Journal of Archaeological Science (1998) **25,** 1185–1198
Article No. as980296

Relict Soils and Early Arable Land Management in Lofoten, Norway

Ian A. Simpson and Robert G. Bryant

Department of Environmental Science, University of Stirling, Stirling FK9 4LA, Scotland, U.K.

Unn Tveraabak

Institute of Biology and Geology, University of Tromsø, 9000 Tromsø, Norway

(*Received 25 June 1997, revised manuscript accepted 21 February 1998*)

Relict arable soils dating from *c.* AD 700 provide an opportunity to identify early arable land management practices in the agriculturally marginal landscapes of the Lofoten archipelago, northern Norway. Synthesis of field survey and soil thin section micromorphology supported by image analysis suggests that there was deliberate management of erodible sandy soils in sloping locations to create small areas of cultivation terrace, with a range of materials used as soil amendments to stabilize the accumulated soil and enhance fertility. Small areas of sandy soils in more gently sloping locations were also cultivated, again with a range of materials used as amendments and which contributed to a significant increase in soil thickness. The last phase of cultivation commenced during the late 1800s and involved the reclamation of wetter, peaty soils by spade. These patterns of arable land management are repeated in different parts of Lofoten and indicate that despite the climatic and economic marginality of arable activity in Lofoten, land management practices were developed and applied to permit barley production from small areas.

Keywords: NORTHERN NORWAY, HISTORIC CULTURAL LANDSCAPES, CULTIVATED SOILS, MANURED SOILS, SOIL MICROMORPHOLOGY, IMAGE ANALYSIS, POLLEN ANALYSIS.

Introduction

Since its introduction *c.* 4000 BP, cereal cultivation has been a small but persistent element of the north Norwegian palaeo-economy. Its marginality has been both environmental, on the edge of Gulf Stream influence and close to climatic limits of viability, and economic, given the seemingly ample marine and forage resources of the region (Johansen, 1979*a*). Temporal patterns of arable activity have been well established through palynological analyses (Johansen & Vorren, 1986), but while arable agricultural implements found in Late Iron Age graves in northern Norway (Sjøvold, 1974) and ard marks from beneath an Iron Age grave at Moland in Vestvågøy, Lofoten have been discussed (Johansen, 1979*b*), little attention has been given to the details of location and type of arable land management practices in northern Norway. This remains a significant omission as an understanding of the nature of arable land management will serve to more fully indicate the position and significance of arable activity within traditionally mixed north Norwegian economies (Urbanczyk, 1992; Dyrvik, 1993).

One way of gleaning evidence on early arable land management practices is through the analysis of soil properties. Soils are dynamic natural bodies who's properties reflect the environment in which they have been formed (Jenny, 1980) and so in cultural landscapes identification and analysis of relict and fossil soil properties (Bronger & Catt, 1989) has the potential to make a considerable contribution to the understanding of practices and patterns of early land management. A soils based approach to elucidating early land management activity has already been successfully applied to soils in Orkney (Simpson, 1993, 1994, 1997; Dockrill & Simpson, 1994), in Shetland (Davidson & Simpson, 1994; Bryant & Davidson, 1996) and in south-west Norway (Provan, 1971; Prøsch-Danielsen & Simonsen, 1988) with manuring practice, intensity of cultivation and land use function established from the interpretation of soil properties. These studies indicate the potential of this approach to shed new light on land management history in maritime north Atlantic regions and in this paper these principles are extended to northern Norway for the first time. The primary objectives of the research presented here are therefore to identify and characterize the properties of relict

0305–4403/98/121185+14 $30.00/0

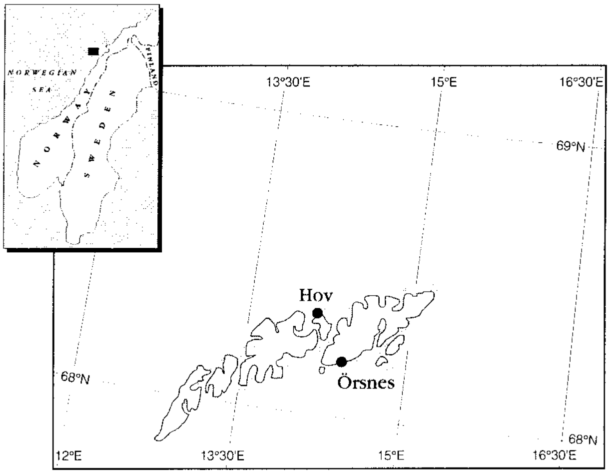

Figure 1. Location of Örsnes and Hov, Lofoten.

arable soils in the Lofoten archipelago (Figure 1) and to interpret these properties in terms of land management practices that include tillage and manuring. These objectives are achieved through combining field survey of soils with the application of conventional soil thin section micromorphology description supported by image analysis. The paper concludes by setting the interpretations made in a wider historical context.

Methods

Study areas and chronology

Two study areas were selected for soil survey, at Örsnes in Austvagøya (VR 753 651) and Hov in Gimsöya (VR 636 811; Figure 1); both are located in the Mid Boreal (northern subzone) biogeographic region of Lofoten, considered to be the most northerly, stable, cereal growing area in Norway under current climatic conditions (Vorren, 1979). At Örsnes, an area of basin peat 1·5 m in depth in the centre of this study area has allowed landscape reconstruction through palynological analyses, with supporting radiocarbon dating from 3305 BP (Figures 2 & 3; Table 1). These analyses indicate that human impact through grazing pressure commenced *c.* 2650 BP with an increase in grass pollen and a slightly later increase in heath species pollen. The first occurrence of *Hordeum* is interpolated to *c.* AD 700 and, allowing for self pollination, limited dispersal (Vourela, 1973) and the influence of what was a wooded mire on pollen influx, marks the commencement of soil cultivation in the vicinity of the bog. A coincident increase in *Poaceae* and decline in *Pinus* and *Betula* suggests that arable activity was part of a wider human impact that included the grazing of domestic livestock and fuel resource extraction. A more major occurrence of *Hordeum* pollen is evident from *c.* AD 1850 indicating an intensification of cultivation activity (Tveraabak, 1995). An interview with an elderly resident of Örsnes indicated that *Hordeum* was last grown during 1939–1945.

