Remote Sensing for Archaeological Heritage Management

Edited by David C Cowley

Remote sensing is one of the main foundations of archaeological data, underpinning knowledge and understanding of the historic environment. The volume, arising from a symposium organised by the Europae Archaeologiae Consilium (EAC) and the Aerial Archaeology Research Group (AARG), provides up to date expert statements on the methodologies, achievements and potential of remote sensing with a particular focus on archaeological heritage management. Well-established approaches and techniques are set alongside new technologies and data-sources, with discussion covering relative merits and applicability, and the need for integrated approaches to understanding and managing the landscape. Discussions cover aerial photography, both modern and historic, LiDAR, satellite imagery, multi-and hyper-spectral data, sonar and geophysical survey, addressing both terrestrial and maritime contexts. Case studies drawn from the contrasting landscapes of Europe illustrate best practice and innovative projects.

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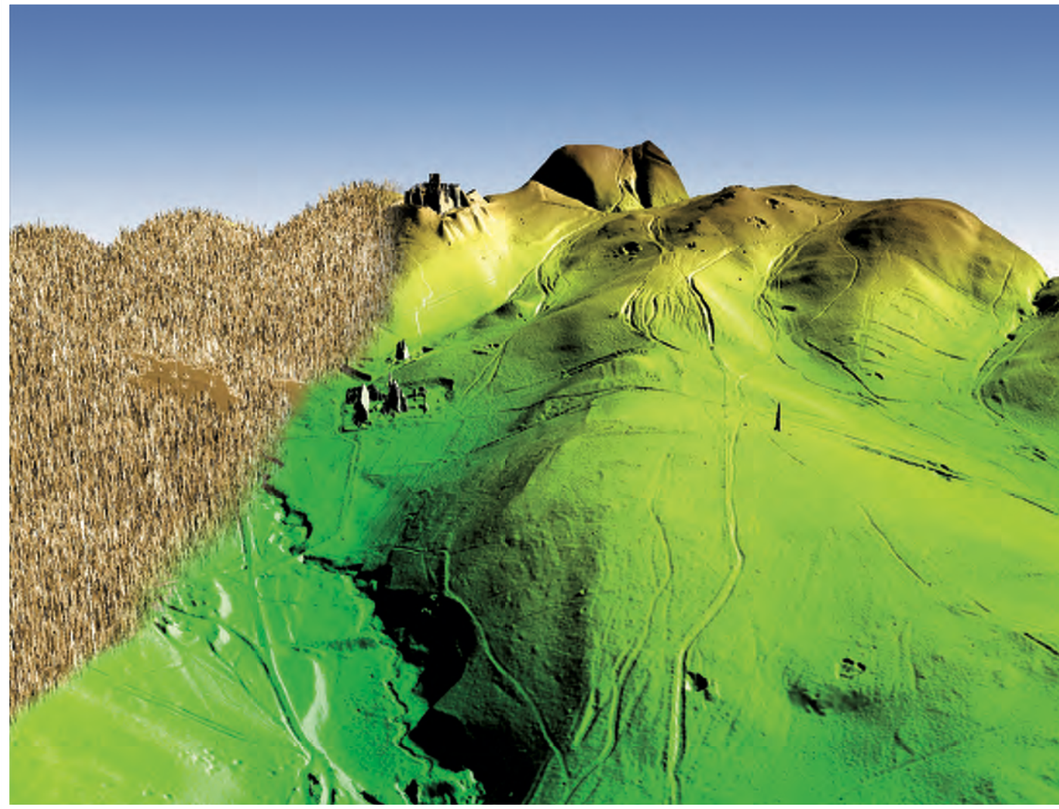

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Edited by David C Cowley

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Edited by David C Cowley

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Airborne Laser Scan (LiDAR) of a forested area before and after filtering
(St. Anna in der Wüste, Austria). © *Michael Doneus and Klaus Löcker, LBI-ARCHPRO, Vienna*

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20 | The archaeological landscape of northeast Iceland: a ghost of a Viking Age society

Árni Einarsson and *Oscar Aldred*

Abstract: A current mapping project of medieval archaeology in an area of over 3,000km^2 in northeastern Iceland makes use of aerial photography on a large scale, including over 2,000 low altitude oblique photographs. Aided by ground surveys and other fieldwork, the project has revealed a whole system of well-preserved remains dating to the medieval period. An extensive network of turf walls is most prominent, but farmsteads, churches, assembly sites, pagan grave fields, peat cutting, charcoal pits and horse tracks are also clearly visible. This medieval archaeological landscape belongs largely to the Viking period and is a relic of the settlement pattern of the first few generations in Iceland. Its high conservation value and future preservation is discussed in the paper.

Introduction

Iceland was discovered and colonised in the late 9th century, following the westward expansion of the Norse seafaring Viking culture. The settlement period and the subsequent three centuries have been immortalised in the rich medieval saga literature of the Icelanders. This period was remarkable for the creation of a new society with a hierarchical system of assemblies with legislative and judicial functions, and the distribution of power among a number of chieftains instead of one central authority. This political system was to last more than three centuries, until Iceland became part of the Norwegian and later, Danish kingdom.

Much of the early archaeological work in Iceland was concentrated on the Viking period (Vésteinsson 2004a; Friðriksson 1994) because it represents a 'glorious past' and also because the identity of the Icelandic nation is rooted in events and processes in this period. The Viking period is still a major focus in the archaeology of Iceland but, in line with global trends in science, the emphasis is now on the dynamic interaction of humans and their environment. This entails a greater focus on off-site archaeology, primarily associated with the use of resources. This wider scope calls for a landscape approach with large scale dating and registration of monuments, preferably aided by remote sensing.

This paper provides the context for and the description of the findings from a research project that has used aerial photography on an unprecedented scale for Iceland. Initial research began as a study of an extensive system of medieval turf walls in northeastern Iceland, using vertical aerial photographs, revealing a complex division of the landscape (Einarsson *et al.* 2002). The project then continued, involving wide ranging oblique low altitude aerial photography supported by archaeological excavations and ground surveys. Augmented by related projects, as well as existing knowledge (McGovern *et al.* 2007), this effort gradually revealed a whole network of walls and other features (Figure 20.1) that were roughly contemporaneous and contained important elements of the Viking period society. Apart from turf walls, these features included assembly sites, burial sites, churches/chapels and farm sites of various characters, and also features that have not been properly dated yet, like routes, peat cuttings and charcoal pits. Many of the oldest features are so well preserved, widespread and prominent that we have been tempted to describe this archaeological landscape as a relic of the Viking period.

Figure 20.1: The great turf wall at Fljótsheiði. Note how the wall traces the edge of the bog to the right. The wall continues in the upper left corner of the photograph. Some of the main horse tracks can be seen as winding linear features and there are peat pits to the right.

