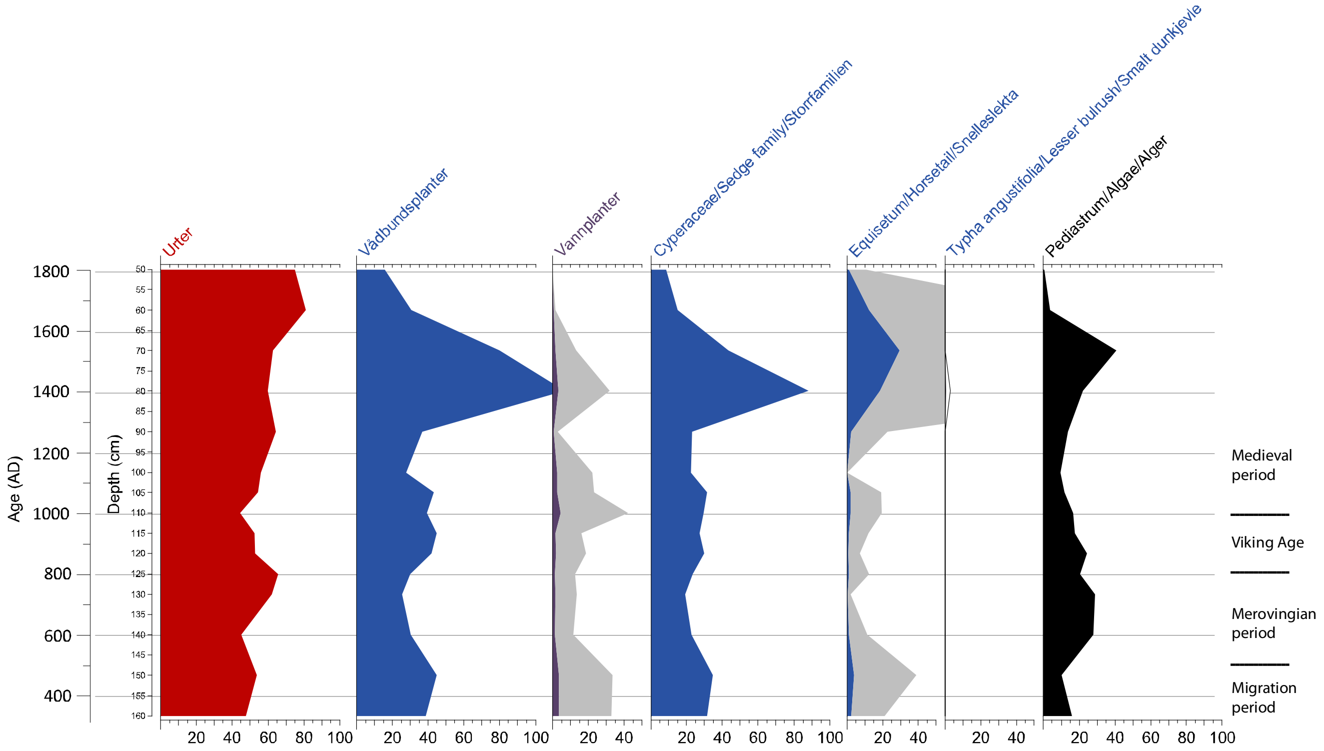


Figure 13. Percentages of pollen taxa indicating the lake to bog transition.

Regional landscape changes

If we assume that the pollen spectra from Bøvatn represents a 2 – 4 km radius, the diagrams shown in Figs. 11 and 12 give information on northern Karmøy and covers Avaldsnes, Visnes, Vormedal and Nordheim. Some plant taxa can spread their pollen many thousands of kilometres and a small proportion, especially of tree pollen, is expected to be transported long distances. The results show that relatively low woodland percentages and concentrations throughout the period from c. 300 AD to present indicate that the region was largely deforested prior to the Migration period. This is also seen at other coastal Norwegian sites where there is a transition to heathland takes place over c. 4000 years but is largely complete by 200 AD (Overland and Hjelle, 2009, Prøsch-Danielsen and Simonsen, 2000). Both the percentage and concentration diagrams from Bøvatn generally show a decreasing trend of woodland taxa for the period 300 AD to 1600 AD. Of interest is the reduction c. 700 - 800 AD and recovery c. 900-1000 AD of woodland taxa seen in both the percentage and concentration diagrams. Many sites in Scandinavia show a regeneration of forest between 600 and 900 AD (Odgaard and Nielsen, 2009) and at Sosteli, Åseral, southern Norway a distinct increase is seen at c. 950 AD (Jessen and Stylegar, 2012).