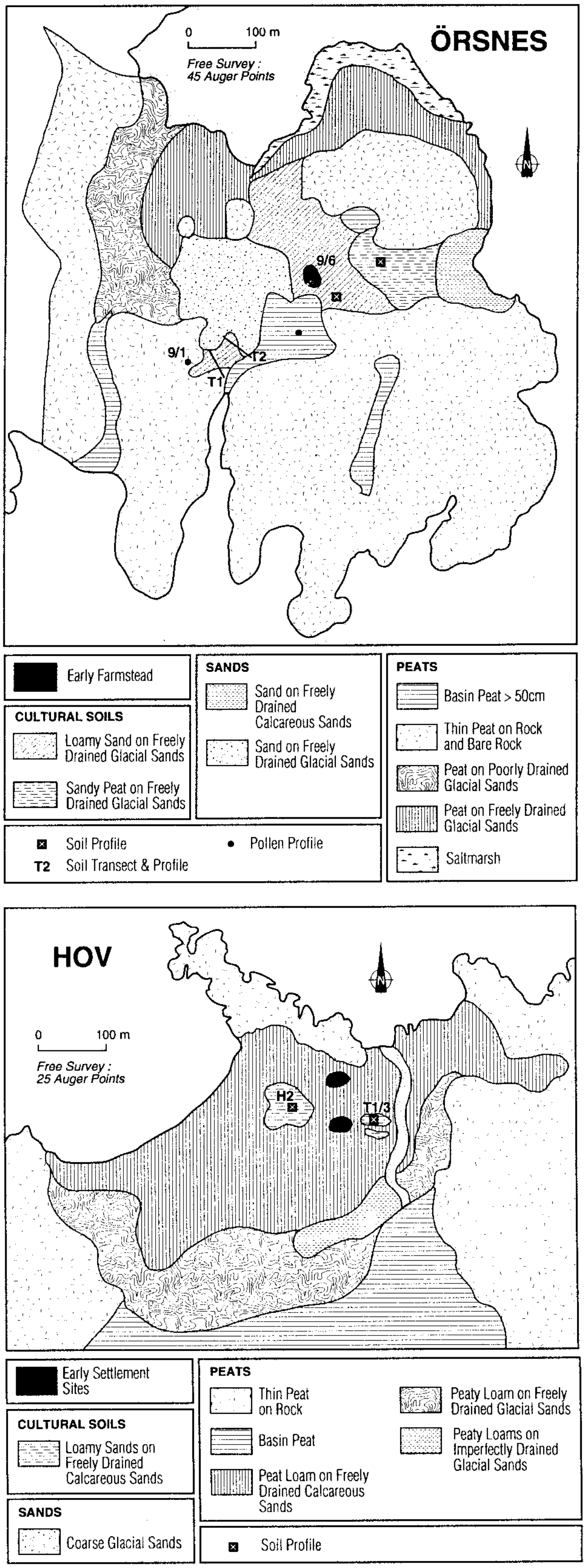

Figure 2. Soils of Örsnes and Hov.

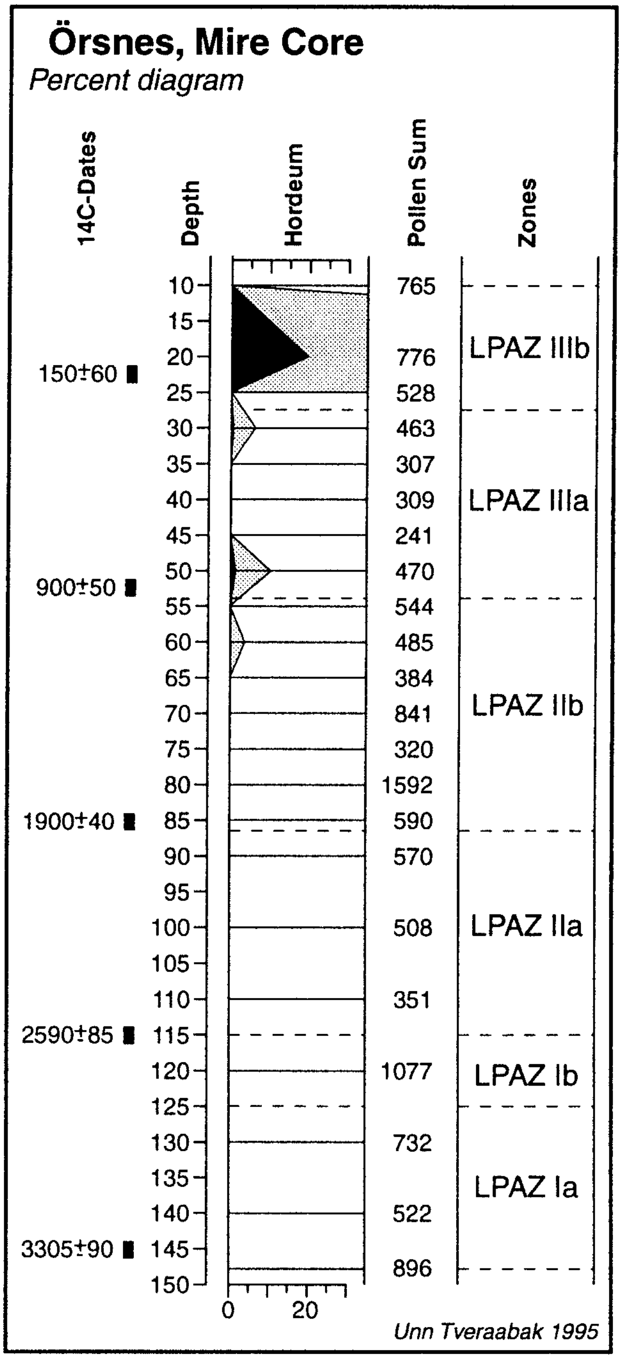

Figure 3. Pollen diagram showing occurrence of *Hordeum*, Örsnes.

Historic documentation for Örsnes suggests that, despite the evidence of agricultural activity, fishing was, as expected, a critical element of the economy, at least throughout the later Mediaeval period; the 1432–1449 tax book indicates that the tax liable from Örsnes was 2 *waager* (a weight of fish), indicating a small farm (Bolt, 1852). Present day farms are located between the 5 m and 15 m contours and land-use is predominantly reseeded permanent pasture used for dairy and beef cattle production; small garden type patches are cultivated for carrots and potatoes.

Table 1. Radiocarbon measurements from Örsnes

Site	Depth (cm)	Lab code	^{14}C age (BP)	Calibrated age
DF-2508	21–24	T-11368	150 ± 60	>AD 1665
DF-2511	51–53	T-11190	900 ± 50	AD 1070–1210
DF-2508	84–87	T-11369	1900 ± 40	AD 75–160
DF-2508	114–117	T-11370	2590 ± 85	825–755 BC
DF-2508	144–147	T-11371	3305 ± 90	1680–1465 BC

Hov was selected as a second study area to determine whether observed soil characteristics were repeated in other areas of Lofoten where little is known of the agricultural history. Here, an early settlement pattern is evident, with the area having Viking Age boat nausts and a farm mound *c.* 1·5 m in thickness with a radiocarbon calibrated age of 640–140 BC (Bertelsen, 1979). The area is part of a coastal strip with two raised beach lines and bounded by peat moorland on three sides. Farm sites are located between the 5 m and 10 m contours with permanent pasture for dairy and beef cattle, and small garden plots given over to potatoes.