In this paper we first give an overview of the use of aerial photography in Iceland for cartography and archaeology. We then focus on our study area in the northeast of Iceland, listing some of the most prominent types of ancient remains we see from the air, Viking period or later, and finally discussing issues relating to heritage management and the conservation value and preservation of the archaeological landscape.

The use of aerial observations in Icelandic archaeology

The history of aerial photography in Iceland can be traced back to oblique photographs taken of Reykjavík in 1919. However, aerial photography was not systematically carried out until 1937-8, when it was used to compliment the ground surveys for the first detailed maps of Iceland at a published scale of 1:100,000 (Bragason & Guðmundsson 1988). World War II marked an expansion in the areas covered by aerial photographs, again for cartography. However, these series of vertical aerial photographs taken by the German, British and American military, as well as later by the National Land Survey of Iceland (Landmælingar Íslands), are an invaluable resource in two related but different ways. The first is tracing landscape change over the last 60 years. This is a period that has seen radical changes in the landscape, especially around farms and urban centres. Secondly these aerial sources are invaluable in the mapping of archaeological sites. The retrospective mapping of archaeology from the earliest available sources often provides a much better understanding of landscape formation and organisation and the status of archaeological features than using conventional map sources (Aldred *et al.* 2010).

In the late 1970s and early 1980s Sveinbjörn Rafnsson used oblique aerial photography as an integral part of his archaeological survey of deserted valleys in the east of Iceland (Rafnsson 1990). This was the first practical use of aerial survey specifically for archaeology. Sveinbjörn used both conventional and infra-red images. However, the flights were largely directed at previously known sites in order to obtain a basic record, and no detailed transcription mapping was involved. In the 1980s, Guðrún Sveinbjarnardóttir conducted regional studies of farm abandonment in Iceland for her doctoral thesis (Sveinbjarnardóttir 1992). She made occasional use of aerial photographs, although this was hampered by the high altitude of the photography and the difficulty in recognising distinct features. In the 1990s, the Institute of Archaeology, Iceland (Fornleifastofnun Íslands), amongst other professional archaeologists, began extensive field surveys. At first, aerial reconnaissance was incorporated into the survey, taking oblique shots in both conventional and infra-red format. This programme, however, was short-lived.

The first publication that presented the explicit use of aerial photographs in archaeology in Iceland was in 1995 (Ísaksson & Helgason 1995). The article discussed the use of the technique in relation to features on farms and land around Reykjavík and particularly highlighted the advantages of photography under light snow cover. Photographs had been taken of the same site under different conditions, using both conventional and infra-red film. The article also attempted to discuss the specific nature of aerial survey in Iceland as well as promote its more systematic use in archaeology.

Although archaeological survey has a long tradition in Iceland, beginning in the 19th century (Friðriksson 1994), it is only in the last quarter of the 20th century that the first systematic archaeological surveys of the country commenced. In the first decade of the 21st century tremendous progress has been made and the number of sites registered increased dramatically. In the same period, usage of aerial photographs in archaeological survey multiplied and currently most archaeological surveys use aerial photographs at some stage. In most cases, these are vertical aerial photographs, often from

Figure 20.2: A medieval turf wall.

a fairly high altitude of 18,000ft or 5,486m, with a focal length of 152mm (a scale of 1:36,000).

Recent survey, driven by new legislation in 1989, has aimed to achieve total coverage of districts and regions (Ólafsson 1991; Friðriksson & Vésteinsson 1998). The underlying premise of contemporary practice is to systematically register all surviving remains to a set standard. The registration is informed by textual and oral histories. Although these are invaluable sources in discerning the presence of archaeology, textual sources can be fragmentary in coverage, and the use of oral sources, derived from place-name surveys, is based on an assumption of continuity in the social memory from one generation to the next. Aerial photography provides valuable additional records of sites which may have been identified by other means. It reveals certain types of sites (e.g. boundaries and charcoal pits) that tend to be under-represented in the other types of evidence and which are difficult to find or comprehend through conventional field walking (Figure 20.2).

While there has been an increase in the use of aerial photographs and other remote sensing in recent years, these techniques are still not routinely used in archaeology in Iceland. Aerial sources have been used *ad hoc* for both research and heritage management, and there are several projects conducted in the last few years that have been laying the foundation for more routine use. These have developed best practices and demonstrate the benefits for archaeology and landscape studies. A few of these projects are discussed below.

A project on the history of the human habitation of the Skagafjörður region in northern Iceland used low altitude oblique aerial photography to register the deserted farmsites in the most remote valleys (Pálsson 1999–2010). Another project on the early arable cultivation in Iceland made extensive use of conventional and infra-red aerial photographs, as well as other sources, to demonstrate the presence or absence of ancient sites with cultivation remains, and to study the discontinuity of arable cultivation in relation to the deteriorating climate from the 14th century onwards (Guðmundsson *et al.* 2004). In addition, another project, conducted in 2007 by an undergraduate student at the University of Iceland, assessed the utility of high altitude vertical aerial photographs for archaeological survey. The photographs were viewed at a magnification of 10x and while new features were mapped, the results showed some limitations. For example, mainly linear and larger features such as areas of peat cutting and boundaries were added to the records, but the ability to recognise smaller and more discrete sites was limited by the photograph scale and resolution (Sveinbjarnarson 2007). In another project, four landscape areas covering about 200km^2 were mapped using DigitalGlobe, pan-sharpened Natural colour and DRA contrast enhanced 0.6m pixel resolution satellite imagery, captured between 2002 and 2006 (Lárusdóttir & Aldred 2008). These projects demonstrated the relative ease of both creating and using aerial and satellite sources to expand and enhance our existing knowledge of archaeology, which can be further illustrated in the main case study of this paper – the ongoing work in northeast Iceland.

The aerial archaeology of northeast Iceland

The main project that encapsulates the foundation work and best practices for aerial survey is focused on northeast Iceland. It was carried out by the Institute of Archaeology and the Mývatn Research Station and funded by the Icelandic Centre for Research (RANNÍS) and Þjóðhátíðarsjóður (a fund that commemorates the 9th century settlement of Iceland) to map the extent and preservation of the ancient wall systems in northeast Iceland. The aim was to determine their date, spatial extent, structure and possible function. The project systematically employed aerial photographs, both verticals and obliques, as well as satellite imagery, to map the archaeology of a large area. At last count over 3,000km^2 have been covered and about 400km of walls have been mapped.