The total pollen concentration curve (Fig. 12) gives an indication of the pollen production (and transport) of the vegetation as a whole. It can be seen that from c. 300 AD through to c. 900 AD concentrations are stable (between around 500,000 and 600,000 grains per cm^3) but subsequently between the period c. 900 AD and c. 1600 AD concentrations are generally low. The especially low values between c. 1300 and c. 1500 AD is coincident with a major increase in wet soil herbs (vådbundsplanter) and may either be due to lake infilling but could also indicate a response to an increase in effective precipitation. At this time period, climate in northwest Europe is generally becoming unstable as the Little Ice Age (c. 1300 – 1900 AD) begins to take hold and historical sources describe years of floods followed by droughts (Fagan, 2000). Areas such as western Norway, which already have a relatively high annual rainfall, may be expected to experience changeable patterns affecting vegetation. The high concentrations of grasses after 1600 AD is evident in both percentages and concentrations (Figs. 11, 12 and 14) and may indicate drier conditions which are less favourable to the wet soil herbs of sedges (storr) and horsetail (snelle). This occurs at the same time as an increase in erosion as indicated by the MS results and a major increase in the percentage and concentration of grass pollen. Together these results suggest an economic shift to one more dependant upon grazing of animals possibly associated with the unpredictable and generally cooler conditions of the Little Ice Age.

Indications of human activity between c. 200 AD and 1800 AD years at Bøvatn

Cultivated cereal pollen does not travel far from the plants themselves, or from the threshing area where pollen can be released, this is especially true for barley (bygg), wheat (kveite) and oats (havre) although rye (rug) is a little more efficient at pollen dispersal. The presence of cereal pollen therefore strongly indicates that the plant was growing fairly close by, but it is important to stress that the absence of cereal pollen does not prove the absence of the plant. A more secure route to identifying cultivation practices may be to look at the weeds which grow on the fields together with cereal crops. Fig. 14 shows some of these indicators seen at Bøvatn grouped into 'cultivated', 'cultivation indicators' and 'grazing indicators' and although the interpretation of pollen diagrams involves looking at the whole picture some of the following factors can contribute to our understanding. Note that the descriptions have been developed based on evidence from northern Europe generally and southern Sweden (Regnéll, 1989, Behre, 1981):

- Barley (bygg) cultivation begins in the early Neolithic and was the dominant crop until Rye (rug) enjoyed a revival (see below).

- Rye (rug) was probably mainly found as a weed crop until it began to be important in the Viking Age/ Medieval period when it was used as a winter crop.

- Wheat/Oat (kveite/havre). Wheat (kveite) was a common crop in many areas of southern Scandinavia throughout the Neolithic but its use decreased in the Bronze Age and was not used significantly again until the 19th century. Although at Fitjar, c. 60 km north of Bøvatn, wheat (kveite) is consistently found

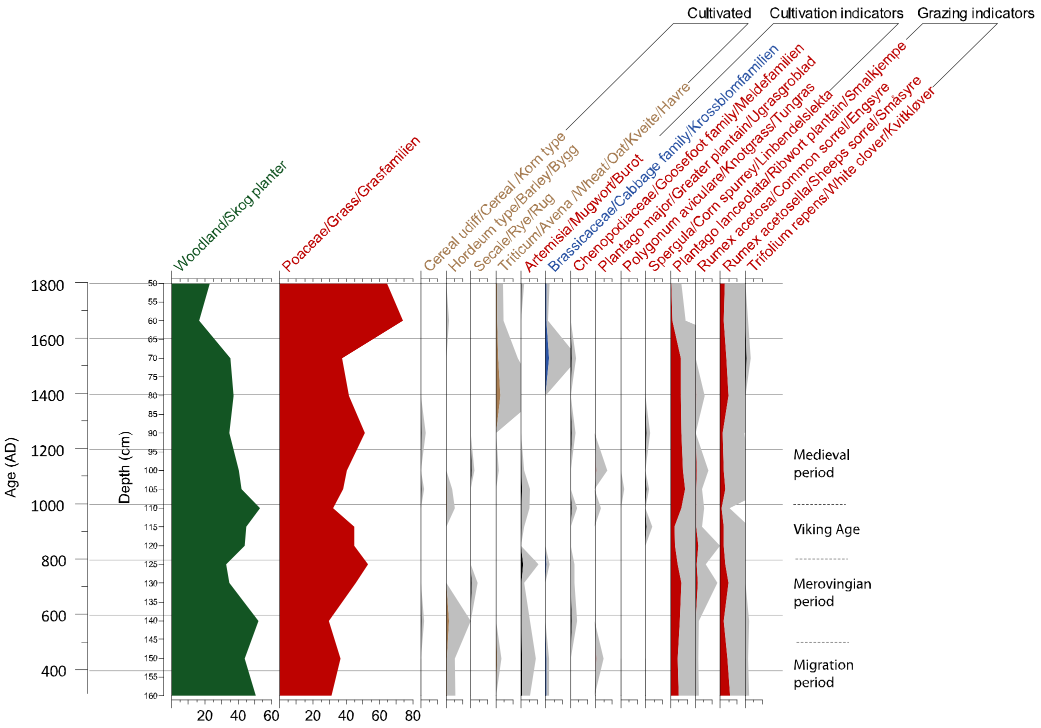


Figure 14. Percentages of pollen cultural indicator taxa.

from th Pre-Roman Iron Age through to c. 1300 AD (Overland and Hjelle, 2009). Oat (havre) has been found since the Iron Age in Scandinavia but the first significant finds began in the Viking Age.