Soil survey and sampling

Soils in the study areas were surveyed at a scale of 1:5000 by air photograph interpretation (black and white; 1:25,000 scale) and free auger survey. At Örsnes, 45 auger sample points were made within the *c.* 60 ha study area, and 25 within the *c.* 36 ha study area at Hov, including more detailed surveys of transects on slope terraces identified in both areas. Classification of soils was based on parent material; soil colour (Munsell colour), soil texture class (hand textured), soil drainage (Munsell colour of mottles) and horizon thickness. Cultural soils were identified in three discrete areas of the landscape at Örsnes and in two discrete areas at Hov by the occurrence of charcoals and bone inclusion, by increases in top soil thickness and by modified soil texture classes. Representative undisturbed samples from freshly exposed soil profile faces in these areas were collected in Kubiena tins for thin section micromorphological analysis. In addition, undisturbed samples were collected from the upper and lower areas of slope transects at Örsnes. A total of 15 samples came from Örsnes and six from Hov.

Thin section micromorphology and image analysis

Thin sections were prepared at the Micromorphology Laboratory, University of Stirling, based on the procedures of Murphy (1986). All water was removed from the samples by acetone replacement and checked by specific gravity measurement. The samples were impregnated using polyester crystic resin "type 17449" and the catalyst "Q17447" (methyl ethyl ketone peroxide, 50% solution in phthalate) to which a UV fluorescent dye (Epodye) was added to highlight void space. The mixture was thinned with acetone and a standard composition of 180 ml resin, 1·8 ml catalyst and 25 ml acetone used for each Kubiena tin. No accelerator was used, but the samples were impregnated under vacuum to ensure outgassing of the soil. The blocks were then cured for 3–4 weeks culminating with 4 days in a 40°C oven. Blocks were sliced, bonded to a glass slide, precision lapped to 30 μm and coverslipped.

Thin sections were described using an Olympus BH-2 petrological microscope and by following the procedures of the International Handbook for Soil Thin Section description (Bullock *et al.*, 1985). This allows systematic description and semi-quantification of soil microstructure, basic mineral components, basic organic components, groundmass and pedofeatures. A range of magnifications (× 10– × 400) and light sources (plane polarized, cross polarized and oblique incident) were used to obtain detailed descriptions and these were recorded in standard summary tables. Point counts of key features were used to check the semi-quantitative estimates. Interpretation of the observed features rests upon the accumulated evidence of a number of workers, notably Courty, Goldberg & Macphail (1989) and Fitzpatrick (1993).

The image analysis system used comprised a 3 CCD colour video camera (Hitachi HVC-10) equipped with both a macro-zoom lens (Hitachi HZ-H713) and a microscope adapter and followed the procedures of Bryant & Davidson (1996). The camera was connected directly to a framegrabber (Data Translation DT2871) housed within a Dell 80486/33DZ personal computer. The video signal was output to a high resolution monitor for data inspection. The image analysis software used was PC-Image Colour, release 1·42 (PCI), which operates within a graphical user interface. Shade correction was undertaken to compensate for uneven illumination of the sample; pixel size was set at a constant 0·0066 mm^2. In this study attention focused on void area, with the 8 cm long thin section systematically sampled in 1 cm bands.

Results and discussion

Relict arable soils

Within the two study areas, sands which generally have 10YR 3/3 top soil thickness of up to 15 cm and 10YR 2/1 organic peats which vary in thickness and underlying soil horizon according to landscape position, are the predominant soil types (Figure 2). Distinct from these soils are 10YR 3/1–2 loamy sand topsoils of between 30–50 cm in thickness containing occasional bone, charcoal and red pottery fragments on freely drained glacial derived sands, and sandy peat topsoils up to 30 cm in thickness on freely drained glacial derived sands at Örsnes (Figure 2). Similarly distinct loamy sand topsoils up to 55 cm in thickness with occasional bone and charcoals on freely drained subangular and subrounded calcareous sands are evident as areas covering a small extent of *c.* 0·5 ha at Hov (Figure 2). Such increased thickness of topsoil and textural classes together with the inclusions are indicative of anthropogenic deposition and of disturbance and mixing as a result of tillage (Simpson, 1997).

The loamy sand topsoils frequently overlie an earlier land surface of thin 10YR 2/1 peat and peaty sand topsoils on sands. Field inspection and thin section micromorphology demonstrates that these fossil soils have been neither amended nor disturbed; cultivation activity therefore commenced with the substantial movement and accumulation of soil material. The loamy sands are also found in distinctive landscape positions at both Örsnes and Hov. One position is as part of a terrace feature, with a second position on flat to gently sloping land; both areas are in close proximity to, but separate from, early settlement sites. The area of sandy peat soils at Örsnes was reclaimed within living memory and can be related to the increase in barley production observed in the pollen sequence from the late 1800s. These soils are distinctive because of their lack of any form of amendment. Explanations have to be sought, therefore, for the distinctive properties of the loamy sands and sandy peats and are considered below in relation to tillage and manuring methods, giving insight into early arable land management practices.

Loamy sands on terrace locations

At both Örsnes and Hov, areas of loamy sand top soils are found associated with small terraces in the landscape. Soil transects and inspection profiles examined across these terraces (Figure 2) suggest movement of soil material from upper slope positions, substantial accumulation in mid-slope positions and lesser or no accumulations on lower slopes (Figure 4). In upper slope positions top soils are characterized in thin section by a bridged to single grain microstructure and random well sorted coarse material arrangements together with a small amount of fine amorphous organic material (Table 2, P1/2–10). Such characteristics are indicative of an eroded soil with little organic material input. In lower slope positions there is evidence of accumulation, although here accumulation is marked by sharp microhorizon stratification. At Örsnes transect 1, stratified distinctions in fine material colour are observed in thin section (Table 2, P4/8–16), and at transect 2 there is a microstratigraphy of different sizes of material ranging from 200–500 μm, together with evidence of standstill periods when organic matter with spongy microstructures accumulated to form an organic topsoil (Table 3, P5/5–13; Figure 5). These properties indicate the accumulation of soil material from upper slope or mid-slope positions in a sequence of depositional phases with little or no post-depositional disturbance.