The study area

Our study area covers 3,164km^2 in the Counties of Suður- and Norður Þingeyjarsýsla (Figure 20.3). The area can conveniently be divided into four main geographical units. Two of them (Kelduhverfi and Mývatnssveit) are within the so-called neo-volcanic zone characterised by extensive postglacial lava fields and flat landscape interrupted by Pleistocene ridges of hyaloclastite, indicative of subglacial eruptions. The Mývatn area (Mývatnssveit) is dominated by Lake Mývatn, a 37km^2 shallow eutrophic lake about 50km from the coast, surrounded by dry lava fields on one side and extensive wetlands on the other. Modern day farms are situated around the lakeshore and around fertile wetlands on the River Kráká delta to the south. Kelduhverfi, down by the coast, is dominated by flat lava fields originating in the shield volcano of Þeistareykjabunga to the south and on the north side by sandur plains deposited by the glacial River Jökulsá á Fjöllum. The modern day farms lie on the border between the lava and the sandur plain, but a large number of ancient deserted farms lie on the lava field to the south.

A third landscape area is the valley and moorland between Lake Mývatn and the coast. This is outside the zone of present day volcanic activity although big prehistoric lava streams did flow down two of the valleys. The bedrock is moraine-covered interglacial basalt carved by ice and with a rather thin layer of organic soil. The shallow valleys are orientated north-south and provide the focus for most of the present day farms. They are separated by ridges of moorland that extend like fingers from the highland plateau to the south. The fourth landscape area is the peninsula of Tjörnes that lies between Kelduhverfi and Húsavík. This area has a low rocky coastline with small streams at regular intervals, and at present only the western half is inhabited. The bedrock is the same as described before but with thick banks of raised marine sediments on the coast.

The whole habitable area of northeast Iceland was apparently covered with birch (*Betula pubescens*) scrubland at the time of first settlement. Today it is almost devoid of woodland. The vegetation on the moorland and lava areas, and in some of the uninhabited parts of the valleys, is mostly heath-like (Nielsen 1995), dominated by dwarf birch (*B. nana*) and

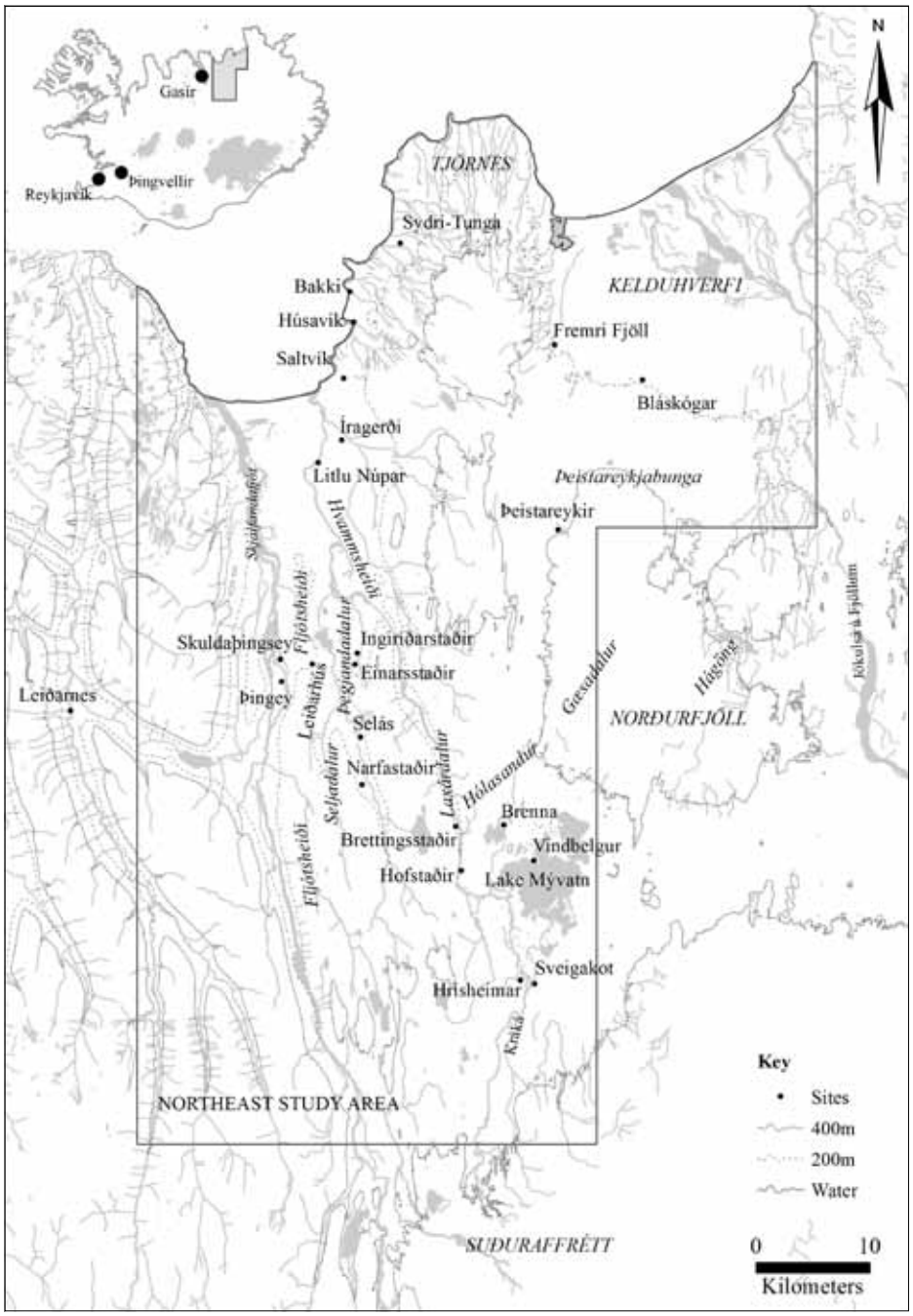

Figure 20.3: The study area in northeast Iceland.

crowberry (*Empetrum nigrum*). The inhabited parts of the study area have much more grassland. Hay for winter fodder is the only substantial crop produced on the hayfields around the farms. Bogs and other wetlands are scattered throughout the area except in the largest lava fields. Extensive blanket and string bogs are a characteristic of the southernmost moorlands. The soil is minerogenic and rather thin (commonly about 1m). The soil cover is mostly continuous but is locally eroded in many exposed and steep places. A massive erosion front migrating from the highlands reached the area south and east of Lake Mývatn in the 17th – 18th century and another erosion front is active in the area northwest of Lake Mývatn (Hólasandur).

The study area has been inhabited from the very beginning of settlement and like elsewhere in Iceland was based on dispersed single-household farms, often accommodating tenant farms within their territory. Wildlife resources include fish such as salmon, trout and Arctic charr in the lakes and rivers and abundant sea fish, mostly cod. Rock ptarmigan, Arctic fox and gyrfalcon occur in the dry upland and coastal areas, and seabirds (and their eggs) on the coastal islands. Duck eggs are utilised extensively in Lake Mývatn and there is a big eider colony on the coast. All these resources were utilised in the Viking period, and the coastal harvest was brought inland (McGovern *et al.* 2006).