- Mugwort (burot) was a common and difficult weed in early agriculture. Many weeds of cultivated fields were significantly reduced with the onset of mouldboard ploughing and it was particularly effective with this species.
- Cabbage family (Krossblomfamilien) pollen grains can only be identified to family level and some of the different taxa are weeds in summer, winter and fodder crops.
- Goosefoot family (Meldefamilien) plant taxa are common field weeds. One taxa, fat-hen (meldestokk), was also eaten in Norway by people and fed to animals until the 20th century (Höeg, 1974).
- Greater plantain (Ugrasgroblad) was a very common weed in crops and is generally found wherever there are people.
- Knotgrass (tungras) is a very common weed especially in winter crops and can be particularly common in rye fields.
- Corn spurrey (linbendel) plant types were common in rye fields and also in summer and root crops but there is evidence that this plant was also cultivated for its seeds.
- Ribwort plantain (smalkjempe) is a strong indicator of human settlement and arable farming with some

suggestion that it indicates rotational farming types. It is generally absent in intensively grazed regions as it seems to be favoured by grazing animals.

- Common sorrel (engsyre) and sheeps sorrel (småsyre) are found in fodder crops and also crops which are not thriving.
- White clover (kvitkløver) is an indicator of grazing.

Cultivated

As stated previously, the absence of cereal pollen does not prove the absence of cultivated cereals. This may be especially true in a lake site surrounded by bog, where some distance to fields and/or threshing zones is likely.

Barley (bygg) is the most common cereal pollen seen between c. 300 AD and through to c. 1000 AD. Somewhere within the Viking Age or shortly afterwards barley (bygg) becomes less visible in the profile and by c. 1300 AD, wheat/oat is the dominant cereal type. It is difficult to see from this analysis where in the intervening 300 years this shift occurs.

Rye (rug) is sporadic in the diagram being found only in two samples at c. 650 AD and c. 1050 AD but the presence of knotgrass (tungras) and corn spurrey (linbendel), both common weeds in rye fields may indicate rye cultivation during this time period. This would need to be confirmed in a study within the field system itself.

Cultivation indicators

Perennial weeds can survive and thrive if using the ard for turning the soil and crop weeds would have been a significant problem, especially if a field rotational system including a fallow period was practiced. With the arrival of the mouldboard plough perennial plants could not survive from year to year and annuals become more prevalent. At Bøvatn, the perennial indicator mugwort (burot) disappears shortly before c. 1200 AD, indicating that the mouldboard plough was not taken into use until early Medieval period and during the Viking Age farming still used the ard.

Grazing indicators

Both ribwort plantain (smalkjempe) and common sorrel (engsyre) are found in crops grown for fodder and are both fairly consistent until c. 1600 AD. Both percentages and concentrations of ribwort plantain decrease for c. 1 - 200 years around c. 900 AD at the same time as a change in grass percentages. Although difficult to specify further with this study, this does suggest some significant changes during the Viking Age which are worth investigating further. As common sorrel (engsyre) remains stable during this time period, this may indicate enhanced grazing during this time period.

Conclusions

Bøvatn has revealed a pollen spectra relatively rich in cultural indicators which was unexpected as larger lakes surrounded by bog are not usually optimal when looking at very local cultural changes in pollen records. The main points are as follows:

- The local area was already a cultural landscape in the Iron Age (c. 200 AD) with limited forest and was well established as farmland many hundreds of years before Harald Fairhair founded his royal farm at Avaldsnes.
- During the Viking Age an increase in grasses coincident with an decrease in grazing indicators could suggest some specific change in economics associated with the establishment of Avaldsnes as a royal farm.
- A transition from dominantly barley cultivation in the Migration period and the Merovingian period to dominantly wheat/oats in early Medieval period is very interesting. Where and how the shift occurred in the intervening 300 years cannot be reconstructed from this study due to the limitations of the large basin and probable distance to cultivation and/or threshing sites.
- Virtual disappearance of mugwort (burot) indicates a technological change to the use of mouldboard plough instead of the ard at c. 1200 AD.
- A major increase in grazing after c. 1600 AD is indicated by increased erosion and grasses. This may have been associated with the climatic shifts of the Little Ice Age.

Recommendations

This investigation from Bøvatn has given a fairly large scale picture of the landscape. Some interesting questions have arisen from this study:

- Was there a detectable shift in agricultural economics associated with the establishment of Avaldsnes as a royal farm with a greater dependance on grazing animals for meat and/or wool?
- Can the shift from dominant barley cultivation to wheat/oat cultivation be confirmed and when exactly did it happen?

To answer these questions and gain more detailed knowledge of agricultural economics of the Avaldsnes farming community, a small basin surrounded by agricultural land such as that at Nordbø Mose would have to be investigated. This basin lies only a few hundred meters from Bøvatn and is relatively unusual in the local area as it is presently surrounded by good agricultural land, and probably has been for many centuries, increasing the likelihood of gaining information on very local farming practices. A further analysis of this basin at Nordbø Mose is strongly recommended.

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