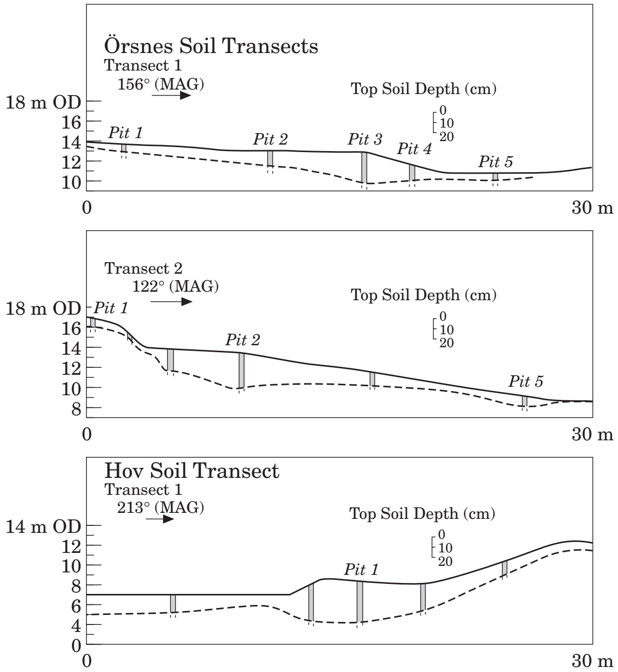

Figure 4. Soil transects on terrace areas, Örsnes and Hov.

The major accumulation of soil material is in mid-slope positions and, given its position on the transect, its primary source is the upper part of the transect with accumulation due to downslope movement. Substantial and rapid accumulation is indicated by the underlying undisturbed peaty and peaty sand topsoils, and the remains of a discontinuous small turf wall running along the downslope edge of this area suggests a deliberate attempt to trap eroding soils to create a soil for cultivation. That these areas were cultivated is supported by the absence of any textural or colour microstratigraphies in thin section; these soils have been disturbed and well mixed unlike those in lower slope positions. Given the size of the areas involved and the depth of mixing it is clear that cultivation would have been by spade.

The managed nature of these soils is further confirmed by the evidence of thin section micromorphology. At Örsnes (Tables 2 & 3), intergrain microaggregate microstructures together with slightly enhanced occurrences of excremental pedofeatures imply amendment with organic material. In view of the few amorphous brown organic fragments containing phytoliths it would appear that a grassy-based turf material contributed to the organic amendment, and the very few occurrences of fish and, less frequently, animal bone fragments in these thin sections suggests that domestic midden material was also applied (Courty, Goldberg & Macphail, 1989). In addition to these materials, a further range of amendments can be identified from the soils at Hov (Table 4). Here, very few occurrences of amorphous brown material containing both phytoliths and diatoms indicate application of wetter turf material, in contrast to the underlying fossil topsoils and the freely drained calcareous soils of the immediate vicinity which are freely drained and lack a diatom component (Simpson & Barrett, 1996). Furthermore, very few clusters of calcium spherulites within the applied turf material indicate a domestic animal manure input (Canti, 1997), while areas of grey, fused fine mineral material with high interference colours are indicative of ash deposition (Dockrill & Simpson, 1994; Courty, Goldberg & Macphail, 1989). It could be suggested that soil amendment strategies involved a wider range of materials at Hov in comparison with Örsnes, but this may simply reflect better preservation in a more calcareous soil environment.

Loamy sands in flat to gently sloping locations

The areas of loamy sand with inclusions on freely drained sands in flat to gently sloping contexts can also be interpreted as resulting from a combination of soil movement and accumulation, soil amendment and tillage, but with a different relative contribution from these processes. At Örsnes (Figure 2; Table 5), micro-horizons of sand accumulation are evident in the peaty fossil topsoils underlying the accumulated material indicating that early small scale erosion was occasionally prevalent even on gentle slopes. It is likely, however, that anthropogenic soil amendment had a greater role in the accumulation of this soil. Intergrain micro-aggregate structures, enhanced levels of mammilate excremental pedofeatures and very few occasional small fish bone fragments, indicate that organic materials were applied to this soil together with fish waste (Dockrill & Simpson, 1994). Furthermore, the few fragments of amorphous black and brown fine organic material with varying proportions of diatoms and phytoliths suggest that turves from both drier and wetter areas were used to create a thicker topsoil for cultivation (Simpson & Barrett, 1996). Not all of these turves were applied directly to the cultivated area; embedding of fish bone and fine charcoal material in the turf fragments suggests that turves may have been part of a midden deposit or of turf building material prior to their deposition on the cultivated area (Table 5). Application of this material in conjunction with tillage practice has resulted in systematically sampled void areas that range from 11–22%, contrasting sharply with void area in the underlying buried soil of peat over sand (Figure 6).

At Hov, the major contributing factor to the formation of these soils has been the input of subrounded calcareous wind blown sands (Figure 2; Table 6). Given the close proximity of this soil horizon to the coastline, the deposition of this material can be attributed to natural processes. Intergrain microaggregate structures and enhanced levels of mammilate excremental pedofeatures indicate organic amendments, but while very few fish bone fragments are evident and the presence of heated stone observed under oblique

Table 2. Thin section micromorphology descriptions; loamy sand in terrace locations, Örsnes transect 1

		Coarse Mineral Material (>10 µm) (angular)													Coarse Organic Material (>5 cells)		Fine Organic Material (<5 cells)						Pedofeatures											
Section		Quartz	Feldspar	Biotite	Garnet	Augite	Compound quartz grains	Sandstones	Siltstones	Metamorphics	Phytoliths	Heated stone	Bone	Fine Mineral Material (<10 µm)	Fungal spores	Lignified tissue	Parenchymatic tissue	Amorphous (black)	Amorphous (brown)	Amorphous (reddish brown)	Cell residue	Charcoals	Pollen	Organic coatings	Textural (clay coatings)	Textural (limpid clay)	Amorphous & crypto crystalline nodule	Amorphous & crypto crystalline infills+coatings	Excremental (mammillate)	Excremental (spheroidal)	Depletion	Microstructure	Coarse Material Arrangement	Groundmass b Fabric	Related Distribution
P$_1$/2–10		***	**	**	*	*	*							–	*	*		*											*			Bridged single grain	Random, well sorted	–	Chitonic
P$_2$/6–14		***	**	**	*	*	*				*	*	*	Brown; organo-mineral; Speckled limpidity	*			*	**	*		*		*					*			Intergrain microaggregate	Random, well sorted	Opaque	Enaulic
P$_2$/18–26	Upper	***	**	**	*	*	*					*	*	Brown; organo-mineral; Speckled limpidity	*			*	**	*		*		*								Intergrain microaggregate	Random, well sorted	Opaque	Enaulic
	Lower	***	**	**	*	*	*					*		–					*			*		t								Single grain	Random, well sorted	–	Monic
P$_3$/21–29		***	**	**	*	*	*					*		Brown; organo-mineral; Speckled limpidity	*			*	*	*		*		*					*			Intergrain microaggregate	Random, well sorted	Opaque	Enaulic
P$_3$/37–45	Upper	***	**	**	*	*	*					*	*	Brown; organo-mineral; Speckled limpidity				*	*	*		*		*					*			Intergrain microaggregate	Random, well sorted	Opaque	Enaulic to chitonic
	Mid	**	*	*	*	*	*					*		Brown; organo-mineral; Speckled limpidity				*	*	*		*		*					**			Intergrain microaggregate	Random, well sorted	Opaque	Enaulic
	Lower	***	**	**	*	*	*					*	*	Brown; organo-mineral; Speckled limpidity				*	*	*		*		*					*			Intergrain microaggregate	Random, well sorted	Opaque	Enaulic to chitonic
P$_4$/8–16		***	**	**	*	*	*					*		Brown and dark brown; organo-mineral; Speckled limpidity	*			*	*	*		*		*					*			Intergrain micro-aggregate to bridged	Random, well sorted	Opaque	Enaulic to chitonic

Frequency class refers to the appropriate area of section (Bullock *et al.*, 1985). t : *trace*; * : *very few*; ** : *few*; *** : *frequent/common*; **** : *dominant/very dominant.*
Frequency class for textural pedofeatures (Bullock *et al.*, 1985). * : *rare*; ** : *occasional*; *** : *many*.