Categories of archaeological features

Although the main task of the project was to map the extensive wall system, the aerial observations have also registered a large number of other archaeological features. Below are some of the main characteristics of the archaeology derived from the aerial surveys. Some of the listed features below date from the Viking period.

Walls

The ancient turf walls are the most prominent feature of the archaeological landscape (Figure 20.4). They run long distances, criss-crossing the moorlands and heaths (a total of about 400km at the last count; Einarsson *et al.* 2002; Aldred 2008). They seem roughly contemporaneous, though there are indications of multiple phases of construction in some areas (e.g. Figure 20.5). For the most part, a basic pattern can be discerned (Figure 20.6), modified by only minor repairs, rebuilds and additions, and it appears that the walls went out of use a few generations after they were built. Dating of some, using tephra (volcanic ash) from 27 trenches to determine the latest and earliest times a wall may have been constructed or fallen out of repair, places the majority in the 10th to 11th centuries. Their maintenance was discontinued sometime before the 13th century and all the dated walls, except one, had collapsed long before a characteristic tephra layer from AD 1477 was deposited. The focus of the study has been on the outfield walls, less on infield ones encircling the hayfields which may have a more complex history due to wall building activities associated with the 18th – 19th century agricultural reformation.

The walls form a basic pattern of home range enclosures (Figure 20.4), each one corresponding to an individual farm but subdivided for more local management of grazing, stock manipulation and protection of growing crops. In the valley landscape the walls run uphill on the probable boundaries between neighbouring farms. A horizontal wall on the hillside divides the rangeland above the farm into a near and far section. It is uncertain if the horizontal wall marks a limit of ownership or is just conveniently placed for stock management. The walls,

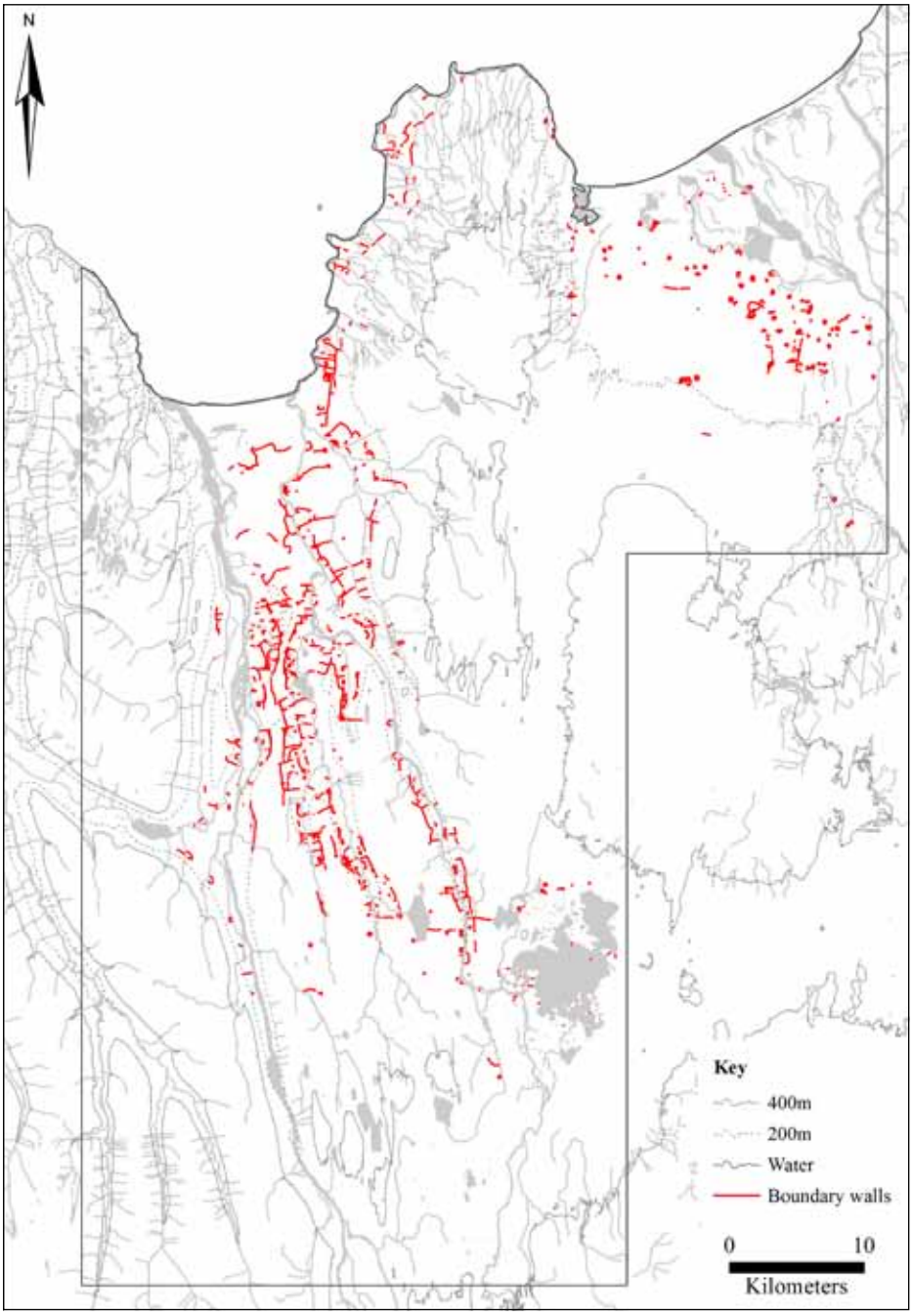

Figure 20.4: A map of the study area in northeast Iceland showing the extent of the medieval wall system.

Figure 20.5: An ancient farm site with walls at Höskuldsstaðir at Fjótsheiði.

enclosing the farm on three sides (the river typically closes the boundary on the downhill side), look like they have been built as a single entity. The horizontal wall usually joins similar ones at the neighbouring farms, creating a continuous structure that fences entire valleys from the surrounding hills.

Most of the walls have collapsed and can only been seen as low earthworks in the landscape. What makes them prominent, especially from the air, is that the collapsed wall is very broad (commonly 4–6m across) and that the ditches on each side, from where the turf had been dug, are still quite deep (often expanded by erosion) and their vegetation differs from that on top of the collapsed wall. The result is that from the air many of the walls look like huge wheel tracks (Figure 20.7).

The wall system is very extensive, and clearly the most extensive archaeological phenomenon in Iceland. The challenge to get it mapped was a major impetus for the aerial surveys presented in this paper. After trying several methods for effective mapping we decided that none of them was working successfully on its own. We ended up with a combination of methods involving both oblique and vertical photographs (the latter being the standard source for geodetic purposes) and field walking. The oblique photos turned out to be essential for the detailed interpretation of the walls in the landscape and often also to ascertain their absence.