Table 3. Thin section micromorphology descriptions; loamy sand in terrace locations, Örsnes transect 2

		Coarse Mineral Material (>10 µm) (angular)												Coarse Organic Material (>5 cells)			Fine Organic Material (<5 cells)					Pedofeatures											
Section		Quartz	Feldspar	Biotite	Garnet	Augite	Compound quartz grains	Phytoliths	Diatoms	Pottery	Heated stone	Bone	Fine Mineral Material (<10 µm)	Fungal spores	Lignified tissue	Parenchymatic tissue	Amorphous (black)	Amorphous (brown)	Amorphous (reddish brown)	Cell residue	Charcoals	Organic coatings	Textural (clay coatings)	Textural (limpid clay)	Amorphous & crypto crystalline nodule	Amorphous & crypto crystalline infills+coatings	Excremental (mammillate)	Excremental (spheroidal)	Depletion	Microstructure	Coarse Material Arrangement	Groundmass b Fabric	Related Distribution
P_2/16–14		***	**	*	*	*	*	*		*			Brown; organo-mineral; Speckled limpidity					**	*			*					*			Bridged to intergrain microaggregate	Random, well sorted	Opaque	Chitonic
P_2/24–32	Upper	***	**	*	*	*	*						Brown; organo-mineral; Speackled limidity					**	**			*					*			Bridged to intergrain microaggregate	Random, well sorted	Opaque	Chitonic
	Mid	*	*					*					–	*			**	****	*	*										Spongy	–	Opaque	–
	Lower	***	**	*	*	*	*				*		–		*		*	*	*		*	**								Pellicular to bridged	Random, well sorted	–	Gefuric
P_4/5–13		***	**	*		*	*						Brown; organo-mineral; Speckled limpidity		*		*	**	*			*					*			Bridged to intergrain microaggregate	Random, well sorted	Opaque	Chitonic
P_5/5–13	1	**	*	*	*	*			*				Brown; organo-mineral; Speckled limpidity	*			**	***	*	*										Spongy	–	Opaque	–
	2	***	**	*	*	*	*						Brown; organo-mineral; Speckled limpidity						*			*				*	*			Bridged	Random, well sorted	Opaque	Chitonic

Frequency class refers to the appropriate area of section (Bullock *et al.*, 1985). t : *trace*; * : *very few*; ** : *few*; **** : *frequent/common*; **** : *dominant/very dominant*.
Frequency class for textural pedofeatures (Bullock *et al.*, 1985). * : *rare*; ** : *occasional*; *** : *many*.

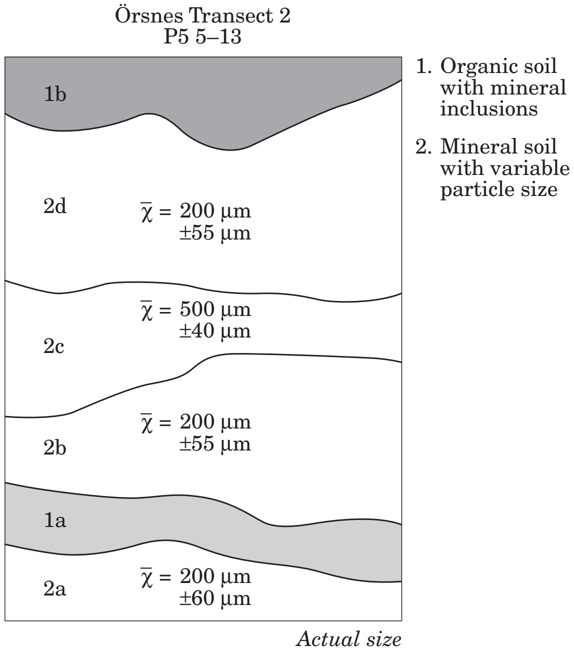

Figure 5. Microstratification in lower transect soils; Örsnes transect 1, pit 5, 5–13 cm.

incident light suggests an ash input, there is no evidence of these soils having been amended through turf application (Table 6).

Peaty sands

Reclamation of peaty soils for arable activity in this area of Örsnes (Figure 2) had taken place within living memory and was described by an elderly male resident. Such soils were reclaimed and cultivated using a sharp pointed spade to turn a row of peat topsoil over to a depth of *c.* 30–35 cm. The exposed sandy soils beneath the peat were then dug out and placed on top of the turned over peat. Peat from the next row was turned into the furrow created by the removal of sandy subsoil in the first row, with this process repeated across the whole field. This process was repeated in subsequent years as the principle tillage method. Areas cultivated in this way were small in any one year, but were systematically rotated over a larger area with 2 years of cereal followed by a year of fallow.

This process of cultivation and tillage has resulted in changing surface peat horizons to sandy peats. The mixing process is evident in thin section, where although the reclaimed soils are dominated by amorphous fine organic material and retain their spongy microstructure, coarse mineral material makes up a significant proportion of the section in comparison to undisturbed peaty soils (Table 7). Furthermore, systematic image analysis of void space demonstrates a substantial increase in void area. Undisturbed peaty soils from this locality have a uniform void area consistently less than 5%, whereas the reclaimed soils exhibit void areas of up to 17% declining down-profile to 9% with compaction evident around the interface of peat and sand where spade cut marks are evident (Figure 6). The lack, however, of any form of inclusion (Table 7) suggests that these soils were not manured and were taken into cultivation after the introduction of inorganic fertilizers.

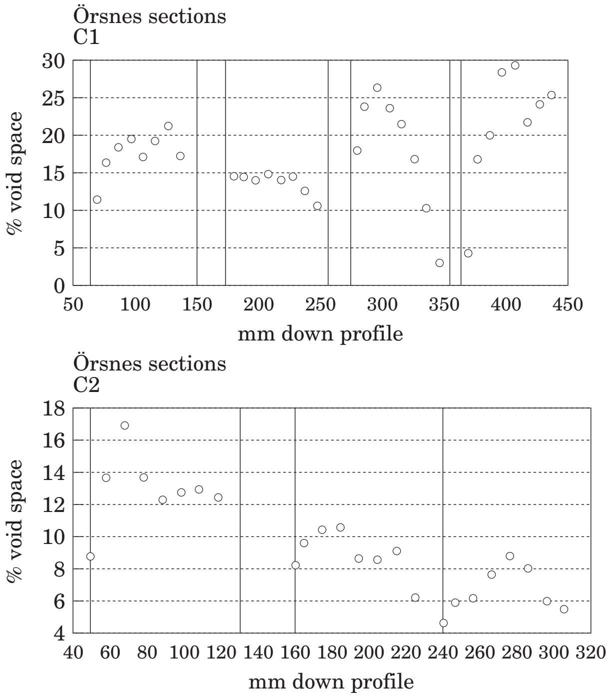

Figure 6. Micromorphological % void area in loamy sand (C1) and sandy peat (C2) soils, Örsnes. % values are for 1 cm thick bands across the thin section.

Conclusions

Field and micromorphological observations clearly demonstrate the occurrence of relict arable soils at Örsnes, dating from *c.* AD 700, with a similar pattern evident at Hov. Increases in top soil thicknesses in sloping locations can be attributed to the deliberate encouragement of upper slope erosion and soil entrapment to provide a flatter terrace area and deeper soil for cultivation purposes. Manuring practices also contributed to increases in soil thickness and explain the inclusions evident in these soils. On more gently sloping locations, increased topsoil thicknesses can be explained by manuring practice with a smaller contribution from eroded soils. In both localities a range of materials were applied including wet and dry turves, ash, fish wastes and domestic animal manures. This management strategy served to increase rooting depths up to 40 cm, with the manuring practice essential to stabilize the erodable soils and to maintain soil fertility in a freely drained soil environment. There was no attempt at either Örsnes or Hov to cultivate more

Table 4. Thin section micromorphology descriptions; loamy sand in terrace locations, Hov

	Coarse Mineral Material (>10 µm) (subangular)															Coarse Organic Material (>5 cells)			Fine Organic Material (<5 cells)					Pedofeatures											
Section	Calcium carbonate	Quartz	Feldspar	Biotite	Garnet	Augite	Compound quartz grains	Sandstones	Siltstones	Calcium oxalate	Phytoliths	Diatoms	Heated stone	Bone	Fine Mineral Material (<10 µm)	Fungal spores	Lignified tissue	Parenchymatic tissue	Amorphous (black)	Amorphous (yellow/orange)	Amorphous (brown)	Cell residue	Charcoals	Textural (silty clay)	Textural (clay coatings)	Textural (limpid clay)	Amorphous & crypto crystalline nodule	Amorphous & crypto crystalline infills+coatings	Excremental (mammillate)	Excremental (spheroidal)	Depletion	Microstructure	Coarse Material Arrangement	Groundmass b Fabric	Related Distribution
16–24	***	***	*	*	*		*				*		*	*	Brown; organo-mineral; Speckled limpidity				*	*	**	*	*						**	*		Intergrain micro-aggregate & sub-angular blocky	Random, well sorted	Speckled	Enaulic
26–34	***	***	*	*	*		*			*	*	*	*	**	Brown; organo-mineral; Speckled limpidity	*	*		*		**	*	*						**	*		Intergrain micro-aggregate	Random, well sorted	Speckled	Enaulic
37–45	***	***	*	*	*		*				*		*	**	Brown; organo-mineral; Speckled limpidity	*	*		*	*	**	*	*						**	*		Intergrain micro-aggregate	Random, well sorted	Speckled	Enaulic
	***	***	*	*	*		*				*				Mineral; grey and orange; High interference colours	*			*	*	**	*							**			Intergrain micro-aggregate	Random, well sorted	Speckled	Enaulic
	***	***	*	*	*		*								Brown; organo-mineral; Speckled limpidity				*	*	*	*							**			Single grain	Random, well sorted	–	Enaulic
	***	***	*	*	*		*				*				Brown; organo-mineral; Speckled limpidity	*			*	*	**	*										Intergrain micro-aggregate	Random, well sorted	Speckled	Enaulic
	***	***	*	*	*		*							*	Brown; organo-mineral; Speckled limpidity				*	*	*	*										Single grain	Random, well sorted	–	Enaulic

Frequency class refers to the appropriate area of section (Bullock *et al.*, 1985). t : *trace*; * : *very few*; ** : *few*; *** : *frequent/common*; **** : *dominant/very dominant*.
Frequency class for textural pedofeatures (Bullock *et al.*, 1985). * : *rare*; ** : *occasional*; *** : *many*.

Table 5. Thin section micromorphology descriptions; loamy sand in flat to gently sloping locations, Örsnes

Section		Coarse Mineral Material (>10 µm) (angular)													Fine Mineral Material (<10 µm)	Coarse Organic Material (>5 cells)			Fine Organic Material (<5 cells)					Pedofeatures								Microstructure	Coarse Material Arrangement	Groundmass b Fabric	Related Distribution
		Quartz	Feldspar	Biotite	Garnet	Augite	Compound quartz grains	Sandstones	Siltstones	Metamorphics	Phytoliths	Diatoms	Heated stone	Bone		Fungal spores	Lignified tissue	Parenchymatic tissue	Amorphous (black)	Amorphous (brown)	Amorphous (reddish brown)	Cell residue	Charcoals	Organic coatings	Textural (clay coatings)	Textural (limpid clay)	Amorphous & crypto crystalline nodule	Amorphous & crypto crystalline infills+coatings	Excremental (mammillate)	Excremental (spheroidal)	Depletion				
C_1/2–15		***	**	*	*	*					*	*	*	*	Brown; organo-mineral; Speckled limpidity	*			*	**	*		*	*					**			Intergrain micro-aggregate	Random	Opaque	Enaulic
C_1/18–26		***	**		*	*					*	*	*		Brown; organo-mineral; Speckled limpidity	*			*	**	*	*	*	**					**			Intergrain micro-aggregate	Random	Opaque	Enaulic
C_1/28–36	1	***	**		*	*					*	*	*		Brown; organo-mineral; Speckled limpidity	*			*	**	*	*	*	*					**			Intergrain micro-aggregate	Random; well sorted	Opaque	Enaulic
	2	*	*		*	*						*			Brown; organo-mineral; Speckled limpidity	*			*	**		*		*					*			Spongy	Clustered; well sorted	Opaque	Porphyric
	3	**	*		*	*						*	*		Brown; organo-mineral; Speckled limpidity	*							*	*					*			Intergrain micro-aggregate to spongy	Clustered; well sorted	Opaque	Porphyric
	4														–	*			*	****	*	*										Spongy	–	Opaque	–
C_1/37–45	1	*								*			*		–	*			*	****	*		*									Spongy	–	Opaque	–
	2	****	**	*	*	*									–					**	*			*								Bridged	Random; well sorted	Opaque	Enaulic

Frequency class refers to the appropriate area of section (Bullock *et al.*, 1985). t : *trace*; * : *very few*; ** : *few*; *** : *frequent/common*; **** : *dominant/very dominant*.
Frequency class for textural pedofeatures (Bullock *et al.*, 1985). * : *rare*; ** : *occasional*; *** : *many*.