Small enclosures

A variety of small enclosures can be seen from the air, but two particular types deserve attention because of their well defined geometry. One type is square on plan, measuring about 20m across and usually located on the infield side of the wall system, sometimes isolated, sometimes combined with the walls and

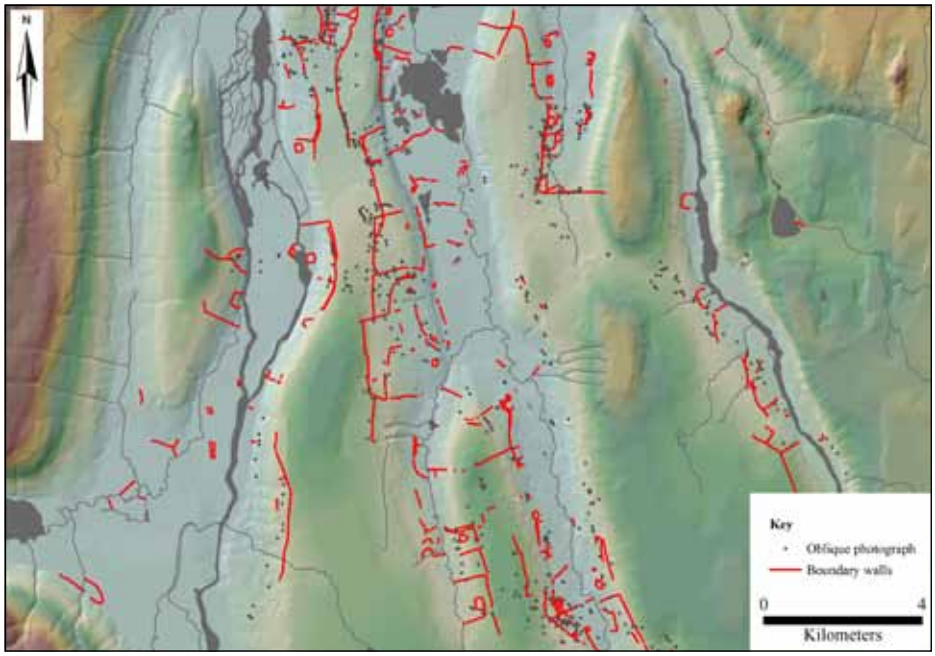

Figure 20.6: A close-up of the medieval turf wall system at Fljótsheiði.

Figure 20.7: Walls in Laxárdalsheiði by the river Laxá.

can then be assumed to be contemporaneous. These square enclosures can for example be seen at the farm sites of Narfastaðir, Ingiríðarstaðir, Einarsstaðir and Brettingsstaðir (see Eldjárn (1981) for similar structures in Skíðadalur, North Iceland). An archaeological excavation underway at Ingiríðarstaðir has discovered ard-marks inside one of the enclosures (Howell Roberts pers. com.). The other type is represented by perfectly circular enclosures, 6–12m in diameter. Further studies are needed to determine if these two types of enclosures represent functional groups or not.

Charcoal pits

The natural climax vegetation in most of the study area is birch woodland. Most of this disappeared rather quickly after settlement (landnám), or in less than a century in the south of Iceland but more gradually in the west and north, including our study area (Hallsdóttir 1987; Lawson *et al.* 2007; Lawson 2010; Gathorne-Hardy *et al.* 2009). Our aerial surveys have disclosed hundreds of charcoal pits scattered between Lake Mývatn and the coast. They tend to occur in clusters on low ridges or flat slopes not far from major horse tracks. Individual pits within a cluster are spaced some 50–100m apart. Sometimes, the pits occur in pairs. Most are about 2m across on the surface (max. 4m) and about 50cm deep and look square-shaped from the air.

Excavations reveal an original circular outline and the squarish shape must be a secondary feature. On the ground a raised rim of soil upcast is clearly visible, but this is less apparent from the air (Figure 20.8). Nine pits in one cluster have been dated, and all fall within the period AD 1000–1200, except one that is slightly younger, but still dates before 1300 (Church *et al.* 2007). Charcoal was produced throughout the history of Iceland, up to the middle of the 20th century. The product was used locally for smithy work (including scythe sharpening), and in medieval times also for the smelting of bog iron.

Figure 20.8: Charcoal pits on Laxárdalsheiði.

Horse tracks

Overland transport in Iceland has taken place either on foot or on horses, and wheeled transport did not exist until the late 19th century when the first roads were made for wheeled carriages. Most road construction was in the form of 'bridges', i.e. short dykes of sod or stone across rock clefts or marshes. Travellers on horseback kept to traditional routes that tended to follow the contours of the landscape. Aerial surveys easily identify horse tracks. The hooves of the horse cut quickly through the topsoil and soon a deep track was formed and then parallel ones when the earlier tracks became too deep to use. The most travelled routes thus developed multiple tracks, with tens or even a hundred furrows in a braided spread across a wide area (Figure 20.9). There are two types of tracks inscribed into the landscape. Inter-region tracks allowed for the movement of goods and people between a resource area and a distribution centre, while intra-region tracks connect individual settlements, as well as activity areas within farmland. The intensity, as well as duration of use, is represented by how deeply incised the track is, as well as its breadth. Fainter traces of tracks, perhaps less used rather than any later in date, are evident in many areas. Occasionally tracks run along the line of walls or on top of them.

The horse tracks are obviously an accumulation of over 1,000 years of transport history and some may retain their medieval period locations and some may not. Many of the tracks seem to postdate the walls as they appear to cut across them. Interestingly, some tracks can still be seen leading to farms that were deserted centuries ago. The most impressive horse tracks in the study area are south of the trading harbour of Húsavík and branches of this massive track can be traced into all the main valleys and all the way to the Lake Mývatn region. Some of the tracks may relate to transport of sulphur from the areas east and southeast of Lake Mývatn to Húsavík and perhaps Gásir by Eyjafjörður for export to continental Europe. Sulphur was mined in this region over seven to eight centuries. In one large area, Hólasandur between Mývatn and Húsavík, the topsoil has been blown away and the underlying sandy subsoil has been exposed. Here the main track expands into a 6–9m broad road where rocks have been cleared to the side to create a soft substrate for riding. The age of this unique construction is unknown but it is probably post-medieval, judging from preliminary dating of the erosion (unpublished data).

Figure 20.9: Horse tracks by Lake Mývatn.

Hay stores

Early 20th century cultivated hayfields only provided about half of the total hay production in the study area (Hólmgeirsson 1978). Most of the other hay came from wetlands. According to 19th and 20th century ethnographic sources, the hay was stacked on raised ground on the edge of the marsh or, if the marsh was large, on specially built platforms (in Icelandic = *heystæði*), until it could be transported by sledge in winter. These hay platforms, square or oval in shape, were used extensively until the mid 20th century and are clearly visible from the air (for example, south of Lake Mývatn, or on the islands within the Lake Mývatn). None of them has been dated but it is not unlikely that their use goes back to medieval times. The hay was covered by turf strips for protection. The remains of the turf tended to accumulate at the edge of the platform, forming a rim that can easily be mistaken for a house ruin.

The medieval law books frequently mention enclosures for storage of hay (Icelandic = *heygarður*). No structures have been identified from the air that fit their description, but it seems likely that such hay enclosures were small infield features and attached to other wall structures.

Herding structures

Some of the walls incorporate variously shaped enclosures that may be related to stock management. Ancient documents, including Grágás, the medieval law code of Iceland, refer to pens for herding (in Icelandic = *rétt*) but their design is not described and they most likely varied with both purpose and landscape. None of the observed structures resembles the modern sheep folds used for managing sheep driven from the upland commons in the autumn. The date of the early medieval phase of the herding structures has yet to be demonstrated archaeologically, but it can be intimated that they were similar to those that have been excavated; dating to the early-17th century (Aldred 2010).

In the Mývatn area, the earliest sheep folds seem to be located away from the settlements in the grazing areas, both to the south in Suðurafrétt, and in Norðurfjöll (Gæsadalur and east of Hágöng), but are also evident in other places across Iceland (Aldred & Madson 2009; Aldred 2010). The earliest structures are simple in their form (c. 500m^2), or utilised topography, rather than the multi-compartment folds of 19th century date and later.

Churches or chapels

In the beginning of Christianity in Iceland churches were private property and most were built close to farmhouses. The church or chapel was oriented east-west and enclosed within a circular wall that was both symbolic and practical (to keep animals away). Most churches were small and the diameter of the circular wall was only 20–30m. Square churchyards became the norm in the 19th century (Jónasson 1961, 347). Only four ancient (but undated) churches/chapels have been

Figure 20.10: Brettingsstaðir, an ancient farm site with a church or chapel (inside the larger circle) and a small circle with unknown function. Remains of a 20th century farmhouse above and an apparently Viking Age longhouse below the circular walls.

seen from the air in our study area: at Ingiríðarstaðir and Einarsstaðir in Þegjandadalur valley, Brettingsstaðir in Laxárdalur valley (Figure 20.10) and Saltvík by Húsavík. A church at Hofstaðir was located through a ground resistance and magnetometer survey (Horsley & Dockrill 2002) and a few other medieval churches are known from historical sources.

Assembly sites

Assemblies (Icelandic = *þing*) were an important part of the social organisation from the very early settlement in the late 9th century and were formalised on a nationwide scale in AD 930 when the general assembly at Þingvellir was established. It is normally assumed that the whole assembly structure collapsed along with the judicial system in the 13th century, to be replaced by a more centralised judicial system and royal executive power in the wake of Iceland's union with Norway in 1262.

Although the assemblies were the stage for many epic events in the Saga literature, surprisingly little is known about their spatial organisation, and there is no clear typology to support aerial observations (cf. Vésteinsson *et al*. 2004; see also Friðriksson 1994). A cluster of small and evenly spaced house ruins in protected locations close to water may qualify as possible assembly sites. Some sites with these characteristics correlate with locations given in the ancient literature and are sometimes supported by place name evidence. The visible layout of the only documented *þing*-site in our study area, Þingey, differs in having a series of house ruins that seem connected gable to gable to form two parallel rows. Extra complexity is added to the archaeology of the Þingey site because of 19th century farming activities.

The nearby site of Skuldaþingsey, however, has a dispersed cluster of 30 ruins (Figure 20.11) that can only

Figure 20.11: An assembly site at Skuldaþingsey where 26 of the 30 booths can be seen.

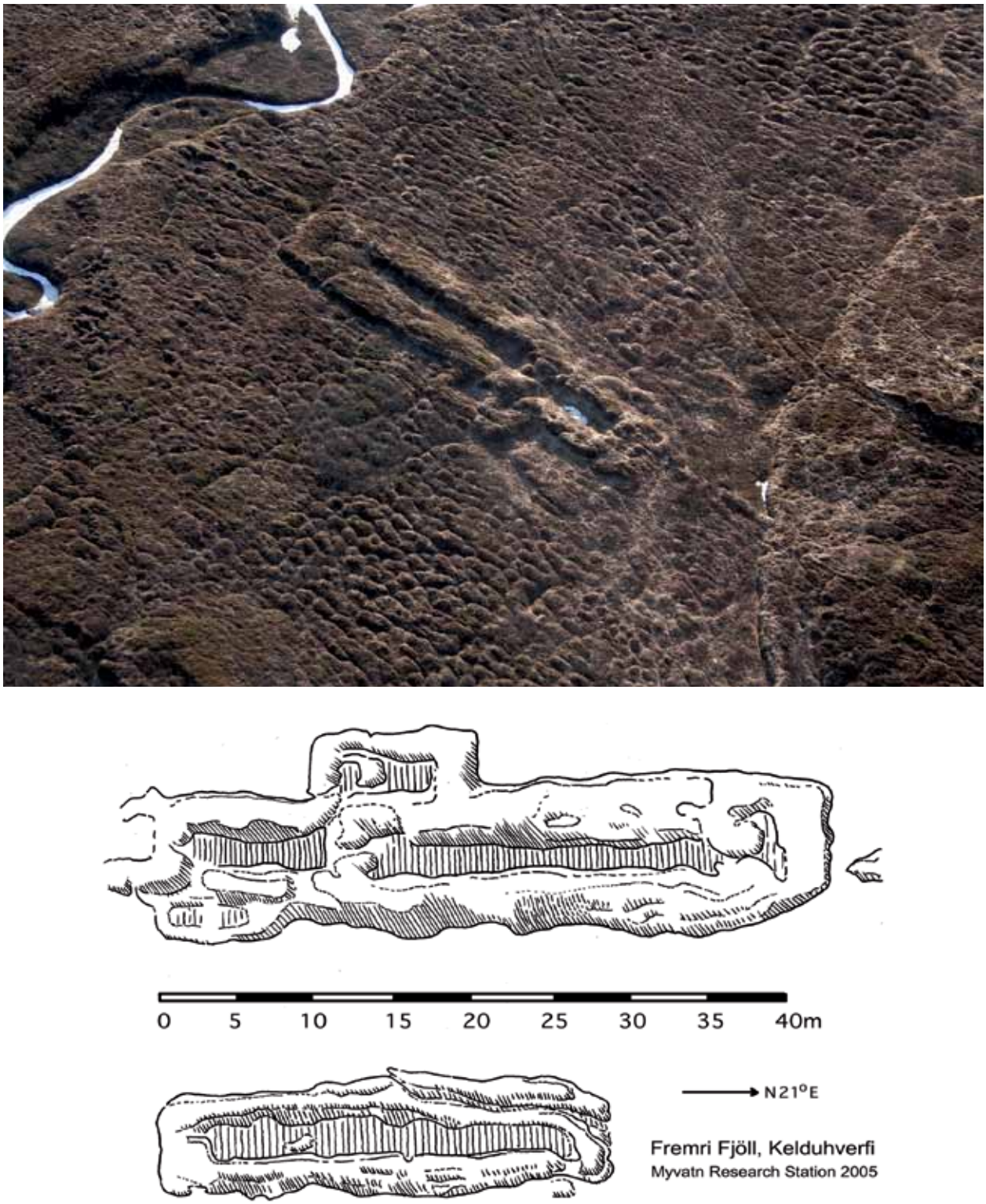

Figure 20.12: Fremri Fjöll, a major farm site in Kelduhverfi. *Top*: The large house from the air. *Bottom*: A line drawing based on detailed measurements of the same house and another longhouse close by.