Table 6. Thin section micromorphology descriptions; loamy sand on flat to gently sloping locations, Hov

	Coarse Mineral Material (>10 µm) (subangular)															Coarse Organic Material (>5 cells)			Fine Organic Material (<5 cells)					Pedofeatures											
Section	Calcium carbonate	Quartz	Feldspar	Biotite	Garnet	Augite	Compound quartz grains	Sandstones	Siltstones	Calcium oxalate	Phytoliths	Diatoms	Heated stone	Bone	Fine Mineral Material (<10 µm)	Fungal spores	Lignified tissue	Parenchymatic tissue	Amorphous (black)	Amorphous (yellow/orange)	Amorphous (brown)	Cell residue	Charcoals	Textural (silty clay)	Textural (clay coatings)	Textural (limpid clay)	Amorphous & crypto crystalline nodule	Amorphous & crypto crystalline infills+coatings	Excremental (mammillate)	Excremental (spheroidal)	Depletion	Microstructure	Coarse Material Arrangement	Groundmass b Fabric	Related Distribution
14–22	***	***	*		*								*	*	Brown; organo-mineral; Speckled limpidity	*			*		**	*	*						**			Intergrain micro-aggregate	Random, well sorted	Speckled	Enaulic
27–35	***	***	*		*								*	*	Brown; organo-mineral; Speckled limpidity	*			*		*	*	*						**			Intergrain micro-aggregate	Random, well sorted	Speckled	Enaulic
43–51	***	***	*	*	*								*	*	Brown; organo-mineral; Speckled limpidity				*				*						**			Intergrain micro-aggregate	Random, well sorted	Speckled	Enaulic

Frequency class refers to the appropriate area of section (Bullock *et al.*, 1985). t : *trace*; * : *very few*; ** : *few*; *** : *frequent/common*; **** : *dominant/very dominant.*
Frequency class for textural pedofeatures (Bullock *et al.*, 1985). * : *rare*; ** : *occasional*; *** : *many*.

Table 7. Thin section micromorphology descriptions; reclaimed peaty sand soil, Örsnes

		Coarse Mineral Material (>10 μm) (angular)														Coarse Organic Material (>5 cells)			Fine Organic Material (<5 cells)					Pedofeatures											
Section		Quartz	Feldspar	Biotite	Garnet	Augite	Compound quartz grains	Sandstones	Siltstones	Metamorphics	Phytoliths	Diatoms	Heated stone	Bone	Fine Mineral Material (<10 μm)	Fungal spores	Lignified tissue	Parenchymatic tissue	Amorphous (black)	Amorphous (brown)	Amorphous (reddish brown)	Cell residue	Charcoals	Organic coatings	Textural (clay coatings)	Textural (limpid clay)	Amorphous & crypto crystalline nodule	Amorphous & crypto crystalline infills+coatings	Excremental (mammillate)	Excremental (spheroidal)	Depletion	Microstructure	Coarse Material Arrangement	Groundmass b Fabric	Related Distribution
C_2/5–13		**	*	*	*	*					t	*			–	*			*	***	*		*						*	*		Spongy	Random	Opaque	Porphyric
C_2/16–24		**	*	*	*	*					t	*			–	*			*	****	**		*	*								Spongy	Random with linear	Opaque	Porphyric
C_2/24–32	Upper	***	*	*	*	*					*	*			–	*			*	**				*								Single grain microaggregate	Random	Opaque	Chitonic
	Mid	**	*	*	*	*					*	*			–	*			*	****	*		*	*								Spongy	Random	Opaque	Porphyric
	Lower	***	**	*	*	*					*	*			–	*				*			*	**								Single grain to bridged	Random	Opaque	Gefuric to Chitonic

Frequency class refers to the appropriate area of section (Bullock *et al.*, 1985). t : trace; * : *very few*; ** : few; *** : *frequent/common*; **** : *dominant/very dominant*.
Frequency class for textural pedofeatures (Bullock *et al.*, 1985). * : *rare*; ** : *occasional*; *** : *many*.

poorly drained, peaty soils before the late 1800s; once taken into cultivation such soils were not manured and appear to be associated with the introduction of inorganic fertilizers.

Such practices on freely drained and erodable soils are likely to be found in other parts of Lofoten given that the land registers of 1667 and 1723 for Vestvågøy suggest that 70–80% of farms were cultivating cereal (Johansen, 1982). Similar terrace features and interpreted management practices have been observed in southwest Norway (Myhre, 1985) and in prehistoric southern England where it has been suggested that ploughing was deliberately employed to erode soils from upper slope positions (Bell, 1992). The early arable land management practices observed in Lofoten are not therefore unique and appear to be local adaptations of well established practices; they do however serve to emphasize the efforts made to secure barley production reinforcing the view that barley production was significant in a mixed north Norwegian economy.

The dated pollen core from Örsnes suggests that such manuring and tillage practices would have been prevalent through the Viking Age and Mediaeval period to the early modern period. During this time cereal cultivation is known to have been maintained and enhanced by Viking chiefs to ensure traditions of feasting and social order. Later deterioration in climate, the Black Death of *c*.1350 with its impact on population numbers and farm abandonment, and increasing commercialization and trade in stock fish saw decline in local cereal production to subsistence levels, or abandonment, and import of cereals from southern Norway, the Baltic and England (Urbanczyk, 1992). These contrasting phases in arable activity cannot be separately identified in the soils data available, but it is likely that although the extent of the arable area contracted going into the Mediaeval period, land management methods remained similar until the late 1800s expansion and the introduction of inorganic fertilizers.

Palynological evidence from northern Norway has indicated earlier periods of cultivation than those identified in this paper. Neolithic cereal cultivation has been identified as sporadic and of short duration, suggesting limited success or a shifting style of arable practice within a dominantly fishing-hunting economy (Nilssen, 1988; Vorren, Nilssen & Markved, 1990). Some have also suggested that it may have been of symbolic significance, adopted by fishing-hunting communities to communicate conformity or solidarity with economic trading partners to the south (Olsen, 1988; see Urbanczyk, 1988, for counter arguments). A heavier reliance on arable cultivation as well as animal husbandry is dated to the Early Iron Age *c.* 2000–2500 BP with permanent farmsteads established at this time (Johansen & Vorren, 1986). Earlier research had suggested that increase in agricultural activity at this time was attributable to immigration from southern Norway; the current view is that this upturn can be attributed to a predominantly indigenous population placing greater emphasis on agricultural activity during a climatic optimum. Little, however, is known of the land management methods associated with cultivation in these periods and how consistent they were through time. Analyses of cultural palaeosols from these periods may provide important new insights into land management practice as they have for the AD 700–1900 period in the landscape history of Lofoten.