be interpreted as booths for some kind of assembly (an interpretation also assisted by the *þing* element in the name). The location of this large assembly site so close to the traditional major site in Þingey is somewhat puzzling. Both assembly sites date to the medieval period and an excavation in Skuldaþingsey shows evidence of prolonged but seasonal use (Vésteinsson *et al*. 2004).

The lack of clear typology exemplified by the striking dissimilarity of the two major and adjacent sites Þingey and Skuldaþingsey makes it difficult to assign a function to two other suspected assembly sites, Leiðarhóll by Helgastaðir and Leiðarnes by the River Fnjóská. The names suggest minor assemblies (Icelandic = *leið* refers to a local assembly for the announcements of decisions made at regional assemblies). The Leiðarhóll site is also

complicated by later farming activities – in fact there is nothing assembly-like about it other than the name. The Leiðarnes site, however, certainly qualifies as an assembly site, judging by the name and by the typology discussed above. It has a group of evenly spaced ruins of similar size, located on a peninsula created by a meander in the river. Both sites are awaiting aerial recording.

Farm sites

The set of ancient farmsteads observed from the air is certainly a biased sample, as the best preserved sites are the marginal ones that were abandoned early. The 12–13th century saw large-scale abandonment of the marginal, mostly upland and interior settlements (Thorarinsson 1976; Rafnsson 1990; Sveinbjarnardóttir 1992). Although farm abandonment may have taken place in other periods, most of the farms that survived the medieval period were still in use in the early 20th century and the ruins of the original settlement have been superseded by modern development. Also, the marginal upland farm sites will tend to have lower soil accumulation rates, and therefore be more visible, than those of the richer lowland.

There are two notable exceptions where major farm sites have survived. One is the well known archaeological site of Hofstaðir by Mývatn, a large 10th century farm with an oversized Viking type longhouse, showing evidence of ritual feasting (Lucas 2010). The wall system associated with the farm is also well preserved. The other is Fremri Fjöll in the Kelduhverfi district. It has not been dated but the ground plans of the houses suggest 9th–11th century (Christian Keller pers. com.). The site is beautifully preserved and the constructions are still prominent above ground with two exceptionally large halls (Figure 20.12), a set of at least seven smaller houses and a complex system of walls.

Two areas deserve special mention because of good preservation. One is the valley of Þegjandadalur that was deserted early (probably long before the 1477 tephra) and has well-preserved farmhouse complexes, walls, a couple of churches and a Viking period grave field. The other site, Brettingsstaðir, is a well-preserved farm site in the valley of Laxárdalur and has what seems to be a double Viking period hall (Figure 20.10), a church or chapel ruin, some outhouses and a system of walls. The ridge above Brettingsstaðir has a large cluster of charcoal pits.

The farm sites in the marginal and usually better preserved settlements are of various types but most share the feature of one or more quasi-circular or sub-rectangular walled enclosures (Figure 20.13). If there are multiple rings of enclosure they are often concentric, and frequently connected by transverse walls. The house complexes are usually in the innermost circle. The district of Kelduhverfi has an impressive concentration of this type of settlement and some of those are truly marginal in every sense, like those at Bláskógar with three large-diameter quasi-circular fences adjacent to each other in the mid-slope lava fields of the shield volcano of Þeistareykjabunga.

The origin of multiple concentric quasi-circular fenced enclosures is not understood, but it has been suggested that they represent stages in an expanding hayfield from the time of first settlement (Líndal 1951). Alternatively they may reflect a contracting hayfield in response to deteriorating environmental conditions, multiple periods of settlement and abandonment, and finally, and perhaps most commonly, they may be a way of subdividing the home range for management purposes.

Many of the well preserved abandoned farm sites show signs, sometimes backed up by historical documentation, of much later use as grazing stations. If this later activity is within the last one hundred years or so the fertilising effect of the activity is easily recognizable from the air by a rich growth of grass. The vegetation on older ruins conforms with the natural vegetation, usually dwarf shrubs. It is possible that a site has oscillated between permanent and seasonal use in response to changing population size

Figure 20.13: A probably medieval deserted farm site with a triple enclosure by the River Reykjakvísl. There is a riding path to the right. The yellow colour inside the innermost enclosure is indicative of farming activity in modern times.

Figure 20.14: A peat pit in Fljótsheiði.

or environmental conditions. Much work remains to correlate the surface appearance of the various houses to their original structure and function.

Single houses

Quite a few ruins of single houses have been located from the air. Some are very small (4 by 4m) and occur along the main riding paths. These may be shelters for travellers (Icelandic = *sæluhús*) or shepherds (Icelandic = *smalakofi*), shielings (summer grazing stations) or temporary stores of bog iron or peat, just to mention a few possibilities.

Pre-Christian graves

Christianity was made the official religion in AD 1000 and in the approximately 130 years before that non-Christian Viking Age burial customs were prevalent. We have been able to see a number of looted pre-Christian graves from the air. Looted graves have a telltale scar and signs of upcast soil, even if the looting dates to the Middle Ages (Vésteinsson 2004b). Untouched graves have no known external features that allow their location either at ground level or from the air.

Peat pits

Peat was used as fuel along with wood from an early date (Simpson *et al.* 2003). The peat was cut in certain peat pits (locally known as '*svarðargrafir*') in the wetlands and dried on nearby hillocks before transport. The pits are easily recognisable from the air by their squareness, but they vary in size and shape. Clusters of small (less than 5m in diameter) pits are frequent. Larger pits (over 10m across) have a characteristic L-shaped internal profile (Figure 20.14). If the wetland is situated on a slope there is usually a narrow cut out of the pit for draining. None of the pits has been dated, but some were used till the mid-20th century.