Acknowledgements

IAS gratefully acknowledges support from the British Council. Reidar Bertelsen, Donald Davidson and Karl-Dag Vorren provided much valued advice and guidance. The farmers of Örsnes and Frode Hov of Hov are thanked for their kind hospitality and access to their land. Muriel MacLeod manufactured the soil thin sections. Radiocarbon determinations were made at the Radiological Dating Laboratory, NTH, Trondheim, Norway. This paper is a contribution to the wider landscape change objectives of the North Atlantic Biocultural Organisation (NABO).

References

Bell, M. (1992). The prehistory of soil erosion. In (M. Bell & J. Boardman, Eds). *Past and Present Soil Erosion*. Oxbow Monograph. **22,** pp. 21–35.

Bertelsen, R. (1979). Gårdshauger i Nord-Norge. En kommentar til de siste 15 års forskingsvirksomhet. In (R. Fladby & J. Sandnes, Eds). *På Leiting Etter Den Eldste Gården*. Oslo: Universitetsforlaget.

Bolt, A. (1852). *Fortegnelse Over Jordegods og Andre Herliheder Tilhørende Erkebiskopstole i Nidaros (1432–1449)*. Christiania: Grøndahl.

Bronger, A. & Catt, J. A. (1989). Palaeosols: problems of definition, recognition and interpretation. In (A. Bronger & J. A. Catt, Eds). *Palaeopedology: Nature and Application of Palaeosols*. Catena Supplement **16,** pp. 1–7.

Bryant, R. & Davidson, D. A. (1996). The use of image analysis in the micromorphological study of old cultivated soils: an evaluation based on soils from the island of Papa Stour, Shetland. *Journal of Archaeological Science* **23,** 811–822.

Bullock, P., Federoff, N., Jongerius, A., Stoops, G., Tursina, T. & Babel, U. (1985). *Handbook for Soil Thin Section Description*. Wolverhampton: Waine.

Canti, M. (1997). An investigation of microscopic calcareous spherulites from herbivore dungs. *Journal of Archaeological Science* **24,** 219–231.

Courty, M. A., Goldberg, P. & Macphail, R. I. (1989). *Soils and Micromorphology in Archaeology*. Cambridge: Cambridge University Press.

Davidson, D. A. & Simpson, I. A. (1994). Soils and landscape history: case studies from the Northern Isles of Scotland. In (S. Foster & T. C. Smout, Eds) *History of Soils and Field Systems*. Aberdeen: Scottish Cultural Press.

Dockrill, S. J. & Simpson, I. A. (1994). The identification of prehistoric anthropogenic soils in the Northern Isles using an integrated sampling methodology. *Archaeological Prospection* **1,** 75–92.

Dyrvik, S. (1993). Farmers at sea: a study of fishermen in north Norway, 1801–1920. *Journal of Family History* **18,** 341–356.

Fitzpatrick, E. A. (1993). *Soil Microscopy and Micromorphology*. Chichester: Wiley.

Jenny, H. (1980). *The Soil Resource: Origin and Behaviour*. New York: Springer.

Johansen, O. S. (1979*a*). Early farming north of the Arctic circle. *Norwegian Archaeological Review* **12,** 22–32.

Johansen, O. S. (1979*b*). Jernaldergårder i Nord-Norge. In (R. Fladby & J. Sandnes, Eds). *På Leiting Etter Den Eldste Gården* Oslo: Universitesforlaget.

Johansen, O. S. (1982). Viking age farms: estimating the number and population size. *Norwegian Archaeological Review* **15,** 45–69.

Johansen, O. S. & Vorren, K.-D. (1986). The prehistoric expansion of farming into "Artic" Norway: a chronology based on ^{14}C dating. *Radiocarbon* **28,** (2A), 739–747.

Murphy, C. P. (1986). *Thin Section Preparation of Soils and Sediments*. Herts.: AB Academic Publishers.

Myhre, B. (1985). Arable fields and farm structure. *Archaeology and Environment* **4,** 69–82.

Nilssen, E. (1988). Development of the cultural landscape in the Lofoten area, North Norway. In (H. H. Birks, H. J. B. Birks, P. E. Kaland & D. Moe, Eds) *The Cultural Landscape, Past, Present and Future*. Cambridge: Cambridge University Press, pp. 369–380.

Olsen, B. (1988). Interaction between hunter-gatherers and farmers: ethnographical and archaeological perspectives. *Archaeologia Poliski* **23,** 425–433.

Prøsch-Danielsen, L. & Simonsen, A. (1988). Principal components analysis of pollen, charcoal and soil phosphate data as a tool in prehistoric land-use investigation at Forsandmoen, southwest Norway. *Norwegian Archaeological Review* **21,** 85–102.

Provan, D. M. J. (1971). Soil phosphate analysis as a tool in archaeology. *Norwegian Archaeological Review* **4,** 37–50.

Simpson, I. A. (1993). The chronology of anthropogenic soil formation in Orkney. *Scottish Geographical Magazine* **109,** 4–11.

Simpson, I. A. (1994). Spatial constraints on anthropogenic soil formation in Orkney. *Scottish Geographical Magazine* **110,** 100–104.

Simpson, I. A. (1997). Relict properties of anthropogenic deep top soils as indicators of infield management in Marwick, West Mainland, Orkney. *Journal of Archaeological Science* **24,** 365–380.

Simpson, I. A. & Barrett, J. H. (1996). Interpretation of midden formation processes at Robert's Haven, Caithness, Scotland using thin section micromorphology. *Journal of Archaeological Science* **23,** 543–556.

Sjøvold, T. (1974). *The Iron Age Settlement of Arctic Norway*. Tromsø: Norwegian University Press.

Tveraabak, U. (1995). *Utvikling av lavlandsheier i Storvågan og Örsnes, Lofoten*. Unpublished Thesis, University of Tromsø.

Urbanczyk, P. (1988). The arctic dilemma. *Archaeolgia Polski* **33,** 442–453.

Urbanczyk, P. (1992). *Medieval Arctic Norway*. Warsaw: Institute of the History of Material Culture, Polish Academy of Sciences.

Vorren, K.-D. (1979). Anthropogenic influences on the natural vegetation in coastal North Norway during the Holocene. Development of farming and pastures. *Norwegian Archaeological Review* **12,** 1–21.

Vorren, K.-D., Nilssen, E. & Mørkved, B. (1990). Age and agricultural history of the *stadir* farms of North and Central Norway. *Norsk Geografisk Tidsskrift* **44,** 79–102.

Vuorela, I. (1973). Relative pollen rain around cultivated fields. *Acta Botanica Fennica* **102,** 1–27.