Discussion

Cultural value of the monuments and their protection

Clearly, the spatial extent of the northeast landscape, its good preservation, as well as the antiquity and importance of its archaeology for Iceland, if not Europe, calls for a policy of protection and other management. There are several challenges that need to be met in order for the archaeological landscape to be protected or otherwise managed to ensure its cultural value for future generations. The northeast landscape, like many areas where archaeology is prevalent, is both a relict and a living landscape. The first challenge is to find ways in which the demands of the relict and the living can be managed to complement each other. The extensive character of the archaeology, especially the wall systems, also presents another challenge of how best to protect or manage a resource that is so widely distributed. Clearly, there is a need to be well informed, and to continue to monitor the resource for any potential or active threats, such as by development associated with infrastructure projects, agriculture, afforestation, as well as natural threats such as volcanic activity or erosion. Providing the opportunity for protection and management that is connected with both natural *and* cultural factors, and archaeology's relationship to both, is an important challenge to meet.

A clear road-map for protection and management lies in two complementary bodies of legislation – firstly Icelandic heritage law (e.g. Law number 107/2001 Þjóðminjalög) and second, European frameworks, such as the European Landscape Convention (ELC, Council of Europe 2000; ESF Science Policy Briefing 41 2010). Both provide a strategic policy to examine how a landscape, such as the one described in this paper, can be protected and managed in a way that accounts for both the historical landscape and the dynamic living one occupied by people depending on it for their livelihood.

Knowledge is a prerequisite for efficient management of the historic landscape. Gaps in our knowledge need to be identified and filled, and a monitoring programme of the status of the landscape should be established, such as Historic Landscape Characterisation (Aldred & Fairclough 2003; Fairclough & Macinnes 2003; Fairclough 2007). These monitoring programmes should be conducted with the aid of different stakeholders, including landowners.

While direct protection is perhaps suited to exceptional landscapes, such as the ones listed below, the majority of the landscape has no such protection and needs to be effectively managed. Protection alone, therefore, leaves some ambiguity over areas not afforded special protection, and one could view this as a rather passive form of heritage management that is subject to contemporary economic and socio-political conditions (Aldred & Friðriksson 2008). A management approach, however, recognises the value of *all* landscape, as indicated through the ELC framework, and a (pro)active approach to land management. Direct protection should then be seen as an extreme and localised case of more wide-ranging management.

The mapping of archaeology from aerial sources, combined with field based archaeological survey, and small-scale excavation designed to date and characterise specific parts of the resource, give the north-eastern landscape a good basis for the development of an exemplar for best practice of landscape management and protection in Iceland.

Much work is needed to classify the archaeological landscape in terms of preservation or management value. Nevertheless, our aerial surveys already allow us to pinpoint ten outstanding areas in this respect. They have a high density of well-preserved and clearly visible remains, often interconnected by a system of walls and horse tracks, in an attractive landscape that is not interrupted by large-scale modern activities.

Those ten areas are:

1. Þegjandadalur, a deserted valley with a multitude of medieval farms with a complex wall system, two churches and a large pagan grave field (Hreiðarsdóttir & Roberts 2009);
2. The upper part of Laxárdalur, including the area between Lake Mývatn and Laxárdalur, with highlights including Hofstaðir, Brettingsstaðir and an unnamed farm 2km north thereof, all with well preserved wall systems, the west side of Lake Mývatn with three well preserved medieval farm sites (Brenna, Selás and Vindbelgur), shielings (summer grazing stations) and a pagan grave field;
3. Fljótsheiði with an extremely long wall and side walls and associated remains of medieval buildings;
4. Hvammsheiði moorland with the farm sites of Litlu Núpar and Íragerði and a few massive walls crossing the moorland, also a boat burial;
5. The concentration of deserted encircled farms above the main row of present day farms in Kelduhverfi, including the extraordinarily well preserved site of Fremri Fjöll;
6. The well preserved system of walls immediately south of Húsavík, including a church, many house ruins and a pagan grave field (cf. Lárusdóttir 2007);
7. The archaeological hotspot of Bakki just north of Húsavík with a dense complex of walls, irrigation structures and peat pits;
8. Seljadalur, a deserted valley with a row of well-preserved farm ruins with an impressive system of walls;
9. Þingey and Skuldaþingsey, the well preserved dual assembly site;
10. The sulphur mining area and farm site of Þeistareykir.

The list above includes areas where pre-modern landscapes remain more intact than elsewhere and covers some of the hotspots of the Viking period society. Of course there is a multitude of more recent archaeological monuments that deserve attention and should influence any plans for regional scale management. These include the extensive (undated) walls built of lava rock by Lake Mývatn and along the River Laxá, and the road on Hólasandur. The various structures associated with sheep farming, folds and pens for milking sheep and feeding lambs many of which are integrated in the lava landscape in an interesting way, should also be included. Unique to the Mývatn area is the extensive use of lava caves as retreats for sheep from the bloodsucking blackfly (*Simulium*).

General remarks

It is rare to have a large scale, one thousand year old archaeological landscape that is so well preserved, as well as one that was moulded within such a short period and still shows the pattern of landholdings, resources and fine scale management. The potential for using the wall system to analyse the settlement pattern in relation to landscape characteristics is enormous. We not only see the pattern of fences but also the communication routes and the distribution of some resources like peat and woodland. Also, religious centres and other assembly sites can be pinpointed. This information is augmented by detailed archaeological and palaeoecological studies of individual sites yielding a good record of diet, fuel and trade (Lucas 2010).

The geography of any human society is the result of dynamic processes that depend on the productivity, dispersion and seasonality of resources and also on population pressures and a range of cultural responses. The Icelandic farming society has always been a dispersed territorial system based largely on an exclusive home range for summer grazing of sheep

and cattle and haymaking for winter fodder (see e.g. Vésteinsson 1998, 2000, 2005). Most farms also had outstations for summer or winter grazing and access to upland commons. Territoriality and animal husbandry stimulates the erection of fences, given the capacity to invest in such structures. Fences are needed to keep your animals within reach and those of your neighbours at bay. The home range may be subdivided for more local management of species, sexes and age groups and also to protect crops or to manure the ground. The configuration of the walls and the large investment involved must therefore tell us a great deal about the geography, structure and resources of the Icelandic society of the Viking period (Aldred 2008). The wall configuration shows evidence of being influenced mainly by landscape characteristics and population density. Tightly packed home ranges tend to have straight boundaries and polygonal shapes. Linear landscapes, like narrow valleys or coastlines, tend to have a single row of square enclosures, while home ranges on a flat terrain tend towards circular or polygonal shapes.

The archaeological remains in the study area may hold the key to understanding the dramatic changes that clearly occurred all over Iceland in the 12th–13th century and involved large scale contraction of the settlements, perhaps preceded by the disuse of the wall system. Hypotheses as to the causal factors include landscape degradation, climatic cooling and an economic shift (see e.g. Dugmore *et al.* 2000, 2005). None of these hypotheses are mutually exclusive, but they involve either migration of people due to shifting resources or the decimation of the population by high mortality rates. Either way, they concern the interaction between people and environment, and the dynamics of the change may be important not only for our perception of the history of Iceland but also that of other settlements in the North Atlantic.

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